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The evolution of car ownership in Cyprus

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Η εξέλιξη της ιδιοκτησίας αυτοκινήτου στην Κύπρο

Αδάμος Αδάμου και Σωφρόνης Κληρίδης

Περίληψη

Το αυτοκίνητο είναι το πιο ακριβό καταναλωτικό αγαθό που αγοράζουν τα περισσότερα νοικοκυριά. Σε χώρες όπως η Κύπρος, είναι απαραίτητο μέσο διακίνησης των πολιτών και παράλληλα σημαντική πηγή ρύπανσης της ατμόσφαιρας με διοξείδιο του άνθρακα και οξείδια του αζώτου. Για τους πιο πάνω λόγους, είναι σημαντικό να γνωρίζουμε την εξέλιξη της ιδιοκτησίας αυτοκινήτου στην Κύπρο και τους παράγοντες που την επηρεάζουν.

Για το σκοπό αυτό, αναλύουμε λεπτομερή δεδομένα για τις εγγραφές και το ιστορικό ιδιοκτησίας όλων των οχημάτων που εισηχθήσαν στην Κύπρο κατά την περίοδο 1997-2007, καθώς και επιπρόσθετα στοιχεία από πολλαπλές έρευνες νοικοκυριών. Η ιδιοκτησία αυτοκινήτου αυξήθηκε με γοργούς ρυθμούς από το 1990 μέχρι και την έναρξη της διεθνούς οικονομικής κρίσης το 2008. Μεγάλο μέρος της αύξησης οφείλεται στην εισαγωγή μεταχειρισμένων οχημάτων· η έκταση αυτής της δραστηριότητας είναι μοναδικό φαινόμενο της Κυπριακής αγοράς. Η κρίση οδήγησε σε μεγάλη συρρίκνωση της αγοράς καινούριων οχημάτων που διήρκεσε μια πενταετία (2008-2013), ενώ παράλληλα οδήγησε σε μείωση των αποσύρσεων. Ως αποτέλεσμα, η Κύπρος έχει σήμερα ένα στόλο οχημάτων ο οποίος είναι πολύ μεγάλος σε αριθμό αλλά και σε ηλικία. Η μέση ηλικία του στόλου το 2017 ήταν 14,1 χρόνια και η μέση ηλικία απόσυρσης τα 20,8 χρόνια. Η ανάκαμψη μετά το 2014 ήταν βραδεία και ευνόησε κυρίως τα μεταχειρισμένα οχήματα, και ως εκ τούτου δεν άλλαξε σημαντικά αυτά τα δεδομένα.

Παρόμοιες τάσεις παρουσιάζονται και στην ανάλυση δεδομένων σε επίπεδο νοικοκυριών. Ο αριθμός οχημάτων ανά νοικοκυριό αυξήθηκε από 1,433 σε 1,600 από το 2003 στο 2009, και μειώθηκε ελαφρά στο 1,577 το 2015. Ο αριθμός αυτοκινήτων ανά ενήλικα το 2015 έφτασε στο εντυπωσιακό 0,890. Εξίσου εντυπωσιακό είναι και το ποσοστό των νοικοκυριών δήλωσαν ότι αγόρασαν καινούριο όχημα το 2009, το οποίο ήταν 16,8%. Το ποσοστό αυτό μειώθηκε στο 6,1% το 2015.

Εξετάσαμε κατά πόσον η μεγάλη επέκταση της αγοράς μέχρι το 2008 μπορεί να αποδοθεί στην ύπαρξη άφθονης τραπεζικής πίστης, κάτι που είχε συμβεί στην αγορά ακινήτων. Τα στοιχεία δεν συνηγορούν προς αυτή την κατεύθυνση. Εντοπίζουμε όμως κάποιες ενδείξεις ότι η συρρίκνωση της αγοράς μετά το 2008 οφείλεται εν μέρει στη

μείωση του τραπεζικού δανεισμού. Το θέμα χρήζει περαιτέρω ανάλυσης με πιο λεπτομερή δεδομένα που θα επιτρέψουν ασφαλή συμπεράσματα.

Η νέα κρίση λόγω της πανδημίας του κορωνοϊού έχει ήδη επιφέρει ένα νέο πλήγμα στην αγορά αυτοκινήτου, προκαλώντας αναβολή αγορών και περαιτέρω γήρανση του στόλου. Η αυξανόμενη συμφόρηση και ρύπανση δημιουργούν την ανάγκη για επαναξιολόγηση των υφιστάμενων προσεγγίσεων στην ιδιοκτησία αυτοκινήτου και τις δημόσιες συγκοινωνίες.

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The evolution of car ownership in Cyprus*

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Abstract

We utilize data on car registrations and multiple household surveys to describe the evolution of car ownership in Cyprus over the last 20+ years. Car ownership expanded rapidly in the 1990s and 2000s, up until the financial crisis. Much of this is due to the importation of used vehicles; the magnitude of this segment is a unique feature of the Cyprus car market. As a result, Cyprus has a large and aging car fleet, and associated level of traffic and pollution. The financial crisis stemmed the increase in the size of the fleet but contributed to its further aging.

Keywords: car ownership, used car markets, vehicle financing.

1 Introduction

A car is the most expensive consumption good most households will ever purchase. In Cyprus, cars are indispensable due to the limited availability of public transportation, and as a result most families own multiple vehicles. Cars are also one of the biggest sources of pollution in terms of both carbon dioxide (CO₂), a global pollutant thought to be responsible for climate change, and local pollutants like nitrogen oxides (NO_x). The car market is an active theater of public policy. Governments use vehicle taxation as a source of revenue through consumption and circulation taxes (and also fuel taxes). They also intervene to achieve policy goals relating to the environment and overall consumer welfare. For example, they provide scrapping subsidies to encourage the renewal of the car stock through the retirement of old vehicles.

