Price Anomalies in the Used Car Market

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Abstract

Using two different samples – one based on newspaper advertisements, the other Internet-based – we identify some price anomalies in the used car market in The Netherlands. First, prices of used cars depend on their age in calendar years rather than months. Second, there is some evidence that crossing 100,000 kilometers induces a sudden additional price reduction. Third, a new license plate format, something with no intrinsic value whatsoever, increases a car's price by about 4 percent. We discuss possible explanations for these results.

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1. Introduction

Mainstream economic theory makes straightforward predictions for prices of used cars. Those prices should bear a close relation to the expected discounted value of the flow of future utility that a car can provide its owner during the remainder of the car's lifetime. As a car grows older, its expected remaining lifetime decreases. The standard model thus predicts that, ceteris paribus, older cars fetch lower prices on the used car market. Also, a car of a given age with high mileage is likely to break down earlier than a car of the same age, but with much lower mileage. Hence, mainstream economics predicts that cars with higher mileage fetch lower prices – again, ceteris paribus. Moreover, it predicts that this relationship is continuous. A discontinuous relationship would imply that one additional mile or kilometer substantially increases the probability of an early breakdown. It is hard to see why that would be the case. A final implication of the standard model is that a car characteristic that does not have any intrinsic value obviously should have no effect on the car's price.

Yet, at least in the Netherlands, both industry folklore and public wisdom contradict these claims. First, when buying a new car one is advised to do so at the beginning of a calendar year. In the used car market, a car's age is said to be evaluated in calendar years rather than in months. This suggests that a car originally bought in January is considered to be one full year younger than a car bought in December of the previous year. Second, both car dealers and consumers often claim that a car should be traded in before its odometer reaches the 100,000 kilometer mark. Once a car crosses that threshold, its value is said to drop considerably. Third, a car with a new license plate format is said to command a premium on the used car market. In the Netherlands, a new license plate format is introduced every few years. Since a Dutch license plate number is a perfect signal of the car's age the exact license plate format does not provide any additional information. Hence, if such a premium indeed exists, car buyers would be willing to pay a higher price merely for the license plate format of a car – something with no intrinsic value whatsoever. These three peculiarities, if true, would qualify as anomalies, in the sense that they contradict standard economic theory.

In this paper, we provide evidence for these alleged anomalies. We thus add to a growing literature in economics and finance, that seeks to establish behavioral anomalies, in which behavior of market participants systematically differs from the standard model of the rational utility-maximizing agent.[1] We find that, on the used car market, a new license plate format increases a car's price by about 4%. Also, our results suggest that crossing the 100,000 kilometer mark induces an additional price reduction that may be as large as 7 percent – but this effect is only discernible in a sample of cars that were advertised in the mid 1990s, not in a more recent dataset. Furthermore, consumers do perceive car age only in terms of calendar years, ignoring more detailed information. We use two data sets to establish these results. One data set is newspaper-based and contains data for a number of years. The other is Internet-based and has information on prices at one point in time. The effects appear to be somewhat weaker in the more recent, Internet-based sample.

The main goal of this paper is to establish the anomalies. Explaining them is far more difficult. Tentatively, the results of our empirical analysis suggest that at least some consumers are unable or unwilling to use the exact information they receive. Instead, they use rough proxies like year of birth. This leads to systematic biases in the prices of used cars. Intriguingly, the most convincing explanation of the plate effect we find is that car buyers want others to infer that their car is newer than it really is. However, to firmly establish these or any other explanations, further research is obviously needed.

There is a wealth of papers studying the prices of cars. A substantial recent literature was triggered by Berry, Levinsohn, and Pakes (1995). Yet, this literature tends to look only at the prices of new cars. Papers that do look at the used car market do not allow the anomalies we study in this paper, but primarily focus on testing Akerlof's (1970) adverse selection model.[2] One related paper is Pashigian, Bowen, and Gould (1995). They find that in the 1980s new cars sell for about 2% more at the start of the model year (November) than they do at the end (October). They explain this as a fashion effect: when new models appear, car manufacturers are able to charge a premium to fashion-conscious early adopters. Note however that this effect is different from the premium for cars born[3] at the beginning of the year that we find. The fact that consumers are willing to pay a premium for being among the first to drive a certain model does not imply that buyers of used cars would also be willing to a pay a premium for a car that *originally* was among the first.

The only economic analyses of license plates we are aware of involve personalized license

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[1] See e.g. Thaler (1994) and Shleifer (2000).
[2] See e.g. Bond (1982), Genesove (1993), or Emons and Sheldon (2002).
[3] In the remainder of this paper, we refer to the 'birth' of a car as the time at which is was sold to its first owner.

plates. Vehicle owners in e.g. some US states can purchase the right to choose the sequence of symbols that will appear on their "vanity license plate". Alper, Archibald and Jensen (1987) estimate the elasticity of the demand for these plates and conclude that most states set a price higher than the profit-maximizing one. Harrington and Krynski (1989) find a similar result. Woo and Kwok (1994) find that in Hong Kong, where some desirable license plates are auctioned, plates that contain lucky numbers command a premium, while those with unlucky numbers carry a discount. Biddle (1991) analyzes whether there is a bandwagon effect in personalized license plates. Bandwagon effects (see Leibenstein (1950)) are said to exist if peoples' valuations of a good increases when they observe others consuming the good. Biddle does find that the demand for personalized license plates is positively related to total demand in the previous period. However, as noted by the author, the effect can also be explained by a diffusion model, in which demand for a new product grows as information about or awareness of the new product spreads.

