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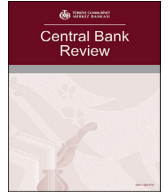
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Estimating light-vehicle sales in Turkey[☆]

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ABSTRACT

This paper is motivated by the surprising rapid growth of new light-vehicle sales in Turkey in 2015. Domestic sales grew 25%, dramatically surpassing the industry estimates of around 8%. Our approach is to inform the sales trend estimate with the information obtained from the light-vehicle stock (the number of cars and light trucks officially registered in the country), and the scrappage data. More specifically, we improve the sales trend estimate by estimating the trend of its stock. Using household data, we show that an important reason for the rapid sales growth is that an increasing share of household budgets is spent on automobile purchases. The elasticity of light-vehicle sales to cyclical changes in aggregate demand is high and robust; its estimates are around 6 with a standard deviation of about 0.5. The price elasticity of light-vehicle sales is estimated to be about 0.8, but the estimates are imprecise and not robust. We estimate the trend level of light-vehicle sales to be roughly 7 percent of the existing stock. A remarkable out-of-sample forecast performance is obtained for horizons up to nearly a decade by a regression equation using only a cyclical gap measure, the time trend and obvious policy dummies. Various specifications suggest that the strong 2015 growth of light-vehicle sales was predictable in late 2014.

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1. Introduction

The motor vehicle sector is a significant part of the Turkish economy. It accounts for 6.6 percent of industrial production, which corresponds to 40.3 percent of capital goods production.¹ Considering its backward linkages to other sectors, its total influence on the Turkish economy should be much higher. It is the leading sector in Turkish exports. Automotive exports were 18.5 billion US dollars in 2015, which was 12.9 percent of all Turkish exports in that year. From the demand side, automobile sales are an important component of domestic demand, accounting for 4.5 percent of all expenditures and 38.3 percent of expenditures on

durables by households.² Turkey's position in the global motor vehicle sector is not negligible. As of 2015, Turkey is the 15th largest producer in the world and 5th largest producer in Europe. Moreover, Turkey ranks 18th in the world and 6th in Europe in total sales.

Our aim is to estimate a trend for the domestic sales of light vehicles, i.e. automobiles plus light commercial vehicles, in Turkey. This springs from our quest to understand the surprisingly large 25 percent growth rate of light-vehicle sales in Turkey during 2015, a year in which there were doubts regarding how strong the pace of macroeconomic activity was. Data from different sectors of the economy were sending mixed signals, raising concerns whether overall growth was weakening or not. Meanwhile, each data release for the light vehicles sales was suggesting that the demand was strong. The time series data on new sales did not offer a clear picture as to where the unexpected strength of demand came from, given that the economy grew 4.0 percent (a rate near its estimated

[☆] We thank Fatih Akçelik for providing data on household expenditures and Burcu Gürçihan Yüncüler for valuable comments. The errors belong to the authors.
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¹ According to the official weights in Industrial Production Index (2010 = 100) published by Turkish Statistical Institute (Turkstat).

² According to the official weights in Consumer Price Index (2003 = 100) published by Turkstat for 2016.

potential), automobile prices increased, and financial conditions tightened. We examine the sales of light vehicles using an approach similar to Greenspan and Cohen (1999) by looking at the progress of the light-vehicle stock (the number of cars officially registered in the country) and scrapped vehicles separately and estimating their trends. Greenspan and Cohen (1999) write that an important advantage of this approach is that it does not require extensive assumptions about the determinants of sales such as demographic trends, the state of the economy, and consumer preferences. In the Turkish case, other advantages are that the data for the stock of light vehicles extend much farther back (1966 as opposed to 1993), and, more crucially, the trend in light-vehicle demand is much clearer in the stock data than in sales data, even in the overlapping shorter part of the sample.

There are two main approaches in the literature to analyze the evolution of vehicle sales. The first one is to use a macro perspective and seek for the relationship between aggregate sales and associated macroeconomic indicators. Vehicles are treated as homogeneous products, whereas product heterogeneity, brand differentiation, consumer preferences or vehicle characteristics are not paid much attention in this approach. The alternative approach has a micro perspective, paying more attention to consumer choices, vehicle properties as well as market structure and hedonic pricing. Those two approaches both have advantages and disadvantages. The macro approach is more convenient for macroeconomic policy making purposes, viewing vehicles as durable consumption goods and understanding the influence of macroeconomic indicators such as household income, prices, interest rates, etc. on sales (Carlson, 1978; Levinsohn, 1988; Arguea et al., 1994; McCarthy, 1996; Verboven, 1996).³ These studies in general estimate the price elasticity of car sales to be below unity, whereas some studies find price elasticity little over unity. Income elasticities are found to be around 2. On the other hand, the micro perspective helps understand individual behavior/preferences in car ownership (Brendemoen, 1994), making a better market analysis such as segment differentiation across cars (Bordley and McDonald, 1993; Bordley, 2006) and investigating the impact of sector specific policy changes easier such as tax exemptions or scrappage programs (Fiuza, 2002; Cantos-Sánchez et al., 2015). This study has a macro perspective as we deal with aggregate sales. Consequently, vehicle properties and consumer choices are not considered in our estimations. We nevertheless bring to bear some facts from the Turkish household surveys and sales by brand in the Turkish market to help understand the rapid growth of Turkish demand for cars.

The studies on automobile demand in Turkey are scarce compared to the extensive literature for other countries, especially for the US. Among them, Alper and Mumcu (2007) find that both the country of origin as well as the quality of brands are important for automobile demand in Turkey. Furthermore, the demand for new automobiles is found to be price inelastic in the short run. Yavaş et al. (2014) find that equipment, design, motor size and fuel type are the main criteria in deciding to buy a car. On the other hand, Özçam and Özçam (2014) find that the demand for automobiles is price elastic, and observe that it is strongly correlated with the business cycle, with an informally estimated elasticity of 5 to 10 with respect to cyclical GDP changes. Against this background, to the best of our knowledge, our study is the first in Turkey to estimate the underlying trend in light-vehicle sales by examining the progress of the light-vehicle stock and scrapped vehicles.

Our results show that while the growth trend of light-vehicle sales is not evident in its own time series, it is evident in the time series of its stock. After adding the estimated scrappage rate (0.84 percent of the light-vehicle stock per year) to the growth rate of the projected trajectory of the light-vehicle stock, we arrive at a total annual number of light-vehicle sales of roughly 7 percent of the existing stock (or 7.5 percent of the last year's stock) for the current cyclically adjusted level of domestic demand. The ongoing increase in the household budget share of automobiles, the low number of registered vehicles per capita compared to other countries, and also possibly the steadily growing car leasing sector, are factors that support this estimated trend to continue in the years ahead. Empirical analysis points out that the demand gap calculated from the final domestic demand explains most of the deviation of sales from its growth trend. Other factors such as real interest rate, fuel prices and automobile prices may provide extra information depending on the sample period; however, their relationships are not as robust as that of the demand gap. Finally, a simple specification (consisting of the vehicle stock's trend, output gap, and a dummy variable controlling for the scrappage program of 2004) produces fairly good out-of-sample forecasts to follow the underlying trend in new sales and identify the ups and downs of light-vehicle sales. Finally, we look at the ability of the wider set of specifications that include additional variables to forecast the strong demand of 2015 out of sample. We find that the sales performance in 2015 should not be considered as a surprise and could have been estimated with the information available at the end of 2014.

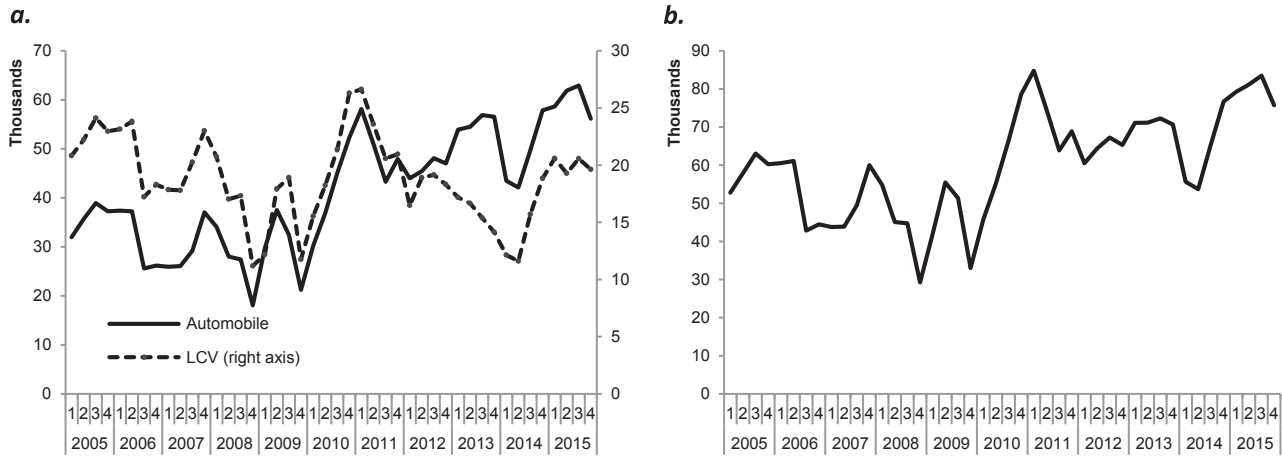
The study proceeds as follows: In the second and third sections, we introduce the data and the methodology for estimating the trend for light-vehicle sales. The fourth section elaborates on the trend estimations. The fifth section discusses potential factors supporting the sales growth trend. The sixth section presents an empirical analysis on the determinants of the deviation of sales from the estimated trend and the out-of-sample forecasts of various models. The last section concludes.

2. Data

The domestic sales data for light vehicles are taken from Automobile Distributors' Association (ADA) and are seasonally adjusted by the authors. In the literature, the majority of the studies analyze only the automobile sales. However, the degree of substitution for the two components of light vehicles, i.e. automobiles and light commercial vehicles, is very high in Turkey, and they behave similarly except when a regulation that differentiates their behavior from each other is introduced. The rate of sales tax is substantially lower for light commercial vehicles than for automobiles, encouraging the substitution of light commercial vehicles for automobiles in noncommercial usage. However, the regulations affecting the tradeoff between the two categories change from time to time, as, for example, in 2012, when a change took place in the regulation for light commercial vehicle sales. That regulation restricted the usage of light commercial vehicles for noncommercial purposes and brought extra costs for acquiring these vehicles. Subsequently, unlike previous periods, the two components' sales paths moved in opposite directions and the composition of demand has shifted in favor of automobiles immediately (Fig. 1a). When those limitations were partially reduced at the beginning of 2014, the two began to move in tandem again. Against this background, taking light vehicles as the unit of analysis instead of decomposing it into two is particularly important in the Turkish case. The time series for the total light-vehicle sales is shown in Fig. 1b.