For all these reasons, the car market is an important one to follow. In earlier work on the Cyprus car market we have looked at the welfare impact of used imports (Clerides, 2008); we have investigated the design of emissions-based vehicle tax reform (Christodoulou and Clerides, 2012; Adamou and Clerides, 2013); and we have analyzed the pass-through of international oil prices to local retail prices (Clerides, 2010; Charalambous and Clerides, 2020). In the current paper we analyze data from multiple sources to document trends in car ownership in Cyprus over the last 20 years. Our main data source is the Cyprus Road Transport Department (RTD), which has provided us with access to its entire database. We also utilize multiple

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waves of two household surveys that include information on car ownership and purchasing. We use the registration data from the RTD to present an analysis of overall market trends, notably imports of new and used cars, transactions in the domestic used market, and scrapping, as well as the evolution of the characteristics of the vehicle stock (section 3). We next explore the importance of credit in financing car purchases and how it evolves over time (section 4). We then move to an analysis of patterns of car ownership and its evolution over time. We do this first at the individual level using RTD data (section 5) and then at the household level using survey data (section 6). A summary of the main findings concludes the paper (section 7).

2 Data

Our data come from three sources. The RTD has provided access to its entire database, which records (i) every vehicle registered in Cyprus since 1971; and (ii) every vehicle ownership (fully available starting in 1996). In addition, we have data from the household surveys, the Household Finance and Consumption Survey (HFCS) of the European Central Bank and the Household Budget Survey (HBS) of the Cyprus Statistical Service.

2.1 The RTD database

We are interested in passenger vehicles purchased by individuals for private use. We select vehicles listed as private cars and light lorries in the RTD database. We keep light lorries because in Cyprus they often double as work and family vehicles. In the RTD data, about 22% of light lorries are reported to be for private use and another 56% for both private and professional use. The majority of private vehicles have body types such as saloon (sedan), hatchback, estate, etc. Some vehicles have unusual body types such as “refrigerator” and “tanker”. We excluded those vehicles from our dataset. After this data trimming process, we ended up with a total of 963,492 private vehicle and light lorry registrations between 1971-2017. Light lorries make up about 20% of that total.

There are 796,774 distinct owners in the data, 93.1% of whom are individuals and the rest are companies. A number of individuals appear to be traders, as they buy and sell many cars that they only keep for a short period of time. We remove companies and traders from the dataset because we are interested in the behavior of individuals purchasing vehicles for their personal use. For individual owners we observe the gender, year of birth, and post code. Ideally we would be able to identify all individuals belonging to the same household so that we can analyze ownership at the household level. Unfortunately this is not possible. An ownership is associated with a vehicle, an owner, a start date, and the ownership type (complete, financed, co-ownership). The data on ownerships start as early as 1971 but they are minimal until the late 1980s. We have essentially full ownership information for every vehicle for the period 2000-2017. The corresponding number of owners for that period is 523,878.

Table 1: Summary description of the surveys

| Survey | Dates | Households | Car information |
|-----------------|-------|------------|---|
| HFCS (ECB) | 2010 | 1,237 | – Number of cars owned by household – Estimated value of cars |
| | 2014 | 1,289 | |
| | 2017 | 1,303 | |
| HBS (CyStat) | 2003 | 2,990 | – Number of cars owned by household – Number of cars purchased in last 12 months, their price and whether purchased new/used |
| | 2009 | 2,707 | |
| | 2015 | 2,876 | |

Information on registrations and cancellations can be combined to construct estimates of the stock of vehicles at any given point in time, as well as its composition in terms of vehicle characteristics. Information on ownerships can be used to construct every vehicle’s entire ownership record as it get transferred from one owner to another. It also allows us to construct each owner’s car holdings at every point in time. We can therefore observe when an owner replaces a vehicle or changes his holdings by adding or removing a vehicle.

2.2 Information from household surveys

We use additional information from two household surveys. The Household Finance and Consumption Survey (HFCS) is ran by the European Central Bank (ECB) and covers all Euro area countries. Three waves have been produced so far (2010, 2014, and 2017), each of which includes 1,200-1,300 households from Cyprus. A significant number of households participate in multiple waves. The second survey we use is the Household Budget Survey (HBS), which is conducted by the Statistical Service of Cyprus (CyStat) every 6-7 years. We use the last three waves of the survey, which include information from 2003, 2009 and 2015/16. The HBS is larger than the HFCS; it covers 2,700-3,000 households (around 1.1% of all households) per wave. The surveys include detailed information on household demographics, assets, expenditures and others. With regard to cars, they both include the number of cars currently owned by the household. The HBS includes additional information on cars purchased during the previous twelve months. A summary of coverage is provided in Table 1. We will use 2015 to refer to the 2015/16 HBS survey.

3 Overall market trends

This section presents an analysis of overall market trends using RTD data. Figure 1 shows the number of new vehicle registrations for the period 1990-2017. We show the overall number, plus a breakdown between new and used imports. It is easy to see the rising importance of used imports starting about 1995, the big boom in the car market in 2004-2008, and the ensuing collapse as a result of the global financial crisis. The market kept shrinking through 2013 and

started recovering in 2014, with the recovery mostly benefiting used cars.