The paper proceeds as follows. Section 2 takes a more in-depth look at the way in which license plates are issued in the Netherlands. In section 3, we develop a theoretic framework for the value of a used car. Section 4 describes our data. Estimation results are reported in section 5. Section 6 discusses possible interpretations of our findings, and concludes.

2. Dutch License Plates

One of the issues we study in this paper is the effect of the license plate format on the price of a used car. To appreciate this effect, some background information is needed on the way license plates are issued in the Netherlands. In this section, we provide that information.

In The Netherlands cars are identified by license plates which are issued when the car is sold to its first owner. The license plate number does not change at resale and remains with the car throughout its life. New plates are issued in alphabetical order. As a consequence, it is possible to deduce the age of any car from its license plate number with a one month precision.[4]

In September 1991 the format on the plates for new cars changed. Cars that were bought

[4] There is an exception for imported *used* cars. For such cars a new (Dutch) license plate is issued when it enters the country.

before that date have a license plate with format XX-##-XX, where each X denotes a letter[5] and each # a one-digit integer. The format of cars bought after September 1991 is XX-XX-##. Prior to the change car dealers reported a drop in sales of new cars, and suggested that this was due to the fact that many potential buyers waited for the new format. Responding to pressure from the automobile industry, the State Agency for Road Traffic decided to expedite the introduction of the new format. The introduction received ample attention from the media. Prime time news programs featured the Minister of Transportation showing the first plate of the new format.

In June 1999 the format changed again, now from XX-XX-## to ##-XX-XX. In an attempt to minimize the effect on sales the State Agency for Road Traffic did not provide any information on the exact timing of the new change of format. Consumers were assured that the license plate format would not have any effect on the resale value of their car. The change occurred earlier than expected, well before all possible combinations of format XX-XX-## were exhausted. [6]

These stories suggest that, other things equal, consumers prefer a new license plate format. This may be because a car owner likes a new plate *per se*, or because he expects that future buyers of used cars will. Note that the order of letters and numbers on a plate provides a crude but simple and cheap informational signal about the car's age[7]. To determine the exact car age, most people would have to consult additional sources of information (e.g. websites like `http://www.hektra.nl/info/kenteken.html`).

The price of a new car does not depend on the license plate format that is attached to it. However, if consumers value the license plate format, this should be reflected in the prices of used cars. The license plate format uniquely identifies any Dutch car as belonging to one of three subsequent cohorts of cars:[8] those with format XX-##-XX date from August 1991 or before, those with format XX-XX-## are from the period September 1991 up to and including May 1999, and those with format ##-XX-XX are from June 1999 or more recent. As a consequence,

[5] Only consonants are used. Combinations starting with B and V are reserved for commercial vehicles, those starting with M are reserved for motorcycles. C, K, Q, and W are not used, since their resemblance to other letters is too close.
[6] The last plate issued of the old format started with ZN. Hence, plates starting with ZP through ZZ were never used.
[7] Law requires that cars have license plates on both the front and the rear side. Plates and characters on plates are about 25 percent larger than in the US.
[8] In fact, there are even more cohorts. For example, XX-##-XX was introduced in 1978. Cars born between

at given point in time the license plate format puts bounds on the car's age. For example, in May 2001, we know that a car with format XX-XX-## is at least two and at most nine years old.

3. Theoretical Framework

As we argued in the introduction, according to standard economic theory, the price a consumer is willing to pay for a used car should equal the expected discounted value of future utility that a car can provide during the remainder of the car's lifetime. We will refer to the latter as the *intrinsic value* of the car, which does not necessarily equal the *market value*, which is the price on the second-hand market. Consider the *instantaneous utility* that a consumer obtains from owning a car at a given point in time. The intrinsic value of the car then equals the expected discounted value of all future instantaneous utilities.[9]

For simplicity, we assume that all consumers have the same preferences, and hence have the same instantaneous utility functions. This is just for expositional convencience; for our results, it is immaterial. With perfect competition, the market value will then equal the intrinsic value. We assume that instantaneous utility is decreasing in mileage: as a car has higher mileage, it is more likely to break down, hence the expected utility that one can derive from it, is lower. Also, we assume that instantaneous utility is either constant or decreasing in the age of the car. This immediately implies that the market value of the car is also decreasing in its age.

When the market value of used cars does not satisfy this standard model, we will consider this an anomaly. More specifically, the model predicts the following:

Hypothesis 1 (*no year effect*) The age of a car is evaluated in months rather than calendar years.

Hypothesis 2 (*no 100,000 km effect*) Crossing the 100,000 km threshold does not lead to a discrete drop in a car's value.

Hypothesis 3 (*no plate effect*) A new license plate format has no effect on the value of a given

1973 and 1978 had a license plate with format ##-XX-## etc. For our story, this is not relevant.

car.

Hypothesis 1 is straightforward. Our model immediately implies that the intrinsic value of a car is a continuous and decreasing function of its age. The age information that consumers possess when they buy a used car concerns the month in which the car was born. Hence, when determining the intrinsic value of a used car, consumers should take that information into account, and not base the value merely on the year in which the car was built.

Hypothesis 2 is more subtle. Note that it does *not* preclude that there may be discrete drop in instantaneous utility from owning a car that has run for over 100,000 km. When determining the intrinsic value of a car, a rational consumer always takes into account that there will be such a drop in instantaneous utility in the future. For example, a rational consumer that buys a car that has run for 95,000 kilometers will realize that this car will yield much lower instantaneous utility after only another 5,000 kilometers, and will take this into account when determining the intrinsic value of that car. As a result, the intrinsic value of a car is a continuous function of mileage, which implies the second hypothesis.