The light-vehicle stock data is taken from Turkish Statistical Institute (Turkstat). The stock value for a specific period is the total number of vehicles registered in the country as of the last day of that period. The data is available in both monthly and annual

³ See Kang and Lee (2014) for a summary of different studies on automobile demand.



Notes: The sales data for automobiles and light commercial vehicles (LCVs) are seasonally adjusted.

Fig. 1. a. Automobile vs. light commercial vehicle sales in Turkey. b. Total light-vehicle sales in Turkey. Source: ADA, Authors' own calculation.

frequency. However, the stock data at annual frequency has an anomaly in 2004. Sales should generally be greater than the change in the stock, because every year some vehicles are totaled in accidents or scrapped, and are consequently removed from traffic. The left panel of Fig. 2 shows the sales data together with the change in the stock as in the original annual frequency data. Sales are indeed often greater than (or at least not noticeably less than) the change in the stock, except in 2004 as seen in the left panel. Anomaly disappears when the level implied by the corresponding monthly data for 2004 is used instead, as shown in the right panel of Fig. 2. The details are discussed in Appendix A.

3. The methodology to estimate the trend

Our aim is to understand how new light-vehicle sales progress over time so that we can evaluate over/under performance of new sales at a certain period by comparing to its trend. In doing so, we follow a methodology that is not practiced much in the literature, one exception being Greenspan and Cohen (1999), who estimate car sales in the US by estimating the stock trend and the scrappage rate separately. In this framework, the time path of the vehicle stock provides an insight on new vehicle sales. An important advantage of this approach is that it does not require extensive assumptions about the determinants of sales such as demographics, the state of the economy, and consumer preferences. Additional advantages in the Turkish case are that the light-vehicle stock follows a particularly smooth trend and dates back to an earlier period.

The stock of vehicles increases by the number of vehicles sold and decreases by the number of vehicles that are retired due to various reasons. Accordingly, the number of vehicles sold should be equal to the sum of the change in the vehicle stock and the number of scrapped vehicles (Equation (1)).⁴

$$Sales_t = \Delta Stock_t + Scrap_t \tag{1}$$

This equation, of course, is an identity and does not imply a causal relationship, such as that scrappage causes new vehicle sales. However, an exogenous shock like the introduction of scrappage program may lead to an increase in new sales, as Greenspan and Cohen (1999) notes and as observed in Turkey in 2004.

⁴ Greenspan and Cohen (1999) decompose total scrap into two as engineering scrap and cyclical scrap. We do not make such a distinction.

Against this background, a trend for new sales can be estimated by first estimating the growth trend of the stock and adding to it an allowance for retired vehicles. In this way, we can get a trajectory for new sales and evaluate each year's sales performance in comparison with the growth rate of the trend. This would allow us to understand if an unprecedented growth in sales rate, such as in 2015, is in fact surprising or not.

4. Trend estimations

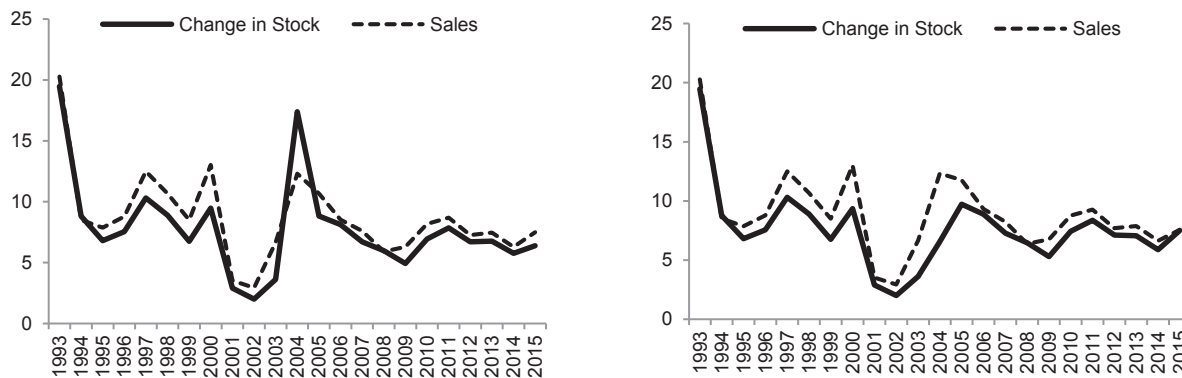
The high volatility of light-vehicle sales makes it difficult to identify the trend of its series. That trend is sensitive to the starting point. As shown in Fig. 3a and b, which present two different comparisons of GDP to domestic light-vehicle sales with different initial points, whether light-vehicle sales have a faster or slower trend than GDP is not clear from the sales data alone.⁵ Similarly, rather than picking 1993 or 1994 as the base year, if we set the average of 1993 and 1994 to 100, the emerging graph suggests that the growth trend of new light-vehicle sales is close to that of GDP (Fig. 4a).

In contrast, a steep upward trend is immediately apparent in Fig. 4b below, which plots the stock of light vehicles together with real GDP.⁶ This is important because the trend of the stock also reveals the trend of sales.⁷ Over the period shown in Fig. 4b, the stock of light vehicles grew at an average rate of 7.5% per year, significantly faster than the average GDP growth rate of 4.1% per year.

⁵ One could combine Fig. 3 with additional information on the cyclical situation of the economy and try to make more informed deductions: For example, given that 1994 was a crisis year, which likely reduced both GDP and automobile sales but reduced the latter more (because vehicles are income elastic durable goods), one could discount the second panel and presume that the first panel to be more reliable. But, as we see below, that presumption would be incorrect.

⁶ Each series in Fig. 4b is also scaled to make the average of the 1993–1994 period equal 100. It would not have made a noticeable difference in Fig. 4b if the base year was chosen instead as either 1993 or 1994.

⁷ To see the relationship between the trend of the stock and its corresponding flow variable, suppose the stock grows continuously over time at a constant rate of g , i.e., $K_t = Ae^{gt}$. Suppose that this stock variable depreciates at rate δ . Then the flow variable that builds that stock, say S_t , would equal $\dot{K}_t - \delta K_t = Ag e^{gt} - \delta A e^{gt} = (g - \delta)A e^{gt}$. Note that $(g - \delta)A$ is a constant, and therefore the last equation means that the flow variable S_t also grows at rate g . In other words, the flow variable has the same trend as its stock.



Notes: The graph in the left panel is derived from annual frequency data, while the one in the right panel is derived from monthly data.

Fig. 2. Total light-vehicle sales vs. change in light-vehicle stock (% of previous year's stock level). Source: ADA, TurkStat.

4.1. Estimating the trend of the light-vehicle stock

The data for the light-vehicle stock start from 1966. We estimate a quadratic trend for the logarithm of the light-vehicle stock by regressing it on a constant, the year and the year squared, as shown in Equation (2).

$$\ln(\text{Stock}_t) = \alpha + \beta_0 * t + \beta_1 * t^2 + \varepsilon_t \quad (2)$$

In Fig. 5, the fitted exponential trend is shown together with the stock of light vehicles. This figure shows that the stock of light vehicles resembles quite well a smooth exponential growth trend where the growth rate slowly declines over time in a linear fashion. One possible caveat to Fig. 5 is that it goes too far back. In the 1980s and the decades before that, the Turkish market for automobiles was not a freely functioning market in terms of market access and production. Turkey restricted international trade greatly and there were also important restrictions on how financial markets operated. Perhaps not surprisingly, the stock series differed much more greatly from its trend in those early years than in the later period (Fig. 6). It would be better to focus on the period since 1993, given the irregular behavior of the stock series before 1993, and given that the new sales series, which is the primary focus in this paper, also starts in 1993.

Fig. 7 presents the replicated estimation of Equation (2) for the period 1993–2015 and the uncertainty band around the estimated path. As in the longer sample, the time series for the stock resembles a smooth exponential trend, with the exception of the deviation caused by the 2001 crisis. Note that the 2009 crisis did not cause an equally sizeable deviation from that trend. The leading reason is that the substantial reduction in special consumption tax on automobiles and light commercial vehicles between March 2009 and October 2009 gave crucial support to light-vehicle sales.

4.2. Estimating the scrappage rate of light vehicles

New sales have to be greater than the change in the vehicle stock by an amount that replaces retired vehicles, as noted earlier (Equation (1)). That, indeed, is the case in Turkey, as shown in Fig. 8, except for 1994 and 2008. That may appear like an error at first sight, because that series represents the number of scrapped vehicles, which should normally be a nonnegative number. However, the time inconsistency between the sales and the registrations may lead to such an outcome. As an example, a vehicle

sold in December may be registered in January of the following year to delay taxes or reduce fees. Since December is the most active month for the market,⁸ the size of the postponed registrations can become noticeable. Moreover, when the following year is cyclically a downturn, the difference can easily become negative.⁹

A reasonable avenue to proceed appears to be to rely on the average of the series shown in Fig. 8. However, the series has a sharp peak in 2004 associated with a scrappage program that introduced tax deductions to incentivize the retirement (i.e. scrappage) of old vehicles, resulting in an unusually large number of vehicles removed from traffic in 2004 (see Appendix A). That large number should be left out of the average to prevent it from distorting the calculated mean. Moreover, the series of removed vehicles has tended to be lower after the 2004 peak. Possibly because many vehicles were retired in 2004, there were fewer vehicles to be retired in the following years—resulting in lower rates of scrapped vehicles after 2004. To summarize, we would use the post-2004 average of that series, which equals 0.84% of the previous year's stock, to be the value currently representative of the difference between sales and the change in the stock of light vehicles.

Note that 0.84% is a relatively low value for the rate of scrappage, considering that the annual rate of depreciation for automobiles is estimated to be 15 percent or even higher by different studies (Peles, 1988; Jorgenson, 1996; Storchmann, 2004). Scrappage is of course different from depreciation. A car is not scrapped when it has depreciated parts; rather, the dysfunctional parts are replaced and the car is put back in traffic. The scrappage rate can therefore be expected to be substantially below the depreciation rate. Nevertheless, 0.84% is still too low, when compared to the rate in the US, hovering around 8% in the 1950s (Fig. 9). The higher scrappage rates in the past (especially before the 1980s) might be due to the replacement of the “gas guzzler” models of the 1970s

⁸ In Decembers, sales tend to be nearly twice as high as the average month of that year.