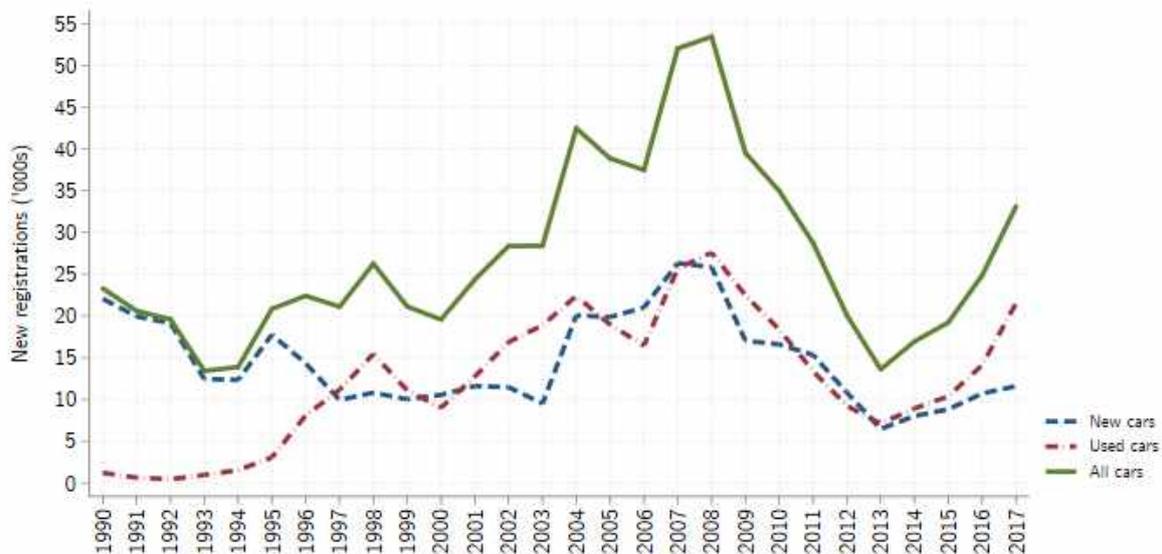


Figure 1: Annual new registrations of new and used cars

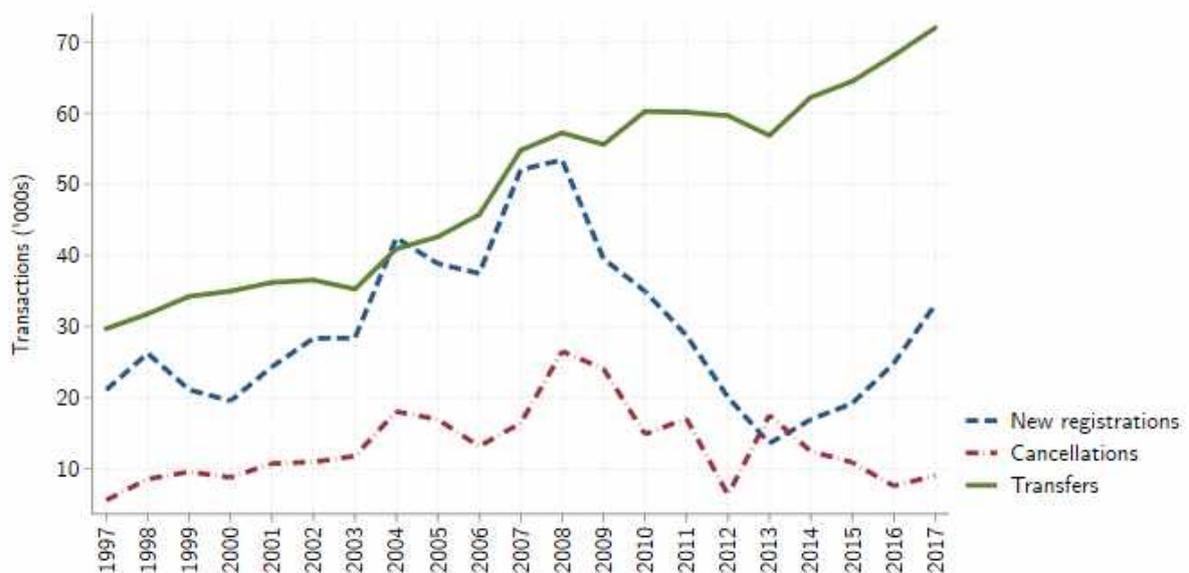


Figure 2: Imports, transfers, and cancellations, 1997-2017

We are interested in seeing how imports of new and used cars relate to activity in the local market, namely transfers and cancellations. Transfers are sales of vehicles from the existing owner to a new one; cancellations are withdrawals from circulation (known in the literature as *scrapping*). Figure 2 plots the number of all new registrations (new and used imports), cancellations and transfers of vehicles starting in 1997, the first year when the last two variables are available. There is an upward trend in all three variables up until the crisis year of 2008. At this point new registrations and cancellations drop substantially, while the number of transfers stabilizes but does not drop significantly. Registrations and transfers start picking up again in 2014. The number of cancellations picks up noticeably in 2013 but declines for the next three years. The pattern of cancellations is a bit of a puzzle. It is not clear why scrapping

would increase in 2013, the year that the Cyprus banking system collapsed, and then decline thereafter, during the period when the economy was recovering and car sales were turning around. Activity in the used car market (transfers) also shows an interesting pattern. It has been growing at a fairly steady pace throughout this period, with only two slight dips in the crisis years of 2009 and 2013.

The size of the local used car market (meaning internal transfers, not imports of used cars) was 1.5–2 times the size of the new car market in the late 1990s. It dropped almost to par in the booming 2000s, and rose to five times the new car market in 2013. The ratio then declined, and in 2017 it stood at 2.5. By comparison, the ratio is about three in the United States (Gavazza, Lizzeri, and Roketskiy, 2014) and two in Italy (Schiraldi, 2011). In Schiraldi’s data, new car sales and scrapping track each other quite closely. In the Cyprus data, new registrations outnumber cancellations by a factor of two to five, except during the crisis period. This is at least partly due to the fact that used imports are counted as transactions in the new rather than the used car market. To further investigate this, Figure 3 presents a different breakdown of the data. It lumps together imports of used cars and transfers to give the total number of used car sales. It plots these along with the number of new imports (“New car sales”), and the number of cancellations. We observe that new car sales and cancellations track each other fairly closely, as in Schiraldi’s Italian data. This suggests that used imports are primarily responsible for the growth in the car stock.