For hypothesis 3, note that a plate effect would imply that consumers systematically attach a higher value to a car that has a new plate. Two otherwise identical cars then have a different value, purely based on the license plate that has been attached. As this plate has no effect whatsoever on the intrinsic utility of the car, this would be an anomalous event from the point of view of the theory set out above.

4. The data

Our analysis requires detailed data on individual transactions in the used car market. The first sample (sample A) is based on advertisements in local newspapers in the Dutch province of Utrecht between January 1992 and December 1998 (with advertised cars from cohorts 1986 up to 1997). Cars can be included in the sample only if the advertisements at least contain information on car make and model, year and month of car cohort (which is the date of "car birth"), the price, and some other main price determinants (engine volume, number of

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[9] A more formal model is available from the authors upon request.

kilometers driven, and automatic/manual transmission). We selected the advertisements by three certified Peugeot car dealers since their ads consistently contained all necessary information and showed substantial variety in terms of models. The sample contains information on Peugeots 106 and 205 (small), 309 and 405 (medium), and 605 (large), with a total of 462 observations.

The second sample (sample B) is based on the Internet site `autoonline.nl`, set up by RDC and Autodata. These are centers that collect data on transactions and the supply of used cars at almost all car dealers in the Netherlands. At the beginning of 2000, this website listed all used cars offered for sale at 1,100 dealers throughout the country (see RDC, 2000). Note that the website merely *lists* these cars, and offers some selection facilities. Consumers still need to go to the dealer to buy the car, without having to reveal that they saw the car listed on the web. Thus, `autoonline.nl` is *not* a referral site, as is the case for most websites in the US offering used cars (see e.g. Morton, Zettelmeyer, and Risso, 2001).

In the first two weeks of 2001 we took a sample of 443 cars from `autoonline.nl`.[10] The site reports all information required for our analysis, including cohort month. Sample B contains data on a larger variety of car makes: Peugeot 406 (medium), Nissan Primera (medium), and Audi A6 (large). The main reasons for choosing these cars was that they were advertised often enough to allow us to create a relatively homogeneous sample. Also, in the cohort periods we consider there were no modifications in the specifications of these car models.

In both samples, the price that we observe is the price asked by the car dealer, which is not necessarily the price that is actually paid. Consider a regression with the *ln* of the asking price as the dependent variable. Suppose that $p=\lambda s$, $0 < \lambda \leq 1$, where p is the actual price and s the asking price. When λ is a random variable independent of the included regressors, using s rather than p will not affect the regression coefficients, except for the constant term.[11] Moreover, when setting prices car dealers usually consult a database that gives the average price actually paid for a particular type of car, based on a large number of recent transactions nationwide. Therefore, asking prices and actual prices will be closely related, if not identical. Finally, even if information on actual prices would be available, its interpretation would be hampered by the fact

[10] Since we had no permission for automated access to the data, the information was secured manually by separately clicking on each observation and storing it into a data file.

[11] If λ is uncorrelated with the vector of independent variables X, and the true relationship is $ln\ p = \alpha + \beta X$, then the one we estimate is $ln\ s = ln\ p - ln\ \lambda = (\alpha - ln\ \lambda) + \beta X$.

that most transactions involve a trade-in.

There are some notable differences between the two data sets. First, sample A contains observations on cars that were advertised during a seven year period, whereas the cars in sample B were all advertised at the same point in time. Second, cars in sample A are older on average than cars in sample B (48 versus 31 months; see tables 3 and 4 in the appendix); in sample A, 25 percent of the cars had more than 100,000 kilometers on the odometer, compared to only 6 percent in sample B. Third, the cars in sample B have larger engines and are more frequently equipped with automatic transmission. The cohort data in both samples show a remarkable seasonal pattern (see tables 3 and 4 in the appendix, and the top panels of figures 3 and 4, also in the appendix). Roughly fifty percent of the cars were 'born' in the first quarter of a calendar year, and the percentages for subsequent quarters decline sharply.

5. Empirical results

5.1 Estimation strategy

This section describes the results of our empirical analysis. We estimate equations with *ln* price as the dependent variable. To explain price, we include the obvious variables that are generally believed to influence the value of a used car. These include the age of the car in months, the number of kilometers driven, engine volume and dummies for the type or model of the car. Moreover, we include variables to test for the hypotheses set out in section 3.

In our regression, we include the age of the car in months as an explanatory variable. When consumers do indeed evaluate the age of a car in months, then the entire effect of age on value should be captured by our age-in-months variable. In that case, dummy variables for whether a car was born early or late in the year should not add any explanatory power. A 14-month old car born in January should have the exact same value as a 14-month old car born in December. If, however, consumers evaluate the age of a car in calendar years rather than months, then we should find that cars born early in the year do have a higher value than what one would expect merely on the basis of their age in months. In that case, a 14-month old car born in January (but with an age of one calendar year) would have a higher value than a 14-month old car born in

December (with an age of two calendar years). Therefore, if hypothesis 1 is true, then dummies that indicate that a car is born early in a calendar year, should have a zero value in our regression where age is measured in months. On the other hand, if consumers do evaluate the age in calender years, then we would expect the value of such dummies to be significantly positive.

Hypothesis 2 is more straightforward to test. If it is true, a dummy that indicates whether a car has crossed the 100,000 km mark, should have a zero value in a regression where the effect of kilometrage is already taken into account. Hypothesis 3 implies that a car that was born after the introduction of a new license plate format, should have the same value as a car that was born before that introduction, but which is identical in every other respect.