⁹ Another hypothetical explanation to why vehicles removed from traffic can become negative is that a notable number of autos might be transferred by their owners from abroad and registered in Turkey, as, for example, allowed by the tax exemptions offered to diplomatic workers, who work in missions abroad for two years or more. Those workers are allowed to bring their automobiles from abroad without having to pay sales taxes—which can be an important advantage. Note that both of the years in which the series in Fig. 8 turns negative are years of cyclical downturns that saw notable slowdowns in auto sales.

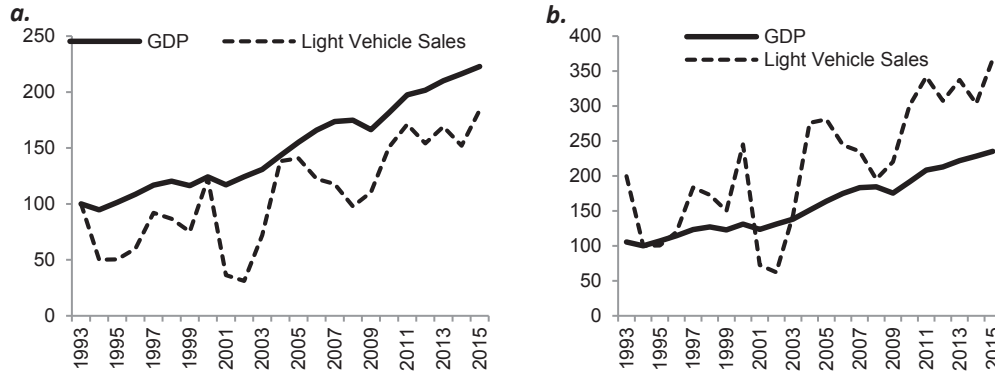


Fig. 3. a. Real GDP vs. light vehicle new sales (1993 = 100). b. Real GDP vs. light vehicle new sales (1994 = 100). Source: Turkstat, ADA.

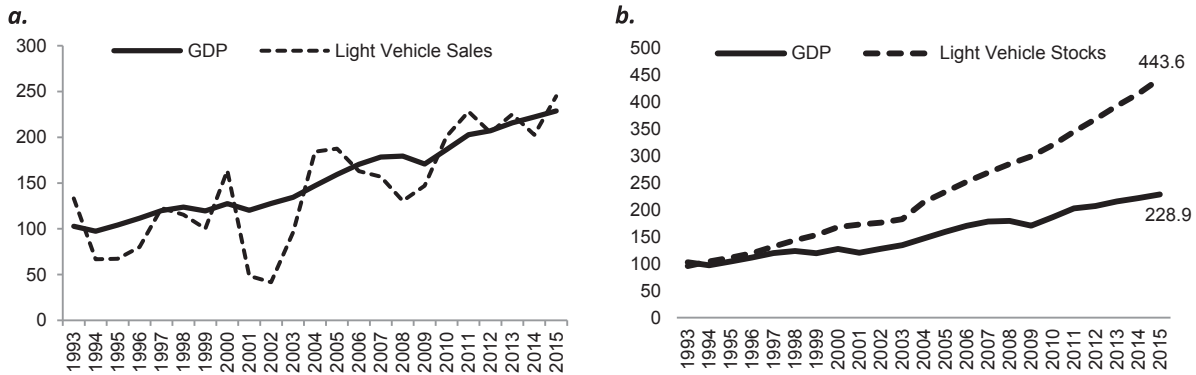


Fig. 4. a. GDP vs. light-vehicle sales (1993–94 = 100). b. GDP vs. light-vehicle stock (1993–94 = 100). Source: Turkstat, ADA, Authors' own calculation.

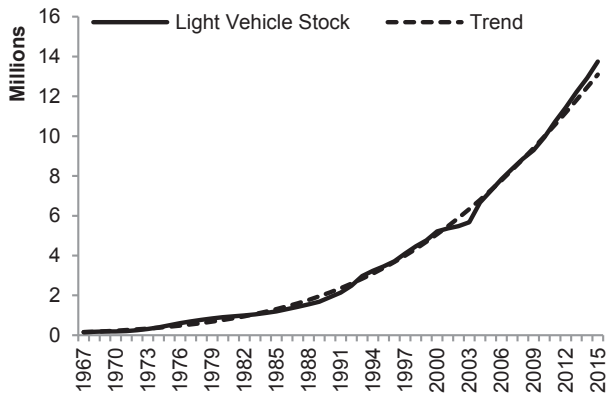


Fig. 5. The stock of light vehicles and the fitted trend (millions). Source: TurkStat, Authors' own calculation.

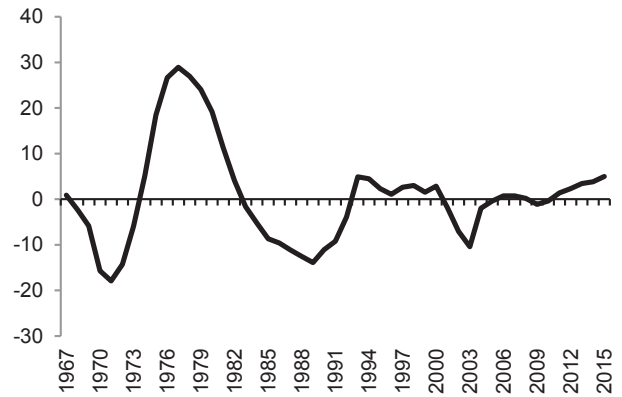


Fig. 6. The deviation of stocks from estimated trend (%).

by more efficient cars.¹⁰ The scrappage rate in the US has fallen to around 5% in the 2000s, which is still about 6 times the average in the post-2004 period in Turkey.

One possibility is that 0.84% might be an erroneous statistic, as a result of, for example, behavior such as households holding back from scrapping their dysfunctional old automobiles with the anticipation of a new scrappage program that would make those

cars valuable for tax deduction purposes. However, such imperfections in the data would not matter for the purpose of this paper. As long as that behavior continues, 0.84% would be a good estimate of the difference between the sales trend and the stock's growth trend.

In fact, 0.84% should not be assumed to be an erroneous statistic for the scrappage rate itself. There are good reasons why the scrappage rate in Turkey should be much lower than in the US. A leading one is that the Turkish light-vehicle stock is much younger. The cars that are scrapped are typically the old ones, and the stock of old cars in Turkey is very small in size. Appendix B shows that the scrappage rate would be 2.65%, about three times as high, if the automobile market had reached a steady state in Turkey. In other words, the freshness of the Turkish stock explains why a mature

¹⁰ A high rate of replacement would not be evident in the Turkish data in that period because the number of cars from that era has been very modest in Turkey in the sample period, i.e., after 1993.

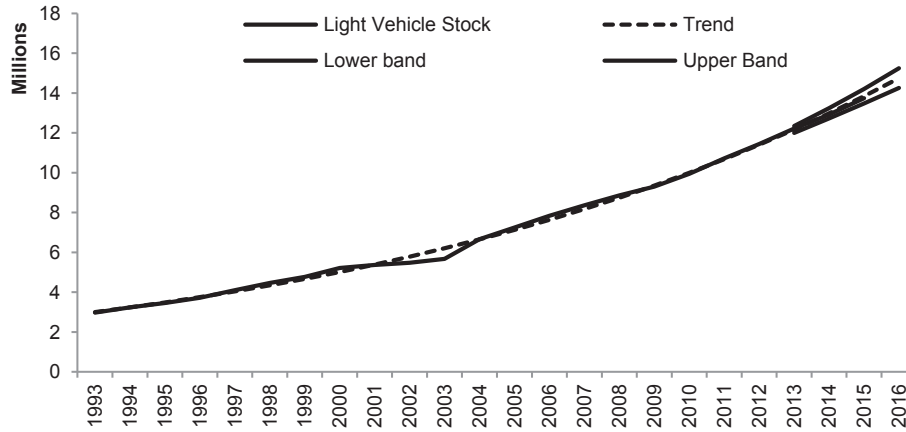


Fig. 7. The stock of light vehicles and the fitted trend, 1993–2015. Source: Turkstat, Authors' own calculation.

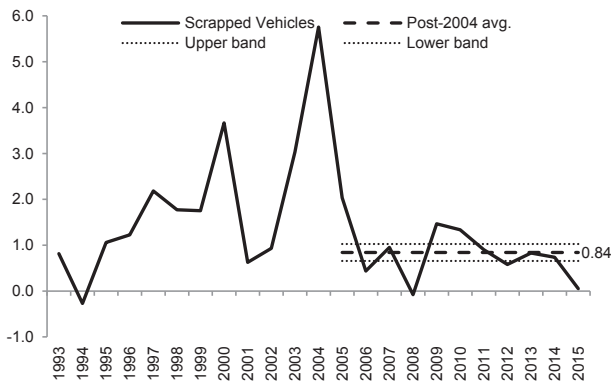


Fig. 8. The scrapage rate (% of previous year's stock). Source: Turkstat, Authors' own calculation.

market such as that in the United States would have a three times higher scrapage rate.

Another explanation may be the difference in the sales tax structure of the country. The sales tax rates on automobiles are very high in Turkey, currently ranging from 71% to 271% of the pre-tax price of automobiles.^{11,12} In contrast, that value is very low in the US.¹³ Moreover, the book value of a scrapped car could be deducted until recent years from taxes in the US, and can still be deducted albeit at a narrower extent than in the past. Finally, ordinary Balassa Samuelson thinking suggests that the price of nontradables relative to tradables is lower in developing countries. Consistent with this and the labor-intensive nature of auto repair, maintenance is far less costly in Turkey than in the US. All of those result in much greater incentive in Turkey than in the United States for maintaining a light vehicle and keeping it in traffic rather than scrapping it. Income level and the fuel prices are other potential determinants of scrapage rate, as put forth in the literature (Hamilton and Macauley, 1996; Greenspan and Cohen, 1999; Eskeland and Feyzioğlu, 1997; Kahn, 1986;

¹¹ The numbers reflect the combined burden of special sales tax and value added tax on automobiles. The lower value is for the automobiles with a motor size of 1600 cc or lower, while higher value is for those having a motor size above 2000 cc. The total sales tax is 36% for light commercial vehicles, 35 percentage points less than the lowest tax rate for automobiles.

¹² Repair and maintenance of cars also have a sales tax in Turkey but its rate is much lower than that on new vehicles and is much less difficult to evade.

¹³ Each state has a different taxation policy. However, sales taxes are known to range between 0 and 11 across states.

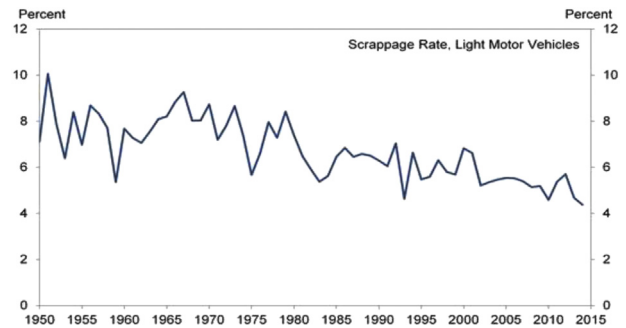


Fig. 9. Scrapage rate in the United States.