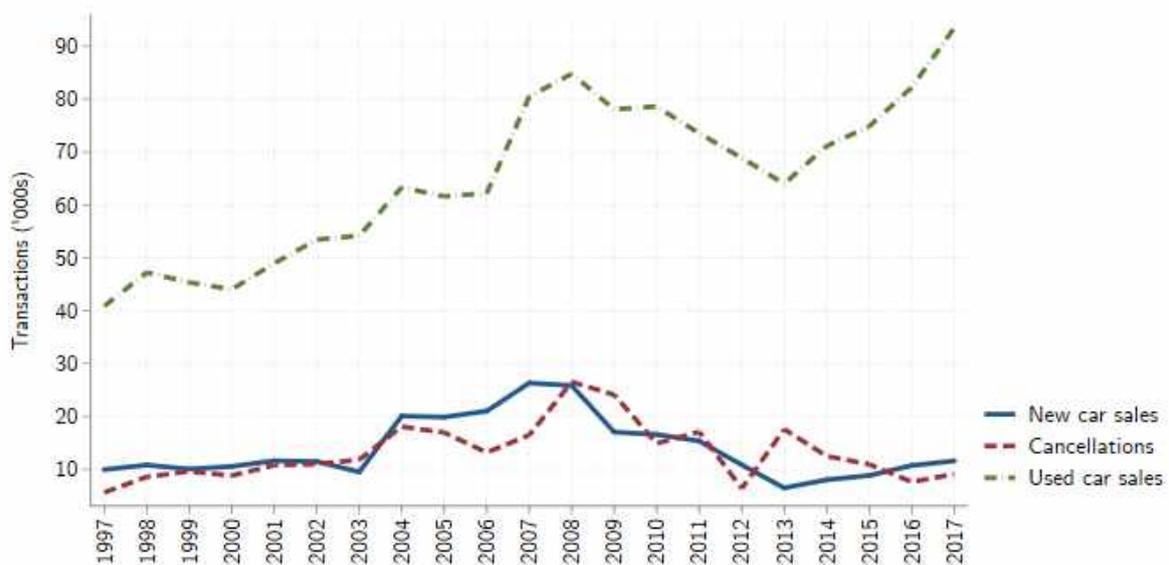


Figure 3: The relative size of markets, 1997-2017

The change in the car stock is the difference between new registrations and cancellations in Figure 2. The large gap suggests that the stock has been growing over time. CyStat publishes the end-of-year stock of vehicles and some information on the age distribution. Because we have RTD’s full database, we can construct our own measure of the stock and, more importantly, fully characterize the evolution of any characteristic of interest. As a first step, we use our data to construct the stock of vehicles and compare it to the stock published by CyStat. Let S_t denote the stock of vehicles at the end of period t . The accumulation equation of the stock

of vehicles is given by

$$S_t = S_{t-1} + R_t - C_t, \quad (1)$$

where the flow variables R_t and C_t are registrations and cancellations respectively during period t . We construct the stock from 1990 onwards using the CyStat 1990 stock as our starting point and applying equation 1 from that point on. We plot our series and the CyStat series in Figure 4. Our measure of the stock of vehicles is a bit higher, likely because we use somewhat different inclusion criteria for our stock.

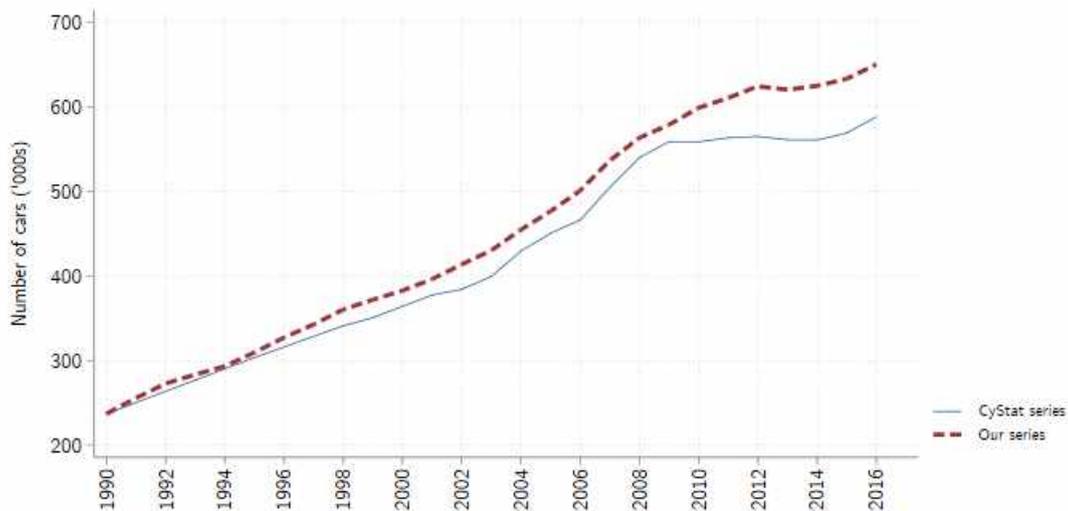


Figure 4: Evolution of the vehicle stock

Figure 5 shows the distribution of car lifetimes (age at cancellation) for the 277,960 cars canceled during 1997-2017. The distribution is slightly left (negatively) skewed; the median lifetime is 20 years, the mode is 21, the mean is 19.8 and the interquartile range is 16-24 years. There is a small unusual peak at 3-4 years, which is likely due to automatic cancellation of vehicles because of non-payment of the circulation tax for three years.