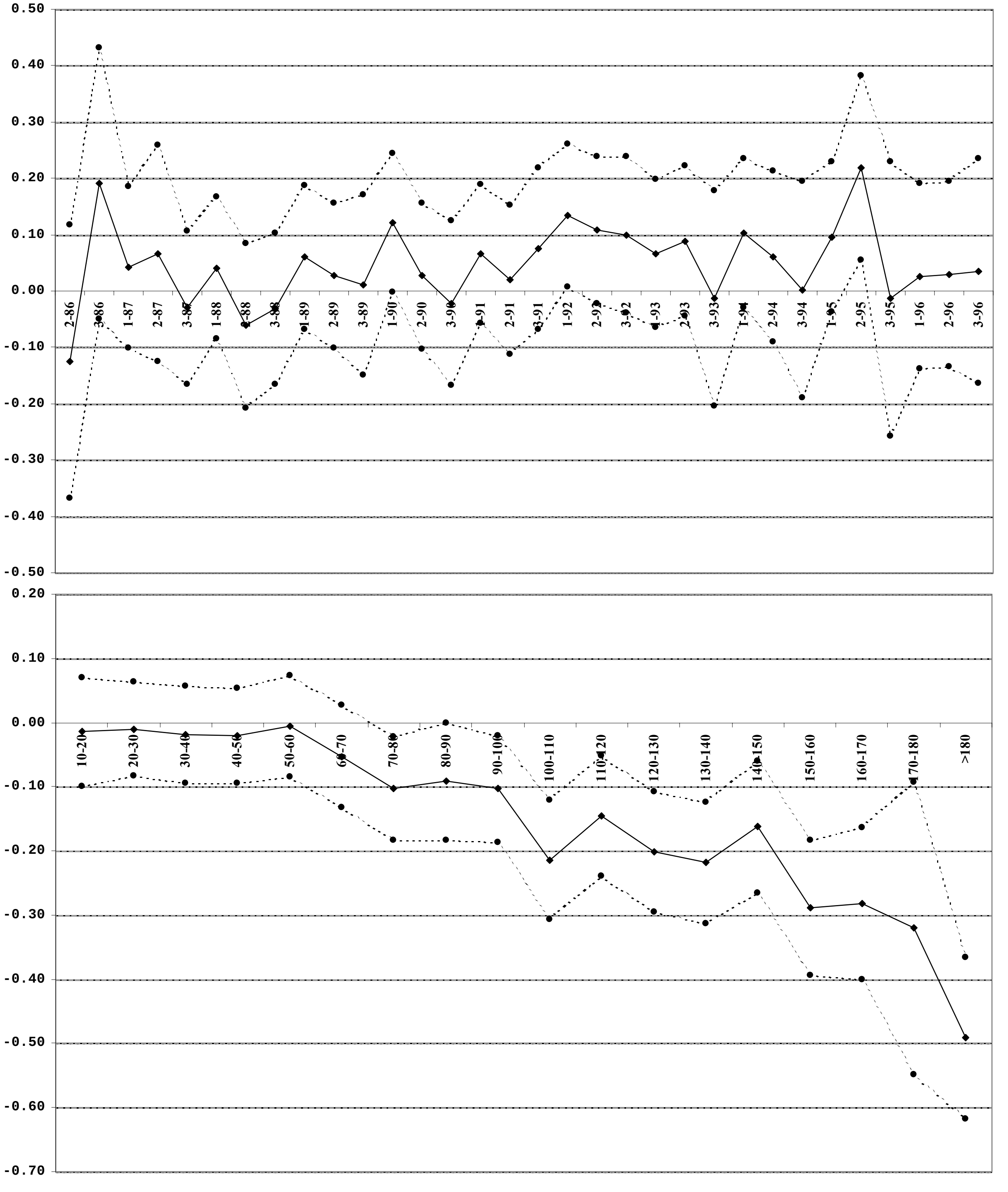
We study both samples separately. To get a feel for the data, and to allow for as much flexibility as possible in parameterizing the cohort effects, we initially use dummy variables for each four-month period in sample A, and for each two-month period in sample B. We also use dummies for each 10,000 km interval in sample A, and for each 20,000 km interval in sample B. We then plot the values of all dummies to get a feel for the general patterns that are present in our data. We also plot the corresponding frequencies of the cohorts and intervals. Finally, we aggregate cohort and interval dummies to formally test our hypotheses.

5.2 Results for sample A

Estimation results for sample A are reported in table 1. In column I, we use dummy variables for each four-month period (or trimester), with January-April 1986 as reference period. Since the new plate was introduced in September 1991, partitioning the data in trimesters rather than quarters allows us to most clearly discern the possible effect of a new license plate format. Similarly, we use 10,000 kilometer interval dummies (with 0-10,000 as reference category) to parameterize the kilometer effects.

In the top panel of figure 1, we have plotted the values of the cohort dummies. As the age in months is also included in the regression, our theory predicts that all these dummies have a value equal to zero. At first sight, the coefficients seem to show a rather erratic pattern. Most of the 32 coefficients are insignificant at the 5 percent level. Upon closer inspection, however, some general patterns emerge. If consumers evaluate the value of a car in calendar years rather than months, then we would expect that the value of the dummy for the first trimester in a given year

Figure 1. Sample A, cohort and kilometer effects.