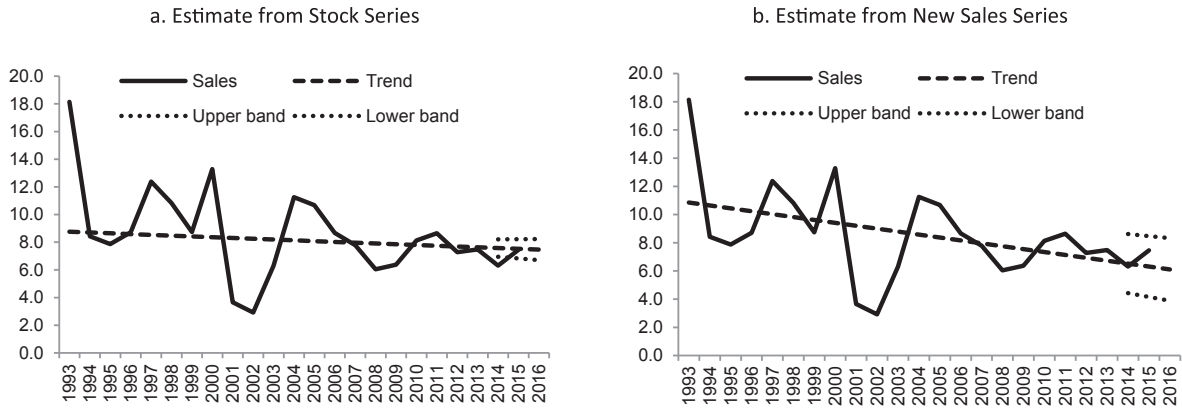
Jacobsen and van Benthem, 2015). When fuel price rises, people become more willing to keep their car's technology updated especially if their income level is suitable for doing that.

4.3. Estimating the new sales trend for light vehicles

The sales trend is obtained by calculating the first difference of the stock trend shown in Fig. 7 and adding to it the 0.84% average scrapage rate from Fig. 8. Fig. 10a below shows that inferred sales trend together with actual sales data as a fraction of the prior year's stock. The uncertainty band is similarly calculated by taking the first difference of the band in Fig. 7 and adding 0.84% of the average scrapage rate. Fig. 10a shows that the trend level of sales currently is 7.5 percent of the previous year's stock, or, equivalently, roughly 7 percent of the existing stock.

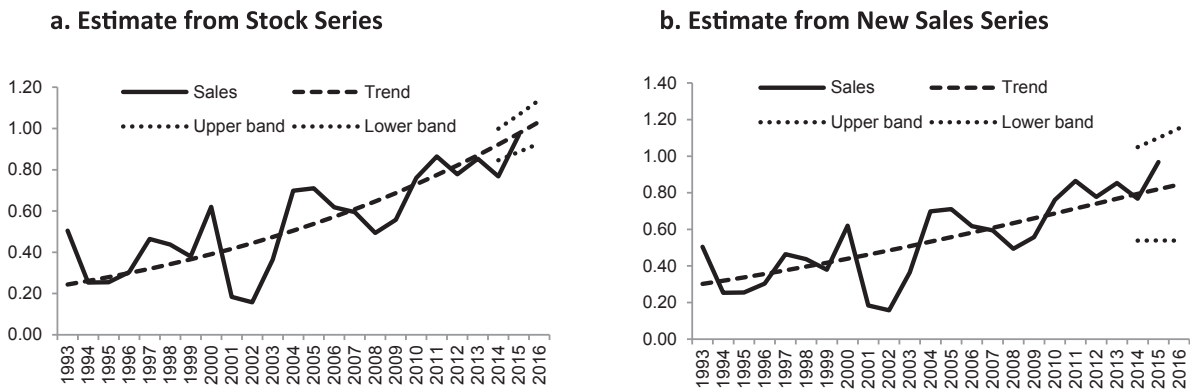
To highlight the benefit of obtaining the trend from the stock series, Fig. 10b shows what happens to the figure when the sales trend is estimated directly from its own time series. The volatile nature of the sales series makes it difficult to estimate that trend with precision, resulting in a wider uncertainty band. Note that the estimated trend line has also a more rapid downward slope. The reason for that is the unusually high sales of automobiles in 1993. The trend obtained from the stock series in Fig. 10a makes it clear that the 1993 sales were an outlier. In contrast, sales series starts in 1993, which obscures the fact that 1993 sales were too far above normal.¹⁴ Interestingly, additional information about the cyclical situation in those years would not help in determining that 1993 is

¹⁴ The reason for the strong 1993 sales appears to have to do with stock catching up to its trend, i.e., a case of "pent-up demand".



Notes: The upper and lower bands show 95% confidence interval.

Fig. 10. The trend estimate of light-vehicle sales (% previous year's stock). Source: TurkStat, ADA, Authors' own calculations.



Notes: The upper and lower bands show 95% confidence interval.

Fig. 11. The trend estimate of light-vehicle sales (millions). Source: TurkStat, ADA, Authors' own calculations.

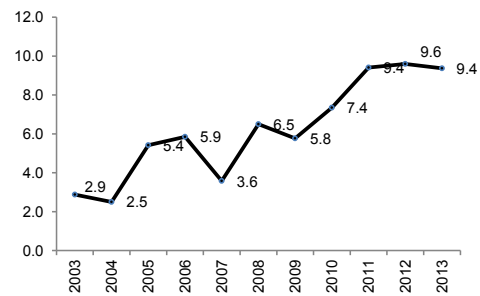
an outlier, because 1994 was a crisis year (and a severe one) while 1993 was not. Cyclical considerations would have (incorrectly) suggested that 1994 is a low sales point and 1993 is the more normal level, which is not the case. Finally, Fig. 11 shows the same series in levels (number of vehicles). The large size of the uncertainty band when the trend is estimated from the sales series is more apparent in Fig. 11b.

As mentioned earlier, the number of light vehicles sold reached in 2015 a historical high and was 30,000 shy of the 1 million threshold, corresponding to 25 percent growth relative to 2014. What does the analysis so far tell about the strong sales performance in 2015? Looking at the figures, a plot of the sales series as a fraction of the stock makes it clear that the 2015 sales were not abnormally high, but were fully consistent with the trend of the Turkish automobile market. The 2015 increase appears to be more of a case of catching up with the trend than a temporary jump due to cyclical or other reasons. For 2016, a sales performance between 0.93 and 1.13 million light vehicles would lie within the 95% confidence interval. The mid-point is 1.03 million. That figure implies a growth rate of around 6 percent for the underlying trend growth in light-vehicle sales.

5. Factors supporting light-vehicle sales growth trend

5.1. Household expenditures

Turkstat's Household Budget Survey contains information on the share of automobile purchases in total household expenditures.

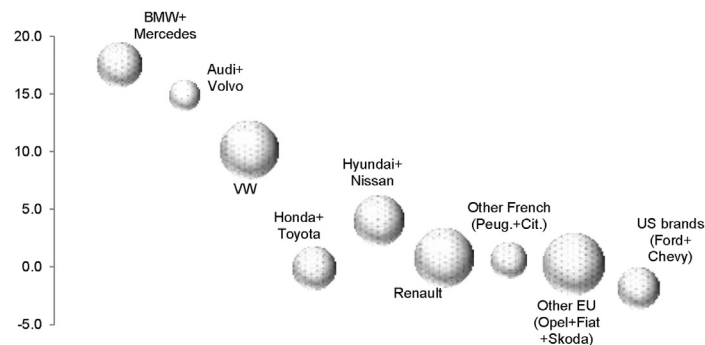


Notes: These numbers show the share of total spending for both new and second-hand cars.

Fig. 12. The share of automobile spending in total household expenditure (%). Source: Turkstat Household Budget Survey, Authors' own calculation

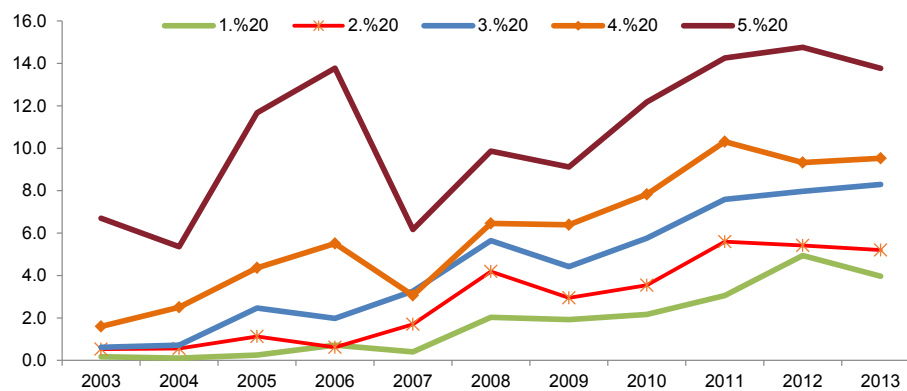
As shown in Fig. 12, total spending on auto purchases as a share of total household expenditures have increased significantly from 2.9% in 2003 to 9.4% in 2013. In other words, the share of autos in household budgets increased at an average rate of 12.5% over that period.¹⁵ Assuming that total household spending increases roughly at the same rate as GDP over that ten-year period, (nominal) spending on automobiles must have roughly increased 12.5 percentage points faster than (nominal) GDP.

¹⁵ That figure is obtained as follows: $(9.4/2.9)^{1/10} = 1.125$.



Note: The size of bubbles indicates 2014 Turkish domestic market sales in terms of the number of units sold. The brands are attempted to be grouped and ordered in a way that keeps the bubble sizes and successive brands comparable. Three brands (Kia, Seat and Dacia) are left out because of relatively new entry into the Turkish market (i.e., for not being well established as of 2004), or for being acquired by major auto producers, which influences production and marketing. The “other brands” category is also left out because it covers a wide price spectrum ranging from modest brands such as Tata to luxury brands such as Porsche and Ferrari.

Fig. 13. Average annual automobile sales growth by brand (% from 2004 to 2014). Source: Turkstat, Authors' own calculation.



Notes: The first and fifth quintiles show the poorest and the richest household groups, respectively.

Fig. 14. Household spending on auto purchases by income quintiles (% of household expenditures). Source: Turkstat Household Budget Survey, Authors' own calculation.