Table 2 shows the annual means of some characteristics of interest. The first three describe the evolution of the age distribution of the stock of vehicles: (i) the mean age of the stock of vehicles, defined as current year minus manufacturing year and calculated over all vehicles up until 35 years old;¹ (ii) the mean age of new vehicles at registration, defined as registration year minus manufacturing year; and (iii) the mean age at cancellation. There is a steady increase in the mean age of the stock of vehicles up until 2003. It remains relatively stable until 2010, and then rises rapidly thereafter. In 2017 the average car on the road is about 14 years old. This is likely the result of the economic crisis, as consumers postponed stock expansion or replacement decisions and retained the current stock (which subsequently ages), or may have purchased older vehicles. The same reasoning explains the average age at registration, which is relatively steady until 2008 and rises fast afterward, reflecting a switch towards imports of

¹Our implicit assumption is that the number of vehicles over 35 years of age that are still in active use is negligible. Vehicles aged 36+ that appear to be in circulation in our data are likely either classic cars held by hobbyists or cars that have misreported data (such as manufacturing age). We believe it is better to leave them out of the active car stock.

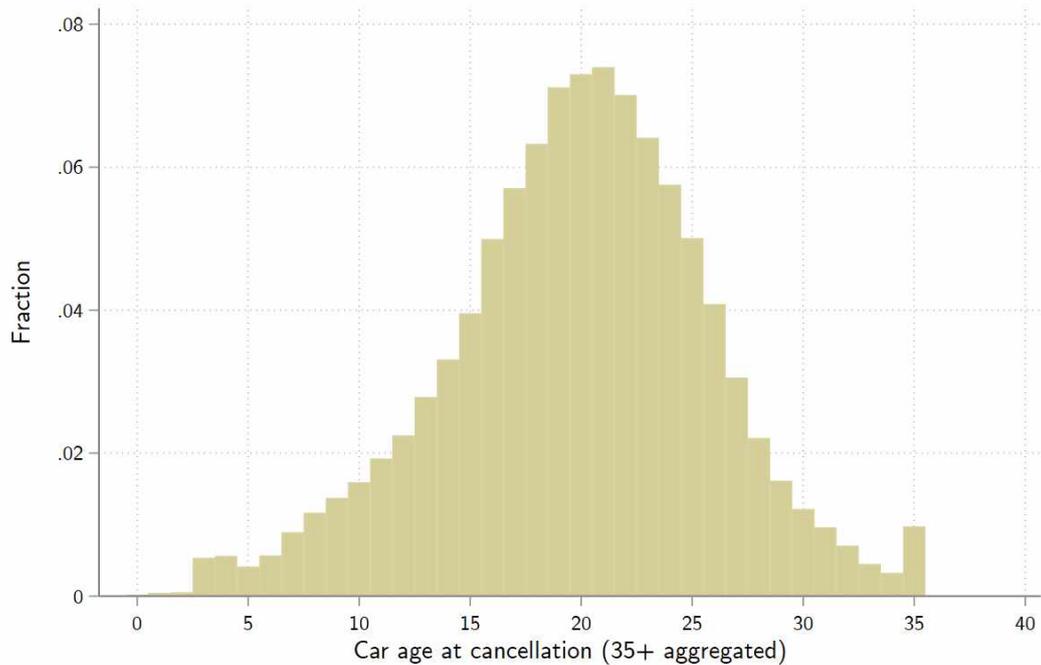


Figure 5: Distribution of lifetimes for cars canceled during 1997-2017

used cars. The mean cancellation age is increasing up until 2004, followed by a significant decline in the subsequent three years. This is likely related to the 2003 reduction in vehicle taxes, which led to a sharp rise in car sales and an increase in cancellations in 2004 and 2005 (see Figure 1). The mean cancellation age declines further in the crisis years, reaching a low in 2010, and has been rising ever since. The link between sales and cancellations merits further investigation.

The last three columns in Table 2 give the means of key characteristics of newly registered vehicles. Engine capacity was on a declining path until 2005, then increased until 2009, and has been declining ever since. The fraction of diesel vehicles was as high as 41% in the late 1990s but declined in the early 2000s reaching a low of 9% in 2004. It bounced back thereafter and reached an all-time high of 49% in 2017. CO₂ emissions are only available since 2005. They have been declining steadily since 2007, except in the last three years where they stabilized at 131 g/km. The declining trend is likely due to a combination of several factors such as improvements in technology, changing consumer preferences, and government schemes to promote cleaner vehicles.

4 Car finance

Many car purchases are financed with bank credit. Availability of credit may therefore play an important role in driving car markets. Does easy credit fuel car booms, like it does housing booms? Are credit crunches responsible for the sharp decline in car sales typically observed