The top panel gives the value of the cohort dummies in the regression in the first column of table 1. Numbers on the horizontal axis denote trimesters. For example, 2-92 refers to the period May-August 1992. The bottom panel gives the value of the kilometer dummies in the same regression. In each panel, the straight curve is the estimated one: the dotted curves represent the 95% confidence interval.

should be higher than that for the second, which should again be higher than that for the third trimester. Also, we would expect the dummy for a third trimester to be lower than that of the first trimester of the following year. These patterns indeed seem to hold for many years – especially in the middle of our sample, where we have the highest number of observations. Note that this seems to contradict hypothesis 1. The most notable exception of the general pattern sketched above is trimester 3-91. The dummy for this trimester has the highest value of all third-trimester dummies. The dummy for the next trimester, 1-92, has the highest value of all first-trimester dummies. But this is inconsistent with hypothesis 3. Since the license plate format XX-XX-## was introduced at the end of trimester 2-91, a plate effect would imply a higher value for cars born after that date. The trimester dummies confirm this.

Table 1. *Estimation results sample A* (dependent variable: *ln*(price); t-values in parentheses).

	I	II	III
Constant	9.36 (180.1)	9.41 (220.7)	9.44 (212.7)
Age in months	-0.0104 (-32.4)	-0.0099 (-31.3)	-
Age in years	-	-	-0.1173 (-29.7)
Engine volume	0.6216 (21.6)	0.6086 (21.3)	0.6187 (20.9)
Automatic transmission	0.1053 (3.5)	0.1039 (3.4)	0.1000 (3.2)
Model 205	0.0087 (0.5)	0.0185 (1.0)	0.0205 (1.0)
Model 309	-0.1226 (-5.5)	-0.1123 (-5.0)	-0.1123 (-4.8)
Model 405	-0.0181 (-0.7)	-0.0090 (-0.4)	-0.0035 (-0.1)
Model 605	0.1220 (3.2)	0.1410 (3.7)	0.1439 (3.6)
New plate	-	0.0490 (3.9)	0.0423 (3.2)
Cohort 1st quarter	-	0.0685 (3.9)	-0.0210 (-1.1)
Cohort 2nd quarter	-	0.0331 (1.7)	-0.0271 (-1.3)
Cohort 3rd quarter	-	0.0110 (0.5)	-0.0228 (-1.1)
# kilometers driven	-	-0.0017 (-6.2)	-0.0018 (-6.6)
≥100,000 kilometers	-	-0.064 (-3.1)	-0.068 (-3.1)
Cohort dummies	see fig. 1	-	-
10,000 kilometer interval dummies	see fig. 1	-	-

The coefficients on the kilometer dummies are depicted in the bottom panel of figure 1. Here, we do *not* expect all these dummies to equal zero, as the number of kilometers itself is not included in the regression. In addition to a steady decline in value when the number of kilometers increases, the figure shows a strong additional drop in value as soon as the car crosses the 100,000 kilometer mark. This contradicts hypothesis 2. Remarkably, this drop seems to disappear when the number of kilometers increases further. The number of cars offered also drops substantially once the 100,000 kilometer threshold has been reached.

To put some more structure on the data and formally test our hypotheses, we estimated an alternative specification; see column II in table 1. The cohort dummies have been replaced by three other variables: age in months, cohort quarter dummies (with the fourth quarter as reference category), and a dummy for a new license plate format (i.e. cohort after the second trimester of 1991). The kilometer dummies have been replaced by a linear kilometer variable and a dummy variable for having crossed 100,000 kilometers.

Conditional on the time of advertising, age effects and cohort effects are obviously tantamount. [12] In sample B, all cars were advertised at the same point in time, but in sample A the time of advertising varies across observations. To control for inflation, changes in market conditions, and seasonal effects within sample A, we included dummy variables for the year of sale, and dummies for the quarter of sale. However, in preliminary regressions all time of sale variables turned out highly (jointly) insignificant. The same holds for dummies for car dealer/region and car color. All these variables were omitted henceforth.

The cohort quarter dummies are jointly significant and reveal a premium of 6.9, 3.3, and 1.1 percent for cars from a first, a second, or a third quarter, respectively. As we argued earlier, this is consistent with a world in which the age of a car is evaluated in calendar years rather than months. When age is defined as the year of sale minus the cohort year, cohort quarter dummies are insignificant (column III of table 1). Thus the results for both age specifications imply that age in years is closest to consumers' perception of car age, and that month information is ignored, rejecting hypothesis 1. Crossing 100,000 kilometers induces a significant drop in the price of the car of almost 7 percent. When replacing the 100,000 km dummy with either a 90,000

[12] Conceptually, cohort and age effects can be different. For example, an individual may prefer a younger car to an older but otherwise identical car because the first one has been exposed to moisture for a shorter period of time (age effect), or because the first one has (or is thought to have) a higher construction quality (cohort effect). However, as cohort and age do not vary independently given the time of advertising, the two effects are indistinguishable in the present setting.

or a 110,000 km dummy, we found that these were not significant. This implies that the sudden drop in value is temporary and uniquely related to cars that have run just over 100,000 km, as the bottom panel of figure 1 also suggests. It also suggests that the effect we find is *not* merely due to some nonlinearity that is not captured by our linear specification. This rejects hypothesis 2. We also find strong evidence against hypothesis 3: the effect of a new license plate format is positive and highly significant: A new plate format increases the value of a used car by almost 5 percent. We also replaced the new plate dummy (which boils down to a dummy that indicates whether or not a car was born after August 1991) with either an August 1990 or an August 1992 dummy. When doing so, we found that these were not significant. This implies that the new plate effect is especially relevant for cars that were born closely after the change in format.