That rapid growth in household budget share hints at an even more rapid increase than is evident in Fig. 4b. According to Fig. 4b, the number of light vehicles stock in Turkey grew at a rate of 7.0%—only 3.2 percentage points faster than real GDP, which grew at a rate of 3.8% per year over that period. That difference, 3.2 percentage points, is much more modest than the 12.5 percentage points suggested by the household spending data. Therefore Figs. 4b and 12 might be suggesting very different trends, but there are good explanations for this, as explained next.¹⁶

A leading possible explanation is that the 7.0% growth rate in Fig. 4b. is for the number of vehicles while Fig. 12 is for the share in spending, and the average vehicle might have become more expensive over time. Any change over time in the composition of vehicles toward more expensive brands would make the growth rate of spending on automobiles exceed the growth rate of the number of units. That has indeed been the case. Data are available from Turkstat on the number of automobiles sold domestically by brand in the period 2004 to 2014. The average growth rates of sales for different brands are shown in Fig. 13. The combined number of sales of BMW and Mercedes, the highest premium brands for which data are separately available, grew 18 percent per year on average over that decade, while Volvo and Audi sales grew 15 percent and

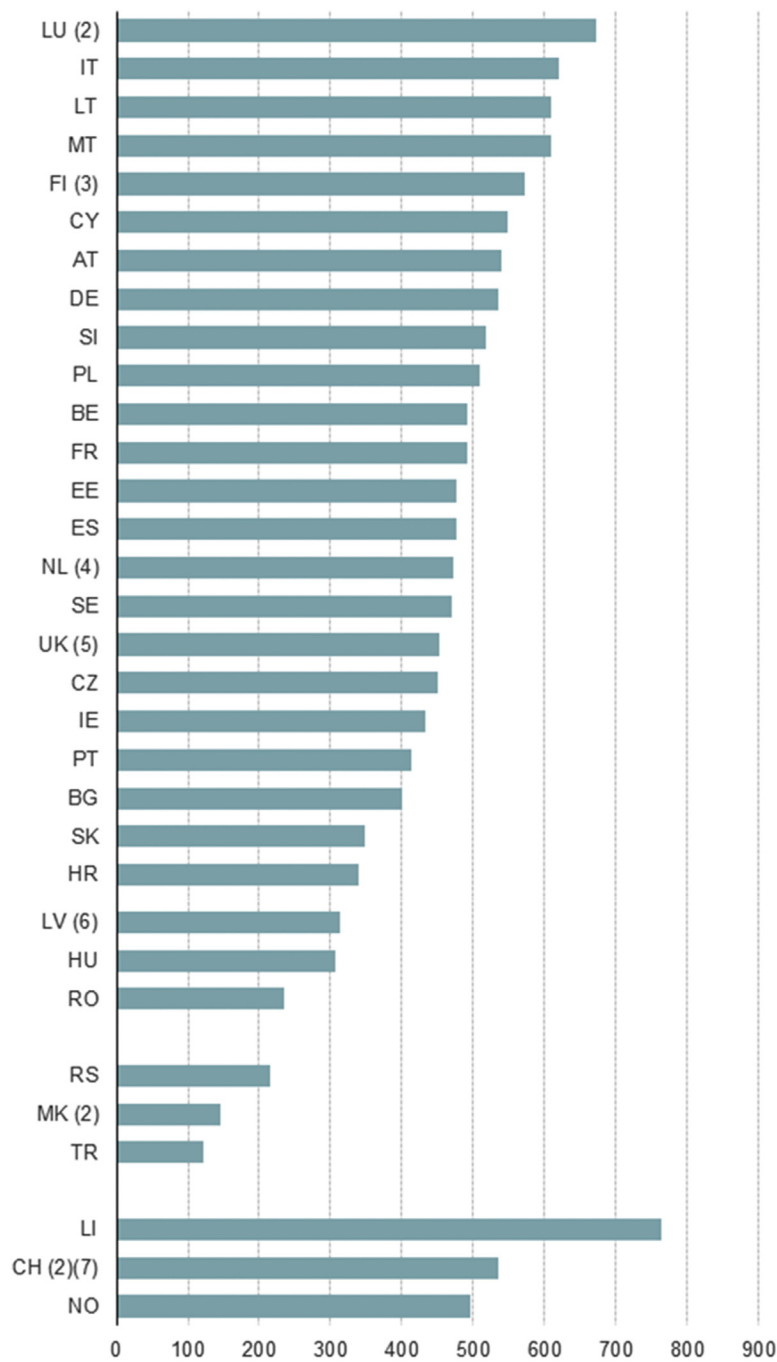
Volkswagen sales grew 10 percent per year. In contrast, the combined sum of all other brands in Fig. 13 grew at the modest rate of 0.7 percent per year. In short, the number of units of premium brands sold has increased dramatically, while that of modest brands stayed relatively flat. This finding is consistent with that of Bordley and McDonald (1993), who argue that, the more luxurious a car is, the higher is its income elasticity.

What may be the reason for the increase in the budget share of automobiles? Fig. 14 shows the distribution of budget share of automobile purchases across different income quintiles. The higher the income level, the higher is the budget share of auto purchases. Moreover, the budget share has shown a tendency to increase in each income group. While it might appear from Fig. 12 that the budget share might have saturated in the last few years of the sample, Fig. 14 reveals that this is not the case. It shows that the higher the household's income is, the greater is the fraction of income that the household would spend on auto purchases.

5.2. Per capita car ownership

The light-vehicle stock has grown rapidly in Turkey since 1993. As of 2015, it is 4.6 times its level in 1993. Nevertheless, the number of vehicles per capita is still very low compared to many countries in the world (Fig. 15). As shown by many studies in the literature (Dargay, 2001; Dargay and Gately, 1999), income is one of the most

¹⁶ One reason could be that the time period in Fig. 4b is different, but it is not. The average annual auto demand growth rate in Fig. 4b is 7.2% for the 2003–2013 period, slightly above 7.0% (the value for the full 1993–2015 period in Fig. 3).



- (1) Denmark, Greece, Iceland, Montenegro: Data not available
- (2) 2012 data
- (3) Including Åland
- (4) 2011 data
- (5) Great Britain only
- (6) Vehicles with no technical inspection for 5 years are excluded
- (7) Estimated values

Note: This figure is taken directly from the Eurostat publication “Passenger Cars in the EU” available at http://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_cars_in_the_EU

Fig. 15. The number of passenger cars per thousand people in European countries. Source: Eurostat.

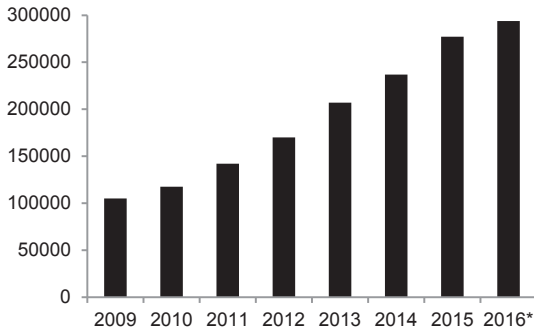


Fig. 16. Estimated vehicle park of the operational leasing sector.

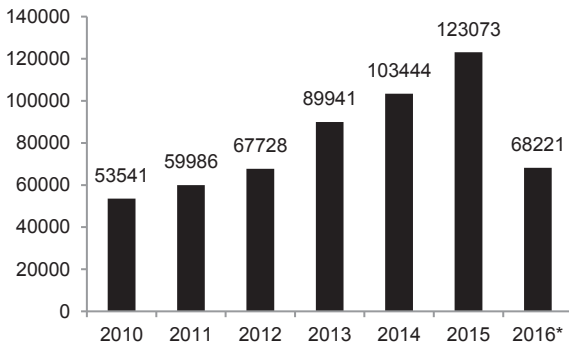


Fig. 17. Number of purchased vehicles by operational leasing sector.

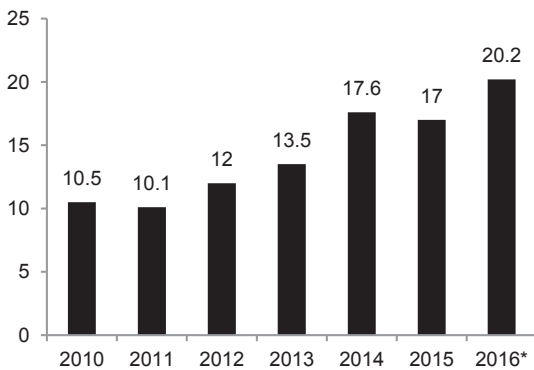


Fig. 18. Share of operational leasing purchases in total automobile sales. * As of June 2016. Source: TOKKDER (2016)

important determinants in car ownership decisions. Turkey's per capita income is still less than the developed countries, which have higher per capita vehicle numbers. Wu et al. (2014) and Rota et al. (2016) show that, the relationship between per capita income and the vehicle per capita has an S shaped relationship. Thus, there is a saturation point inherent to the nature of the demand in the car market. The response of car demand to income is higher at low levels of per-capita number of cars than at levels that are close to the saturation level (Rota et al., 2016). IMF (2005) estimates that the saturation point is approximately 850 vehicles per 1000 people, while Rota et al. (2016) fits a Gompertz curve and estimates a joint saturation level of 622 vehicles per 1000 inhabitants based on data from 59 countries. Against this background, the rise in per capita income and the low number of vehicles per capita compared to developed countries hints at a prolonged time for strong sales growth in Turkey.

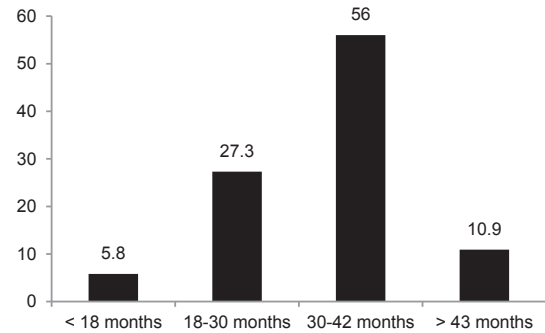


Fig. 19. Contract features of operational leasing sector (term based, percent of all contracts).

5.3. Operational leasing firms

The demand for new cars does not originate only from households. The operational leasing firms are also one of the main actors in the market. According to the TOKKDER (2016), the vehicle stock of the sector has reached to almost 300,000 as of June 2016 from 105,000 vehicles in 2009 (Fig. 16). The sector has a much more significant presence in new sales. Figs. 17 and 18 show the number of vehicles purchased by the sector and its share on total automobile sales.¹⁷ The purchase numbers are increasing rapidly and, as of 2016, the sector's share has risen up to 20.2 percent of all sales. The level of the purchases is 7th highest in Europe.