Table 2: Annual means of key characteristics

| Year | Mean age | | | Eng. cap. (cc's) | Fraction diesel | CO ₂ (g/km) |
|------|--------------|----------|---------------|---------------------|--------------------|---------------------------|
| | Entire stock | New regs | Cancellations | | | |
| 1997 | 9.64 | 2.48 | 19.36 | 1822 | 0.38 | |
| 1998 | 9.92 | 2.56 | 19.55 | 1907 | 0.41 | |
| 1999 | 10.26 | 2.57 | 19.65 | 1914 | 0.40 | |
| 2000 | 10.59 | 2.34 | 20.84 | 1870 | 0.38 | |
| 2001 | 10.83 | 2.55 | 20.48 | 1834 | 0.34 | |
| 2002 | 10.97 | 2.81 | 20.72 | 1754 | 0.25 | |
| 2003 | 11.15 | 3.16 | 20.76 | 1687 | 0.15 | |
| 2004 | 11.01 | 2.38 | 21.61 | 1588 | 0.09 | |
| 2005 | 10.83 | 2.20 | 19.89 | 1572 | 0.10 | 171 |
| 2006 | 10.78 | 1.94 | 19.72 | 1579 | 0.12 | 172 |
| 2007 | 10.64 | 2.28 | 19.68 | 1707 | 0.16 | 184 |
| 2008 | 10.52 | 2.34 | 20.31 | 1739 | 0.21 | 182 |
| 2009 | 10.48 | 2.69 | 19.63 | 1757 | 0.26 | 177 |
| 2010 | 10.59 | 2.59 | 17.83 | 1717 | 0.28 | 170 |
| 2011 | 10.99 | 2.56 | 18.14 | 1687 | 0.27 | 163 |
| 2012 | 11.49 | 2.88 | 18.88 | 1633 | 0.24 | 157 |
| 2013 | 12.22 | 3.55 | 18.88 | 1647 | 0.24 | 153 |
| 2014 | 12.74 | 2.80 | 19.42 | 1624 | 0.36 | 135 |
| 2015 | 13.27 | 2.92 | 20.04 | 1597 | 0.35 | 131 |
| 2016 | 13.73 | 3.29 | 20.20 | 1643 | 0.42 | 131 |
| 2017 | 14.12 | 3.97 | 20.76 | 1697 | 0.49 | 131 |

during recessions? Benmelech, Ralf, and Ramcharan (2017) examined the causes of the 40% decline in vehicle sales during the financial crisis in the United States (2007-09). They found that the market collapse was caused in part by a credit supply shock due to the illiquidity of the most important providers of consumer finance in the automobile loan market. Their estimates suggest that the shrinking in the supply of nonbank vehicle credit might explain about one-third of the collapse in car sales during the crisis period. In more recent work, Dupor, Li, Mehkari, and Tsai (2020) examined three potential explanations that may have led to the collapse in car sales during the same period: increasing oil prices, falling home values, and falling household income expectations. They found that the latter explanation was by far the most important, accounting for about 65% of the decline in car sales; increases in oil prices explain another 15% of the decline, and falling home values the remaining 20%.

Table 3: Percent of car purchases on credit in the HBS

| | 2003 | 2009 | 2015 | Total |
|---------------|------|------|------|-------|
| New cars | 69.2 | 68.9 | 39.6 | 64.2 |
| Local used | 60.9 | 59.0 | 20.0 | 50.9 |
| Imported used | 68.1 | 64.8 | 8.9 | 59.8 |
| All cars | 66.3 | 64.7 | 22.3 | 58.5 |

The HBS surveys provide some information on car financing. Respondents are asked to report how they financed their last vehicle purchase. Possible answers are (i) purchase without loan, (ii) purchase with loan, (iii) gift, or (iv) provided for free by employer or other party. Table 3 shows the fraction of car purchases made on credit as reported in the HBS surveys. The figure is about 65% for 2003 and 2009, but drops to just 22% in 2015. This is likely a reflection of the liquidity crunch following the banking crisis.

The RTD data provide further information on this topic. Every new ownership is classified in one of four types, one of which is “finance”. This means that the car was purchased with a loan from a financial institution and the car is registered to the institution until the loan is paid off, at which point it is transferred to the individual. We are therefore in a position to know which cars were bought on credit from financial institutions. Figure 6 reports this fraction for new cars, used cars, and overall. The overall numbers are lower than those in the HBS. For example, 25% of purchases in 2003 were on credit according to the RTD data, but 66% of households reported buying a car with a loan in the same year’s HBS survey. This suggests that there are many cases where the buyer takes ownership of a car purchased on credit. This may be because the creditor is not a major bank. Since we are primarily interested in bank credit, it is still useful to look at the trends. The fraction of new cars bought on credit is roughly stable up until the crisis, hovering between 17-22%. The fraction is higher for used cars in the early years and declines over time. The higher level of financing for used cars is surprising as they are cheaper on average and we might expect that more of them would be purchased with the buyer’s own funds. After the crisis the fraction of cars purchased on credit collapsed to the single digits. It recovers after 2015, primarily for new cars, but does not reach the pre-crisis levels.



Figure 6: Fraction of cars purchased on credit

The declining share of car sales using bank financing in the pre-crisis period does not indicate a credit-led boom in the car market. On the other hand, the post-crisis credit crunch *may* be responsible for at least part of the large decline in car sales. The analysis is of course purely descriptive and does not lend itself to establishing a robust causal relationship between bank credit and the car market.

5 Ownership at the individual level

We now turn to an analysis of ownership at the individual level using the RTD data. Table 4 shows the distribution of vehicles owned in a single year for three indicative years: 1997, 2007 and 2017. We observe that the distribution shifted to the right between 1997 and 2007: the fraction of single-vehicle individuals declined while the other three fleet sizes grew. In 2017 there was a partial reversal, as the fraction of single-vehicle individuals increased while the fraction of two-vehicle individuals decreased. This is likely a result of the economic crisis that led to a collapse of the car market in the period 2009-2014. It may also reflect other factors, such as young people registering cars in their name instead of the name of a parent. The bottom line shows the mean number of vehicles per individual. Consistent with the discussion above, the mean increased between 1997 and 2007 but was lower in 2017.