Most of the coefficients on other car characteristics are significant and have the expected signs. The value of a car depreciates by one percent each month. An additional deciliter of engine volume increases the car's price by six percent, while the presence of automatic transmission induces a ten percent price increase. Driving an additional thousand kilometers results in a price decrease of one sixth of a percent. The coefficient for model 309 is negative and significant. This may be related to the fact that this model is originally a Talbot which was renamed after the Talbot company was acquired by Peugeot. Moreover, the production of the 309 ceased in 1992.

The "new plate" variable may proxy a cohort effect which is unrelated to the introduction of the new license plate format but took place at the same time. However, scrutiny of the history of all models revealed that in 1991 the only published quality change was the introduction of optional power windows and power locks for model 309. Estimation without the observations on model 309 resulted in a coefficient of 0.0480 (t-value: 3.5) for the "new plate" variable. The result of this check and the estimates in table 1 suggest that the "new plate" dummy indeed reflects the effect of the new plate rather than any other cohort effect.

Our results may be biased due to the fact that some cars are advertised more than once. To investigate this potential problem, we have re-estimated the model without the 84 observations that could potentially refer to a car advertised earlier. This does not change the estimation results in any significant manner.

5.3 Results for sample B

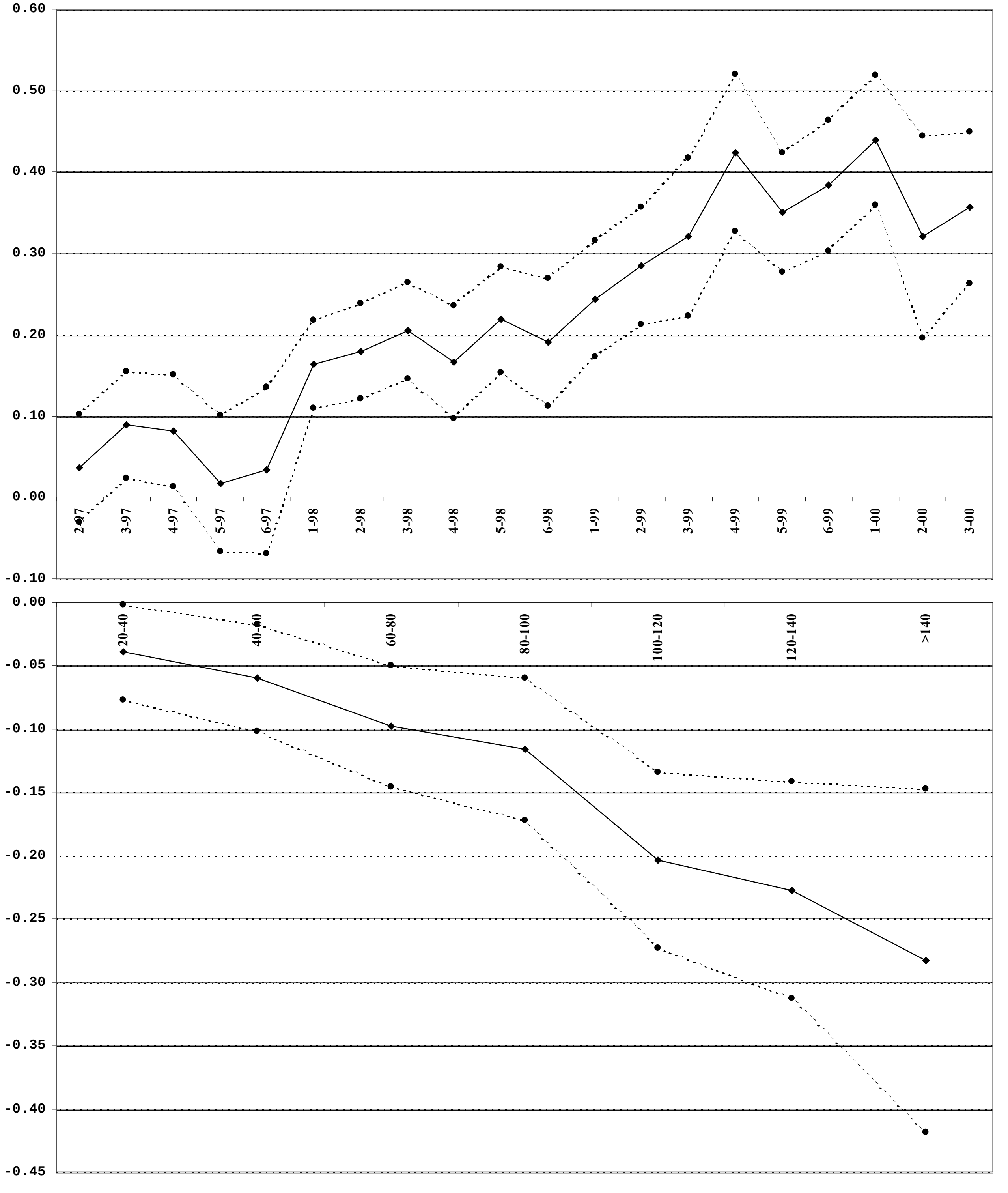
The estimation results for sample B are reported in table 2. The much shorter range of cohorts allows us to estimate separate cohort effects for bi-monthly periods, rather than four-month periods. On the other hand, we have to use 20,000 rather than 10,000 kilometer intervals since in sample B there are fewer observations with high mileage. The top panel of figure 2 displays the cohort effects. Note that these are not directly comparable to those in the top panel of figure 1. Since sample B only contains cars advertised at one point in time we cannot include both the age in months and a dummy for each separate cohort in this regression. Thus, we expect the coefficients to exhibit a decreasing pattern.