Compared to the stock, the sales figures are fairly high. The reason is that the leasing companies do not lease the same car to another customer after the contract ends and sells it in the secondary market. The distribution of term-based contracts shows that 90 percent of the leased cars have a contract less than 3.5 years (Fig. 19). Thus, the renewal rate each year is very high. Although the sector has a high share in new vehicle sales, most of those units are put on the secondary market in a short time, and consequently the sector commands a small share of the overall automobile stock. Moreover, leased cars are likely to displace private ownership of automobiles to some extent. Nevertheless, the displacement of private ownership is likely to be significantly below the full number of leased cars; one reason is that there are important tax advantages to leasing. Therefore, the growth of this sector would likely result in some increase in the overall stock of vehicles.

The extent the private firms lease cars is still far beyond the saturated markets in Europe (Çakmak, 2015). Accordingly, the sector is expected to grow for a long period of time. Thus, the steadily increasing activity of the operational leasing sector and their renewal policy in Turkey may be considered to be another reason for the continued increases in demand for new light-vehicle sales in the future.

6. A regression analysis to estimate elasticities and produce out-of-sample forecasts

As a final step, we try to test empirically which factors play a role on the deviations of sales from the estimated stock trend. To this end, we run the regression shown in Equation (3). The left hand side variable is quarterly sales of light vehicles normalized by dividing by the estimated trend of the capital stock, K^* . As explanatory variables, we include the most probable

¹⁷ We compare the purchases only to automobile sales because the firms are not allowed to lease light commercial vehicles to their customers by law.

Table 1
Estimation results for the period 1994Q1 – 2015Q4.

	(1)	(2)	(3)	(4)	(5)
Constant	0.004895*** (5.89)	0.004898*** (6.74)	0.006249*** (7.11)	0.00633*** (7.14)	0.006233*** (5.93)
Trend	-0.000008 (-0.73)	-0.000009 (-0.99)	-0.0000365** (-2.49)	-0.0000374** (-2.54)	-0.0000344** (-1.79)
Gap	0.001099*** (10.76)	0.001183*** (13.05)	0.001169*** (13.25)	0.00119*** (12.85)	0.001212*** (12.12)
ln(price_auto/CPI)			-0.01558** (-2.13)	-0.015143** (-2.06)	-0.012318 (-1.20)
ln(price_fuel/CPI)				0.002441 (0.77)	0.002963 (0.87)
Auto_Annual Inflation (+4)					3.73E-05 (0.48)
Dummy_Tax		0.003345*** (5.02)	0.008388*** (4.82)	0.008573*** (4.87)	0.008732*** (4.81)
Dummy_Scrap		0.008962* (1.97)	0.00344** (2.10)	0.003509** (2.13)	0.003603** (2.14)
Obs.	88	88	88	88	84
R ²	0.574	0.683	0.698	0.700	0.704
Adjusted R ²	0.564	0.668	0.680	0.678	0.677
Durbin–Watson	1.827	1.964	2.097	2.095	2.103

Notes: *, **, *** show significance at 10%, 5%, 1%, respectively. *t*-statistics are in parantheses. The estimates are obtained after correcting for autocorrelation.

Table 2
Estimation results for the 2002Q1 – 2015Q4 sample.

	(1)	(2)	(3)	(4)	(5)	(6)
Constant	0.006007*** (3.00)	0.004931*** (3.02)	0.006681*** (3.45)	0.007487*** (3.98)	0.007141*** (3.81)	0.008783*** (4.38)
Trend	-0.000019 (-0.8)	-0.000010 (-0.5)	-0.000041 (-1.55)	-0.0000487* (-1.9)	-0.000036 (-1.34)	-0.000043 (-1.62)
Gap	0.000794*** (4.89)	0.001021*** (7.54)	0.000999*** (7.46)	0.001045*** (8.07)	0.001006*** (7.70)	0.000908*** (6.66)
ln(price_auto/CPI)			-0.015324 (-1.62)	-0.017562* (-1.93)	-0.006538 (-0.56)	0.00153 (0.12)
ln(price_fuel/CPI)				-0.014036** (-2.33)	-0.011501* (-1.86)	-0.010527* (-1.75)
Auto_Annual Inflation (+4)					0.000141 (1.45)	0.000175* (1.83)
Interest rate						-0.000258* (-1.95)
Dummy_Tax		0.00839*** (5.21)	0.007802*** (4.80)	0.007264*** (4.62)	0.007425*** (4.77)	0.007921*** (5.17)
Dummy_Scrap		0.003255** (2.14)	0.00328** (2.19)	0.002635 (1.81)	0.002871* (1.98)	0.002775* (1.98)
Obs.	56	56	56	56	56	52
R ²	0.335	0.596	0.618	0.658	0.674	0.700
Adjusted R ²	0.308	0.563	0.577	0.614	0.623	0.645
Durbin–Watson	1.789	1.929	1.977	2.083	2.164	2.077

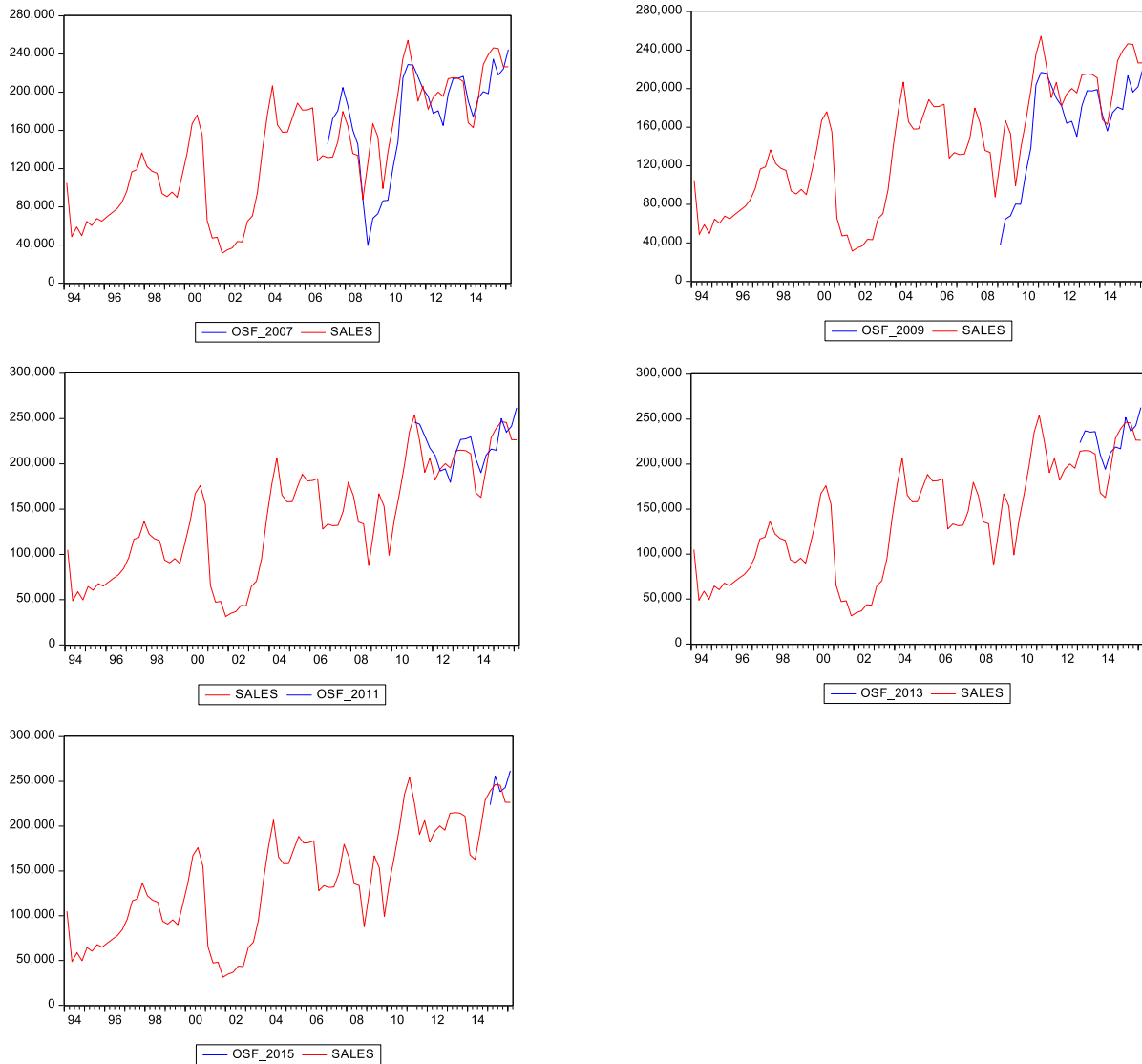
Notes: *, **, *** show significance at 10%, 5%, 1%, respectively. *t*-statistics are in parantheses. The estimates are obtained after correcting for autocorrelation.

macroeconomic determinants of vehicle sales. We preferred using the “demand gap” instead of the output gap, which uses final domestic demand rather than GDP, in order to account for demand conditions in the economy. The demand gap is obtained by estimating the trend of final domestic demand by a HP filter and then by taking the difference of final domestic demand from that trend. The demand gap is conceptually more appropriate for the purpose of this paper and also works better in the regressions than the output gap. Another explanatory variable that we use is the price index for automobiles divided by the consumer price index (CPI). Similarly, another explanatory variable is obtained by dividing fuel prices to CPI. We use real interest rate for the auto loans. Finally we add the annual future increase in car prices (simply next year's car price inflation) to test the tendency of consumers to demand cars

when a price increase is expected.¹⁸ This is motivated by the anecdotal conjecture that consumers may sometimes be anticipating upcoming increases in automobile prices and consequently deciding to buy earlier rather than later. We expect that the demand gap and future price movements to increase current demand for automobiles, and expect the other determinants to reduce it. The data source of all price indicators and the final domestic demand measure is Turkstat. The interest rate data is retrieved from the Banking Regulation and Supervision Agency of Turkey. Price data are seasonally adjusted by the authors.

Besides economic indicators, we use two dummy variables. The first one is the scrappage dummy, which takes the value of 1 between 2003Q2 and 2004Q4, when the government instituted a scrappage program to promote automobile sales. The second dummy takes the value of 1 during the period from 2009Q1 to 2009Q4, when government applied temporary tax reductions for light vehicles to mitigate the adverse effects of the 2008 global financial crisis on the Turkish economy. Those dummy variables

¹⁸ We tried different time spans for the future path of car prices, however the most explanatory one is found to be the four quarter ahead prices.



Notes: Each out-of-sample forecast is obtained by first estimating the stock trend K^* and then the regression equation in Table 1 column (2) using only the data before the year indicated, and then using those estimates together with the demand gap realized over the forecast period. For example, to obtain OSF_2007, K^* and the regression equation are estimated using the data up to 2006Q4, and the estimated regression coefficients and the projected K^* trend are used together with the actual realization of the demand gap after 2006.