We use the information on ownerships to construct every owner's car stock at year-end

Table 4: Distribution of vehicles owned in selected years

| Number of vehicles | 1997 | | 2007 | | 2017 | |
|--------------------|---------|-------|---------|-------|---------|-------|
| | Freq. | % | Freq. | % | Freq. | % |
| 1 | 163,255 | 79.43 | 234,494 | 72.13 | 285,536 | 73.42 |
| 2 | 37,546 | 18.27 | 73,311 | 22.55 | 80,917 | 20.80 |
| 3 | 4,398 | 2.14 | 15,253 | 4.69 | 18,836 | 4.84 |
| 4 | 336 | 0.16 | 2,048 | 0.63 | 3,642 | 0.94 |
| Total owners | 205,535 | | 325,106 | | 388,931 | |
| Total cars | 252,885 | | 435,067 | | 518,446 | |
| Cars/owner | 1.230 | | 1.338 | | 1.333 | |

of every year. We can therefore track the evolution of an individual's stock over time: when they upgrade their stock by replacing an older vehicle with a newer one, or change their stock either by adding a vehicle (expanding the stock) or removing a vehicle (shrinking the stock). Let n_{it} denote the number of vehicles owned by individual i in period t . In Table 5 we present the transition probabilities $Pr(n_t|n_{t-1})$ for $t = 2016$ and for $n_t \in \{1, 2, 3, 4\}$. Recall that the maximum number of vehicles per year is four, hence an individual with four vehicles cannot expand his fleet. The transition from zero vehicles to one is not included because the set of individuals with zero vehicles at $t - 1$ is not clearly defined. The sum of the numbers on the diagonal, .9095, gives the fraction of individuals who kept the size of their 2016 stock the same as in 2015. This means that they either did not make any transaction or they replaced one car with another. The sum of the numbers in the upper right triangle, .0494, is the fraction who expanded their stock and the sum in the lower left triangle, .0413, is the fraction who shrunk their stock.

Table 5: Transition probabilities for individual's stock between 2015 and 2016

| | | Vehicles owned in 2016 | | | | |
|------------------------|-------|------------------------|-------|-------|-------|-------|
| | | 1 | 2 | 3 | 4 | Total |
| Vehicles owned in 2015 | 1 | .6939 | .0337 | .0014 | .0000 | .7289 |
| | 2 | .0289 | .1756 | .0110 | .0006 | .2161 |
| | 3 | .0013 | .0088 | .0349 | .0027 | .0476 |
| | 4 | .0000 | .0004 | .0019 | .0051 | .0074 |
| | Total | .7241 | .2185 | .0491 | .0083 | 1 |

Transition probabilities do not provide any information about individuals who replaced their vehicle(s) while keeping the size of their holdings the same. In order to examine this activity we created a variable that describes the action taken by the owner in a particular year. There are five possible actions: *inaction*, *expand*, *shrink*, *replace up (upgrade)*, and *replace down (downgrade)*. *Expand* and *shrink* mean that the individual either increased or decreased the size of their holdings.² The two *replace* actions are introduced in order to differentiate between

²In order to have a reasonably accurate measure of ownership, we have to account for the fact that some actions may be taken with a lag. We used the following general rule: if the gap between an increase and a decrease in

individuals who upgrade or downgrade their fleet. *Replace up* means that the individual replaced one or more vehicles with younger vehicles; *replace down* means that the replacement vehicles were older. In the case of more than one cars, we flag the action as a *replace up* if the average age of the new cars is smaller than the average age of the old ones. Using a vehicle's age as an index of quality is not foolproof but it is an easily available measure that should serve its purpose sufficiently well.

Table 6: Action probabilities for year 2016

| Vehicles owned in previous year | Action | | | | | Total |
|------------------------------------|--------|--------------|-----------|------------|--------|-------|
| | Shrink | Replace Down | Unchanged | Replace Up | Expand | |
| 1 | .0000 | .0048 | .6777 | .0186 | .0278 | .7289 |
| 2 | .0213 | .0025 | .1765 | .0069 | .0087 | .2161 |
| 3 | .0073 | .0008 | .0359 | .0017 | .0019 | .0476 |
| 4 | .0017 | .0001 | .0052 | .0003 | .0000 | .0074 |
| Total | .0304 | .0084 | .8954 | .0275 | .0384 | 1 |

The results of this exercise for the year 2016 are presented in Table 6. Replacement actions are relatively infrequent. Among one-vehicle owners, only 2.34% engaged in a replacement action in that year. As expected, most replacements are for a better (younger) vehicle (about 4 out of 5). Note that the transition probabilities $Pr(n_t|n_{t-1})$ in Table 5 do not match exactly any of the action probabilities in Table 6 because the action definitions are different. For example, *Expand* in Table 5 is 4.94% while *Expand* in Table 6 is just 3.84%. This is because, as described above, some actions that are considered expansions for Table 5 have been relabeled as *inaction* for Table 6.

6 Ownership at the household level

We now turn to the two household surveys in order to analyze ownership at the household level. The top panel of Table 7 shows the distribution of the number of vehicles owned by the households in each survey wave.³ The distributions in the two surveys are broadly similar, but there are also some differences. In the 2003 HBS, 36.3% of households own one car and 35.5% own two. In 2009 the fractions of two-, three- and four-car households increase at the expense of no-car and one-car households. The 2010 HFCS is similar except it has even more three- and four-car households and fewer zero- and one-car households. The difference is greatest between the 2014 HFCS and 2015 HBS. The latter shows a shift from two cars to a single car, while in the former there is a large decline in three-car households and corresponding increase in households with zero, one or two cars. The bottom two lines show the number of cars per

holdings is 1 year and they do not cancel each other out, we define this as a single event (an expansion or a shrinkage). If the gap between an increase and a decrease is at least 2 years then we define it as a sequence of two actions.