Table 2. *Estimation results sample B* (dependent variable: *ln*(price); t-values in parentheses).

	I	II	III
Constant	10.16	10.80	10.78
	(17.9)	(133.5)	(134.4)
Age in months	-	-0.0916	-
		(-10.4)	
Age in years	-	-	-0.1120
			(-10.5)
Engine volume	0.2579	0.2659	0.2664
	(8.1)	(8.6)	(8.6)
Automatic transmission	0.081	0.082	0.079
	(3.8)	(4.0)	(3.9)
Nissan Primera	-0.6068	-0.6015	-0.6000
	(-23.5)	(-24.0)	(-24.0)
Peugeot 406	-0.5587	-0.5578	-0.5583
	(-22.15)	(-22.8)	(-22.9)
New plate	-	0.0394	0.0378
		(1.8)	(1.7)
Cohort 1st quarter	-	0.0367	-0.0464
		(2.0)	(-2.4)
Cohort 2nd quarter	-	0.0350	-0.0169
		(1.8)	(-0.9)
Cohort 3rd quarter	-	0.0167	-0.0072
		(0.8)	(-0.4)
# kilometers driven	-	-0.0017	-0.0017
		(-5.7)	(-5.6)
≥100,000 kilometers	-	-0.032	-0.031
		(-1.1)	(-1.1)
Cohort dummies	see fig. 2	-	-
20,000 kilometer interval dummies	see fig. 2	-	-

The top panel of figure 2 shows a remarkable spike at the time of the introduction of license plate format ##-XX-XX (period 4-99). It also suggests that a change of calendar year is associated with a larger price change than transitions between other two-month periods. The

Figure 2. Sample B, cohort and kilometer effects.



The top panel gives the value of the cohort dummies in the regression in the first column of table 2. Numbers on the horizontal axis denote two-month periods. For example, 2-92 refers to the period March-April 1992. The bottom panel gives the value of the kilometer dummies in the same regression. In each panel, the straight curve is the estimated one: the dotted curves represent the 95% confidence interval.

100,000 kilometer effect in the bottom panel of figure 2 is similar to that in figure 1. Columns II and III in table 2 reveal that a new license plate commands a premium of almost 4 percent, slightly smaller than the corresponding effect for sample A. Also, the effect is only significant at the 10 percent level. The coefficient on the 100,000 kilometers dummy is negative but not significant, which may be related to the fact that in sample B only 6 percent of the cars has crossed this threshold. The cohort quarter dummies in table 2, second column, show the same decreasing pattern as they do in sample A, albeit to a lesser extent. In column three, where age is defined in years (ignoring month information), we find a negative effect of the first quarter. Finally, the effect of engine volume is much smaller in sample B than in sample A, but the effects of automatic transmission and the number of kilometers driven are about equal across the two samples.[13]

Summarizing, we conclude that both samples yield qualitatively similar results, apart from the 100,000 km. effect. For that effect, we only find some evidence in the older sample. The other two hypotheses that we derived from the theory, are rejected in both samples, which implies that we have identified some anomalies in the used car market. Yet, in terms of size and significance of coefficients, the effects appear to be somewhat weaker in the more recent, Internet-based sample.

6. Discussion and conclusion

This paper identified price anomalies in the used car market in the Netherlands. First, consumers are willing to pay a premium of some 4% for a car that has a license plate from a newer series. Second, used cars are priced based on their age in calendar years rather than their age in months. Third, we find some evidence that the value of a used car drops once it reaches the 100,000 km threshold. These effects are found both in a sample of newspaper advertisements centered around

[13] Sample B contains data for cars that are very diverse: Peugeot 406, Nissan Primera, and Audi A6. To see whether this diversity somehow drives our results, we have also done the analysis for just one of the models. Therefore, we have also done our analysis for the subsample of Nissan Primeras, for which we have 238 observations, the largest number of observations on a single model. The new plate effect is then as large as 8 percent, implying that a new plate increases the price of a Nissan Primera by about 2500 guilders (some USD 1000). Given that the new plate effect for sample B as a whole is 4 percent, this indicates that there is quite some variation in the size of the license plate effect across models. Details are available from the authors upon request.

the 1991 change in license plate format, and in a sample of price quotes on the Internet centered around the 1999 change in license plate format. The effects in the Internet-based sample appear weaker, especially that of the 100,000 km. effect.

Our results establish that the market for used cars in the Netherlands is not efficient in the standard economic sense. There are systematic biases in the prices of used cars, which cannot be rationalized by standard economic arguments assuming optimizing behavior. The fact that these anomalies exist on this market is all the more surprising since for many people buying a car is one of the more important financial decisions they make. One would therefore expect consumers to be willing to spend a lot of time, effort, and money to make the right decision. The sums at stake are substantial. In sample B, given the average price, a premium of 4% implies a premium for a new license plate format of on average Dfl. 1500, or € 680.[14] The fact that people fail to make the "right" decision on this market sheds even stronger doubt on the efficiency of markets where the amounts at stake are smaller.

Our results suggest that at least some consumers are unable or unwilling to use the exact information they receive. Instead, they use rough proxies like the year of birth, and whether a car has run more or less than 100,000 kilometers. This leads to systematic biases in the prices of used cars. For example, cars that are born in the beginning of the year are overpriced, while those born in the end of the year are underpriced.