Fig. 20. Out-of-sample forecasts for various horizons.

represent the events over the sample period that have had a non-negligible impact on sales and are therefore useful to include in the regression in order to prevent them from distorting the relationship between vehicle sales and the other variables.

$$\frac{Sales_t}{K_t^*} = f\left(gap_t, \frac{P_{auto,t}}{CPI_t}, \frac{P_{fuel,t}}{CPI_t}, Inf_{auto,t+4}, r_t, Dummy_{tax}, Dummy_{scrap}\right) \quad (3)$$

Our sample covers the period 1994Q1–2005Q4, except for the interest rate, which is available for this analysis starting only from 2002Q1. Thus, we first run regressions excluding the interest rate

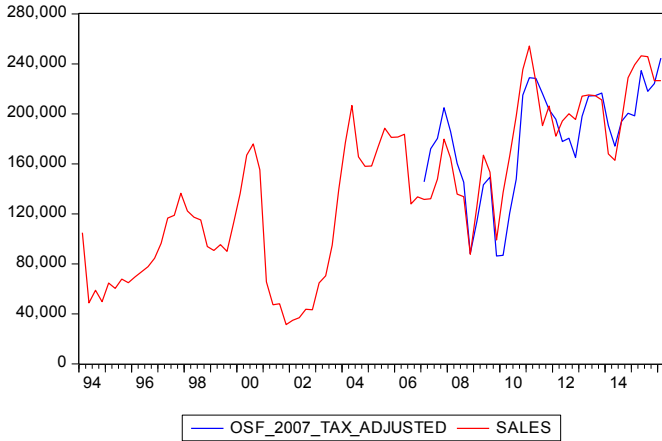
for the whole sample, and then we re-estimate the full set of regressions for the period 2002Q1 and 2015Q4.

6.1. Estimation results

The first part of this subsection presents the regression results and the second part compares the out-of-sample forecast performances of various specifications.

6.1.1. Regression results for 1994Q1 – 2015Q4

We start with an elementary specification consisting of a gap variable in addition to a constant and the trend, which are the strongest predictors of auto demand, and successively add other explanatory variables. As shown in the first column of Table 1, the gap variable is statistically very significant. As the second step, we



Note: See the note in Figure 20. This figure is the same as the upper left panel of Figure 20 except that the forecast is augmented with the estimated impact of a temporary but major reduction in automobile sales taxes introduced in 2009. That impact estimate is obtained from the regression equation in Table 1 column (2).

Fig. 21. Out-of-sample performance for 2007 after correcting for the effect of 2009 tax reduction.

add price variable for the automobiles. The real price of automobiles is also found statistically significant and has the expected negative sign in all but the last of the specifications. We then add the relative price of fuel, but it does not seem to provide extra information. The last variable, next year's annual inflation of automobile prices, which is used as a proxy for expected increases in automobile prices, is also insignificant. Considering the significance of coefficient estimates, third specification in Table 1 has the best performance.

The elasticity of sales with respect to those determinants can also be computed from those estimates. A one percentage point decrease (increase) in the demand gap lowers (raises) sales by around 6 percent. The relative price elasticity of light vehicle demand is around 0.8 percent, i.e., slightly inelastic. This finding is in line with the findings of other studies for other countries.

As mentioned before, we cannot add the interest rate variable to the regression utilizing the longest sample period. We therefore limit our attention to the shorter sample that begins from 2002Q1 and repeat the same exercise but this time also including the interest rate. As shown in the last column of Table 2, the specification that includes all the explanatory variables find all variables significant at 10 percent or less except for automobile prices. (The latter ceases to be significant in the shorter sample—it is significant only in one of the specifications and only at 10 percent.) The elasticity of sales to the demand gap is also slightly lower in Table 2—around 5—but is still strongly significant. The elasticity of sales with respect to the real interest rate is around 1.5, but is not estimated precisely due to low significance. All coefficients have the expected sign.

6.2. Out-of-sample forecast evaluation

In the previous section, estimation results of various specifications for both sample periods have shown that the demand gap is the most significant as well as the most robust variable in explaining light-vehicle sales. Against this background, it would be a good starting point to check the out-of-sample performance of the demand gap in forecasting light-vehicle sales. Fig. 20 presents the out-of-sample forecasts for various horizons. Those forecasts show that the specification with the demand gap alone performs

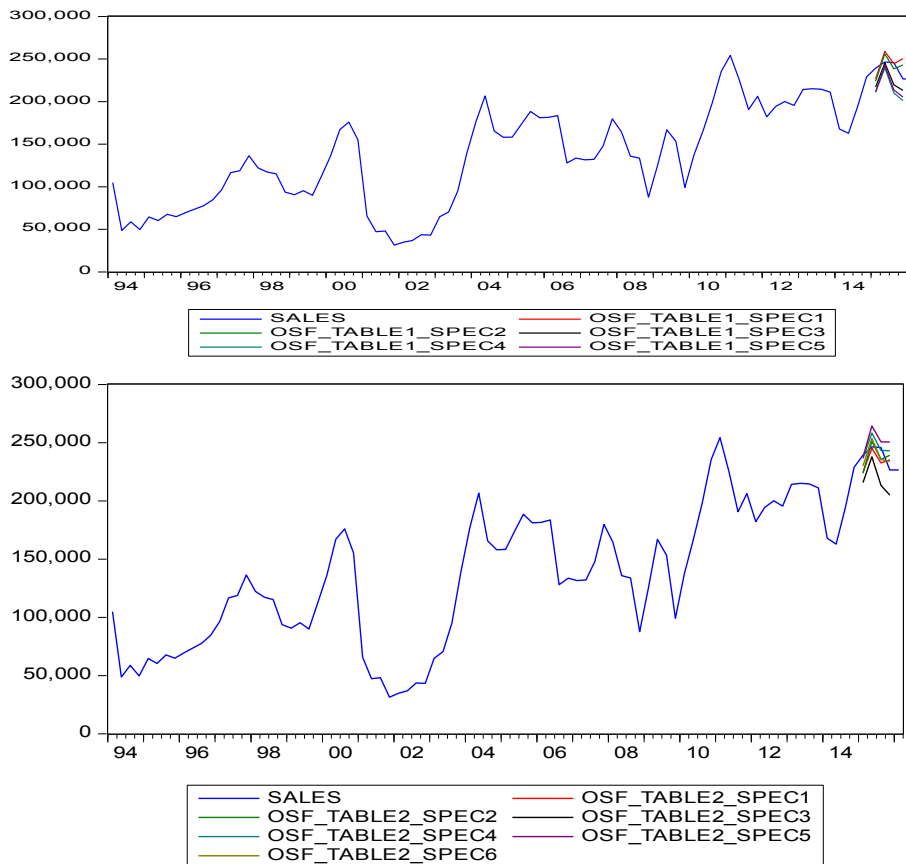


Fig. 22. Out-of-sample performance of various specifications for light-vehicle sales in 2015.

fairly well. Even the out-of-sample forecast that starts in 2007, which throws out the last 9 years of data before estimating the stock trend K^* and the regression coefficients, is able to track not only the underlying trend of sales in the remaining 9 years, but also the cyclical ups and downs.

Note that first two out-of-sample forecasts (OSF_2007 and OSF_2009) may appear to have failed to forecast 2009—the out-of-sample forecasts predict a sharp drop in sales in 2009 that did not occur. This is because of a large temporary reduction in light-vehicle sales tax in 2009 that substantially stimulated the sales, making the actual realization of sales higher than what it otherwise would be. That policy reduced the Special Consumption Tax (a type of value added tax), which lowered automobile prices and prevented a deep slump in sales in 2009. When the out-of-sample forecast is corrected with the estimated impact of that policy, the forecast tracks actual sales also in 2009, as shown in Fig. 21. The difference between Fig. 21 and the upper-left panel of Fig. 20 sheds light on the effectiveness of the tax reduction policy in 2009. Given the dynamics of the pre-crisis period, the demand conditions could have led to a big slump in light-vehicle sales similar to that in the 2001 crisis if that policy action was not taken.

Fig. 22 presents the out-of-sample forecasts for 2015 of all specifications in Tables 1 and 2 above, obtained by using the information until 2014Q4. The upper panel of Fig. 22 uses the specifications in Table 1 and the lower panel uses those in Table 2. In the upper panel, the first two specifications, which are the most parsimonious among all and contain only the demand gap variable, edge their competitors by giving closer estimates to the realized sales. For the shorter sample period (the lower panel), the situation is different: specification 6 containing all possible explanatory variables performs the best. That specification also has the smallest forecast error among all specifications, both Tables 1 and 2, based on the root mean squared error criterion. Specifications 4 and 1 in the shorter sample period provide the second and third best forecast performances, respectively.

As a final remark, the models provide very close forecasts for the 2015 total sales figure even when they fail to track well the quarterly time path of 2015 sales. The best performer, i.e. the sixth specification in the shorter sample, has a forecast error for the 2015 total as low as 0.53 percent. The second and third best performers also provide forecast errors of 1.3 and 2.2 percent, respectively. Given the 25 percent growth in light-vehicle sales in 2015, these forecasts can be considered quite successful, compared to for example the industry forecasts even at the beginning of 2015 that were quoted in business news articles as around 8 percent. That result suggests that the 2015 surge in light-vehicle sales perhaps should not have been a big surprise.

7. Conclusion

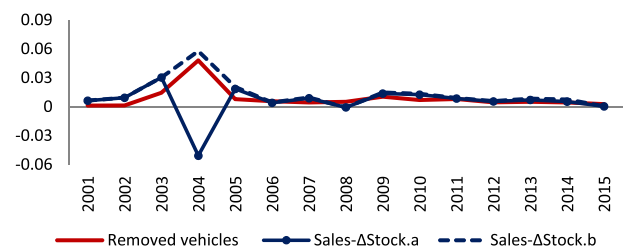
In this study, we aim to estimate an important demand component in the Turkish economy, automobile sales, from the data on its stock and the number of scrapped vehicles. Our interest has sprung from the strong 25 percent annual increase in light-vehicle sales during 2015, which was thought to have been not supported by macroeconomic fundamentals. Our approach in analyzing the issue is similar to Greenspan and Cohen (1999), who approximate sales in the US by estimating the change in the vehicle stock and the scrappage rate.