³The distributions are obtained after weighting the households in the sample to correct for oversampling.

household and per adult member of the household. The overall trend is the same as in Table 4: ownership increased until the financial crisis and decreased thereafter.

Table 7: Distribution of vehicles owned

| Vehicles | HFCS | | HBS | | |
|------------|-------|-------|-------|-------|-------|
| | 2010 | 2014 | 2003 | 2009 | 2015 |
| 0 | 11.18 | 12.85 | 16.92 | 13.85 | 13.31 |
| 1 | 31.15 | 32.63 | 36.33 | 33.66 | 37.10 |
| 2 | 36.74 | 38.41 | 35.52 | 36.34 | 34.29 |
| 3 | 14.25 | 10.32 | 9.14 | 11.92 | 10.61 |
| 4+ | 6.68 | 5.79 | 2.09 | 4.23 | 4.69 |
| Cars/hhold | 1.761 | 1.656 | 1.433 | 1.600 | 1.577 |
| Cars/adult | 0.794 | 0.764 | 0.748 | 0.879 | 0.890 |

| Vehicles | RTD | | | | |
|------------|-------|-------|-------|-------|-------|
| | 2011 | 2014 | 2003 | 2009 | 2016 |
| 1 | 72.09 | 72.63 | 74.21 | 71.45 | 72.59 |
| 2 | 22.32 | 21.87 | 21.50 | 22.80 | 21.64 |
| 3 | 4.88 | 4.77 | 3.84 | 5.03 | 4.92 |
| 4 | 0.71 | 0.73 | 0.45 | 0.72 | 0.85 |
| Cars/owner | 1.342 | 1.336 | 1.305 | 1.350 | 1.340 |

The bottom panel of Table 7 shows the distribution of vehicles owned at the individual level from the RTD data in years that match the years of the surveys for comparison purposes. There are no individuals with zero vehicles, as the dataset only includes vehicle owners.⁴ It is nonetheless clear that the distributions are quite different. In the RTD data 72-74% of owners have one car. The corresponding figure in the 2014 HFCS is 37.4% ($32.6/(100-12.85)$) and in the 2015 HBS is 42.8% ($37.10/(100-13.31)$). The distributions would match if all cars in a household were registered to the same individual. The large disparity suggests that in many households there are multiple owners.

The HBS provides some additional information on car ownership. It asks respondents whether the household purchased a vehicle in the past 12 months. For up to three such vehicles it records the price and whether the car was bought new or was a used import or was bought used from the local market. Table 8 presents the distribution of purchases among households. The trends are similar as in the earlier analysis of ownership. Purchases increased between 2003 and 2009 but decreased in 2015. In 2003, 14.6% of households purchased at least one car. This fraction increased to 16.8% in 2009 but dropped to just 6.1% in 2015. Most purchasing households bought one car, but several bought two and a few even three.

Table 9 shows the types of cars purchased and their prices. Overall, 42.3% of households

⁴We could make an assumption on the number of potential owners based on population figures, but we decided that it would be too ad hoc.

Table 8: Distribution of number of cars purchased in previous 12 months

| n | 2003 | 2009 | 2015 | Total |
|--|-------|-------|-------|-------|
| 0 | 2,553 | 2,252 | 2,700 | 7,505 |
| 1 | 411 | 431 | 168 | 1,010 |
| 2 | 23 | 24 | 8 | 55 |
| 3 | 3 | | | 3 |
| <i>Households that purchased at least one car:</i> | | | | |
| Number: | 437 | 455 | 176 | 1,068 |
| % of total: | 14.6 | 16.8 | 6.1 | 12.5 |

(478/1,129) bought an imported used car, whereas 28.4% bought a new car and 29.2% bought a used car from the secondary local market. The effect of the crisis is reflected in the much smaller number of transactions in 2015 relative to 2003 and 2009. It is also seen in the shift in 2015 from new cars to used cars. The average price of used cars in 2015 is much lower than in previous years. We were surprised by this figure and double-checked the source data, but were unable to find any obvious errors. The number likely reflects a shift from high-end used cars to low-end used cars, again as a result of the financial crisis.

Table 9: Car purchases in HBS surveys

| | 2003 | | 2009 | | 2015 | | All years | |
|--------------------|------|------------|------|------------|------|------------|-----------|------------|
| | N | Mean price | N | Mean price | N | Mean price | N | Mean price |
| New cars | 107 | 23,324 | 161 | 22,209 | 53 | 24,053 | 321 | 22,885 |
| Local used cars | 133 | 6,179 | 122 | 6,929 | 75 | 5,738 | 330 | 6,356 |
| Imported used cars | 226 | 11,747 | 196 | 14,297 | 56 | 4,047 | 478 | 11,891 |
| Overall | 466 | 12,816 | 479 | 15,080 | 184 | 10,499 | 1,129 | 13,399 |

7 Summary

The Cyprus car market has gone through many changes in the last 25 years: the influx of used cars, several tax reforms and policy shifts, a major economic boom and a subsequent spectacular bust. All this came on top of changes at the global level, including the rise of diesel cars and their setback because of Dieselgate, the emergence of new technologies, and the ups and downs of the international oil market. Prior to the financial crisis, car ownership was expanding rapidly, as evidenced by the number cars per adult. This trend was halted and partially reversed as a result of the severe recession and reduction of incomes after 2013. The recovery in the last few years was slow and mostly benefited used cars. The new crisis caused by the coronavirus pandemic is likely to cause another setback for the car market, leading to delayed vehicle replacement and further aging of the fleet. Increasing congestion and pollution call for a serious reevaluation of current approaches to car ownership and public transportation.

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