Our analyses show that the light-vehicle stock follows a strikingly smooth trend and the annual scrappage rate is on average around 0.84 percent of the light-vehicle stock. Those imply that a total annual sales figure of around 7 percent of the existing vehicle stock can be considered a normal trend level. Empirical

estimations indicate that deviations from this estimated trajectory can be mostly explained by the demand gap. The relative price of automobiles, interest rates and relative price of fuel are also found to be statistically significant in some specifications with the correct sign, but their significance levels are not robust. The estimated price elasticity is about 0.8, which is similar to findings in the literature, but, again, that estimate is not robust. The rapid growth of the vehicle stock is expected to continue in the years ahead as households continue to spend an increasing share of their income on vehicle purchases. As income in the Turkish economy continues to rise, automobile demand will continue to rise. The per capita income developments and the low level of registered vehicles per capita in comparison to developed countries confirm that there is still much room for such growth. Finally, the continued rise in the activity of operational leasing firms may prove to be another important factor to add dynamism to new vehicle sales. Finally, out-of-sample forecasts of various models suggest that the high level of light-vehicle sales in 2015 was predictable with the information available at the end of 2014. The out-of-sample forecast performance of the basic specification, which has sales as a fraction of the estimated capital stock trend on the left hand side and includes only a cyclical gap variable and dummy variables to control for some major policy programs in the automotive sector (in addition to a constant and a trend), is fairly successful in terms of tracking the future trend as well as the movements around that trend at horizons as long as nearly a decade.

Appendix A. The anomaly in the light-vehicle stock series in 2004

The monthly and annual data for light-vehicle sales show an inconsistency in 2004. That year might be special perhaps because of a scrappage program—a tax deduction offered to buyers of new vehicles if they scrap their old ones—introduced in mid-2003 aiming to stimulate auto sales, which stayed in force through the end of 2004. The annual stock data may have continued to include vehicles that were actually retired in 2004 under that policy. We are not aware of the exact reason why the annual and monthly data differ in 2004. But the figure implied by the monthly data for 2004 appears to be more plausible than that implied by the annual data: Sales should generally be greater than the change in the stock because of retired or totaled vehicles, and they indeed tend to be so in both panels of Fig. 2, but not for 2004 in Fig. 2a. In other words, the data point for 2004 in Fig. 2a is an anomaly. That problem does not exist in Fig. 2b, which plots the one derived from the monthly data. Consequently, we opt to rely on the monthly data for the level of stocks in year 2004 in the regression analysis and out-of-sample forecasts.



Source: Turkstat, Authors' own calculations.

Notes: Sales-ΔStock.a is a proxy for removed vehicles derived from the original annual frequency data, while Sales-ΔStock.b is a proxy for removed vehicles derived from the monthly frequency data.

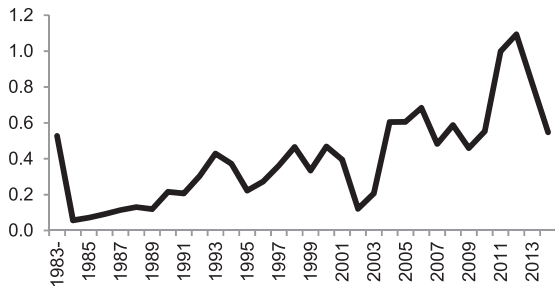
Fig. A.1. Removed vehicles, direct and indirect measures (% of previous year's stock).

The difference between sales and the change in the stock is a measure of the vehicles that are retired from traffic in a given period. The difference of the series shown in each panel of Fig. 2 produces one such measure—Fig. 2a produces one for the annual data and 2. b for the monthly data. Each of those measures can be compared to a line item available in the monthly data entitled *vehicles removed from registration*, which attempts to measure retired vehicles directly. Fig. A.1 above compares that direct measure with the two alternative indirect measures obtained from Fig. 2. We see from Fig. A.1 that the indirect measure obtained from the monthly data (from Fig. 2b) is more consistent with the direct measure in the data.

As a separate concern, the above-mentioned line item for removed vehicles itself presents a puzzle itself. It indicates too few retired vehicles in the years before 2003 (not shown in Fig. A.1). This paper will not be concerned either with this puzzle or with the question of whether the fix for the year 2004 provides a more accurate stock series or not, because the purpose of this paper is not constructing a good series for the auto stock. The purpose here is to try to make use of the available stock data to understand and estimate the trend in sales, and the foregoing fix appears to serve that purpose well.

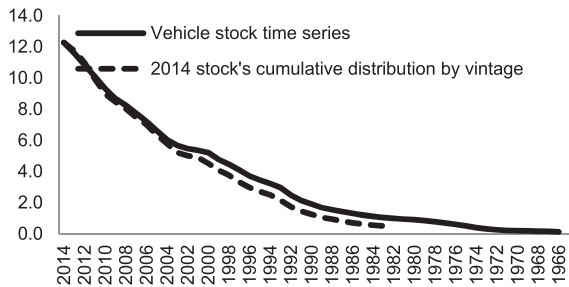
Appendix B. The rate of removal of vehicles from the light-vehicle stock

Fig. B.1 shows the distribution of the light-vehicle stocks in 2014 by model year. The initial point is an exception, because it is the sum of all vehicles whose models are 1983 or before. The accumulation of that series from 1983 onwards shows how many of the vehicles with model year *t* or earlier has survived until 2014. Fig. B.2 compares it with the level of stock as of year *t*. These two series can be used to calculate the survival rate for each year's light-vehicle stock since 1983.



Source: Turkstat
Notes: The first data point shows the sum of all model years up to and including 1983. The other points show each model year separately.

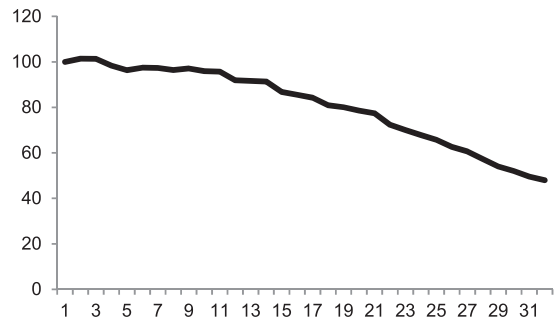
Fig. B.1. Stock of light vehicles by vintage year. (Number of vehicles, in millions).



Source: Turkstat

Fig. B.2. Stock as of year *t* and the stock that survived until year 2014. (Number of vehicles, in millions).

The calculated survival rate is shown in Fig. B.3.¹⁹ Note that the survival rate falls by age not linearly but in an increasing manner, consistent with the idea that the scrappage probability should be rising in parallel to the vehicle's age. We explore what kind of depreciation structure might generate such a survival rate profile. We consider three different possibilities for how the scrappage rate might increase by age: in a linear, quadratic or cubic fashion. Given a certain scrappage rate profile, and given the time series for the light-vehicle stock tracing back to 1966, one can start from 1966 (when the auto stock was less than 1% of its current size) and, under the innocuous assumption that the initial year's stock was produced in that year, can calculate how much of each year's stock was carried over from previous years and how much of it was produced in that year. Each depreciation profile implies a survival rate profile for the Turkish light-vehicle stock, and the depreciation rate with the least mean square error is chosen for each of the three functional forms. The quadratic functional form provides a more desirable fit and the resulting scrappage rate is shown in Fig. B.4, while the fitted survival rate is shown in Fig. B.5 together with the survival rate implied by the data.



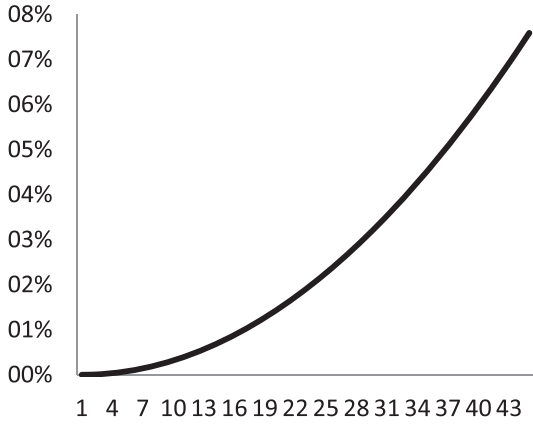
Source: Authors' own calculations.

Fig. B.3. Survival rate implied by Fig. B.2 (% of the stock level).

The estimated scrappage rate is very low initially and reaches only 1% by age 15 of the vehicles, reaching 1.6% by age 20 and 3.5% by age 30, albeit increasing more rapidly and reaching almost 10% by age 50. The estimated scrappage profile implies that overall scrappage rate is 0.84% for the current overall stock of light vehicles (the same estimate in the text obtained from the difference between the sales and the change in the stock of light vehicles).

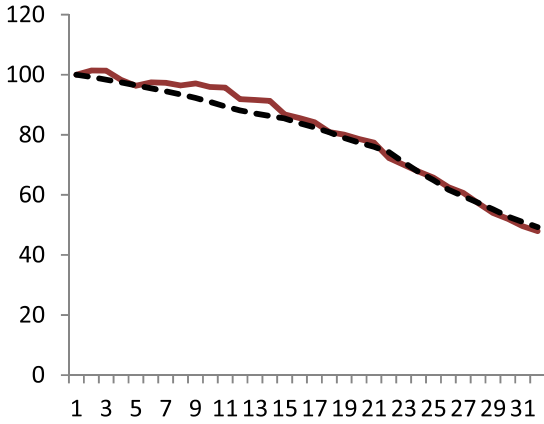
That estimated scrappage profile can be used to explore the source of the low scrappage rate in Turkey. More specifically, the relatively young age of the overall Turkish vehicle stock is one reason why the overall scrappage rate is low in Turkey. The contribution of that factor can be estimated based on the estimated scrappage profile. If the automobile market was not rapidly growing (as it were in Turkey in the sample period) but instead was in a steady state where sales were constant over time, the age profile would exactly have the same shape as the survival profile shown in Fig. B.3. When the estimated depreciation profile is applied to that hypothetical age profile, the overall scrappage rate (as a fraction of the existing stock) rises from 0.84% to 2.65%. The scrappage rate of 2.65% is still low relative to the rate in US, which has been around 5% recently, as shown in Fig. 9. However, there are other reasons for that rate to be higher in the US, as discussed in the text.

¹⁹ It should be noted that the distribution of the current stock by the model year is provided by Turkstat. The time series for the stock of vehicles is not by model year but by registration year. The sale of vehicles for a model year used to start in the last half of the previous year and would largely be registered in that calendar year. That convention was changed in 2012. The mismatch between the model year and the registration year of vehicles may be one of the reasons why the survival rate profile is not very smooth.



Source: Authors' own calculations.

Fig. B.4. Estimated depreciation rate based on the survival profile of the auto shown in Fig. B.3. (%).



Source: Authors' own calculations.

Fig. B.5. The estimated survival rate and the fit with the survival rate implied by the data. (%).

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