Interestingly, consumers do seem to be aware of these anomalies. Indeed, such popular wisdom is exactly what triggered this paper in the first place. Also, consumers seem to take these effects into account when offering their used car for sale, and when buying a new car. Our data suggests that on the used car market, relatively many cars are offered with kilometrage just below 100,000. Data from new car registrations show that relatively more cars are born early in the year.[15] Hence, even though people make systematic mistakes when evaluating the *value* of a used car, they do seem to have the right view of the *price* of a used car.

One reason that such anomalies may persist in this market, is the impossibility of arbitrage. When some market participant is aware of the anomalies that we observe, it is virtually

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[14] Note that this is also much higher than what is charged for a vanity license plate in the US. See e.g. Alper et al. (1987).

[15] For example, out of all the cars born in the Netherlands in 2001, 13.3% were born in January, and 31.8% were born in the first quarter as a whole. For Western Europe as a whole, the effect is less substantial, but still existent: in the period 1991-2001, 27.2% of all cars in Western Europe were born in the first quarter of a year, and only 21.7% in the last quarter. See http://www.acea.be

impossible to use that information to arbitrage away the inefficiencies. First, transaction costs are substantial. Second, arbitrage requires that it is possible to buy cars that are undervalued, to resell them at their proper value. But the latter is only possible if one can convince prospective buyers that those cars are actually worth more than what they usually trade for.

In the case of the plate effect, one could argue that this is merely due to buyers using the plate format as a rough short-cut to determine a car's age. When people only use license plate format to evaluate age, one can expect buyers of a used car to overpay for cars that are among the first to have a certain format. Yet, we already saw that people also use information on the year of birth to determine their willingness to pay for a used car. Once that is used, the license plate format does not add any information. Hence, there must be a different reason why people are willing to pay more for a new license plate format.

Note however that, whereas the year of birth is readily observable for a prospective car buyer, it is not for someone observing somebody else's car. The license plate format, however, *is* readily observable for everyone. That raises the possibility that buyers of used cars are willing to pay more for a car with a new plate, not because they *themselves* use information about plate format to evaluate the age of a car, but rather because they expect *others* to do so. Suppose that utility of car owners is decreasing in the age of their car as perceived by others. Then it makes sense to pay more for a car that others are more likely to perceive as being relatively young. When those others use the license plate format as a rough proxy for the age of a car, then they will perceive a car with a new license plate format as being relatively young. Hence, car owners are willing to pay more for such a car.

Arguably, this is a Veblen effect. Veblen effects are said to exist when one good is sold at a premium relative to a second good that is functionally equivalent; see e.g. Bagwell and Bernheim (1996).[16] Veblen (1899) refers to that premium as conspicuous waste, that part of the value of a good that cannot be accounted for by the intrinsic usefulness of the good. Theoretical analyses of Veblen effects include Ireland (1994, 1998) and Glazer and Konrad (1996). The model that is most closely related to our plate effect is Bagwell and Bernheim (1996). They derive conditions where a good that is functionally equivalent to another one can still command a premium if consumers use consumption of that good to signal their wealth.

[16] Some papers (see for example Corneo and Jeanne (1997)) define a Veblen effect as a case in which demand is increasing in price. However, we think that the definition of Bagwell and Bernheim is much closer to the spirit of Veblen's work.

The effects we find in sample B are smaller, both in size and significance, than those in sample A. One possible explanation is the following. The cars considered in the Internet sample are born much later than the cars in the newspaper sample. Therefore, these cars may have a higher intrinsic quality and therefore, other things equal, fetch a higher price in the used car market. The *relative* effect of a new license plate and crossing the 100,000 kilometer mark may then be lower. Note from tables 4 and 5 in the appendix that the average price in sample B is twice as high as the average price in sample A. Since the relative license plate effect found for sample B is more than half as large as that found for sample A, this still implies that the absolute license plate effect in sample B is higher than the one in sample A.

An alternative explanation for the smaller effects in sample B is that the market for used cars may have become more efficient. There are two reasons why that may be the case. First, due to the introduction of the Internet, it is much easier for consumers to look around and compare prices, reducing the scope for the anomalies we identify in this paper. Second, an increase in market efficiency may be due to this very research. Note that the new plate in sample B concerns the change in format that took place in June 1999, while the one in sample A concerns the change in September 1991. An earlier version of this paper, with only the results for sample A, was published in Dutch in June 1999 – only a few weeks after the most recent format change (Haan and Kooreman, 1999). This generated a lot of media attention, with dozens of newspapers reporting on our results, many of them including the advice to buy a used car which has just run over 100,000 km and is among the last to have an old plate.

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APPENDIX

Table 3. *Sample A: Sample statistics.*[a]

Variable	mean	st. dev.	min.	max.
Price (Dfl.[b])	18511	8575	4700	69950
Age in months	47.7	24.9	6	114
Age in years[c]	3.80	2.06	0	9
# kilometers driven (x0.001)	71.9	42.6	4	196
100,000 kilometers or more	0.249			
Engine volume (liters)	1.447	0.332	1.0	3.0
Automatic transmission	0.035			
Year car cohort	90.81	2.21	86	97
Cohort 1st quarter	0.526			
Cohort 2nd quarter	0.219			
Cohort 3rd quarter	0.158			
Cohort 4th quarter	0.097			
Year of sale[d]	94.61	2.12	92	98
Sale in 1st quarter	0.227			
Sale in 2nd quarter	0.305			
Sale in 3rd quarter	0.314			
Sale in 4th quarter	0.154			
Peugeot 106	0.126			
Peugeot 205	0.327			
Peugeot 309	0.182			
Peugeot 405	0.305			
Peugeot 605	0.061			
New plate (cohort after August 1991)	0.368			

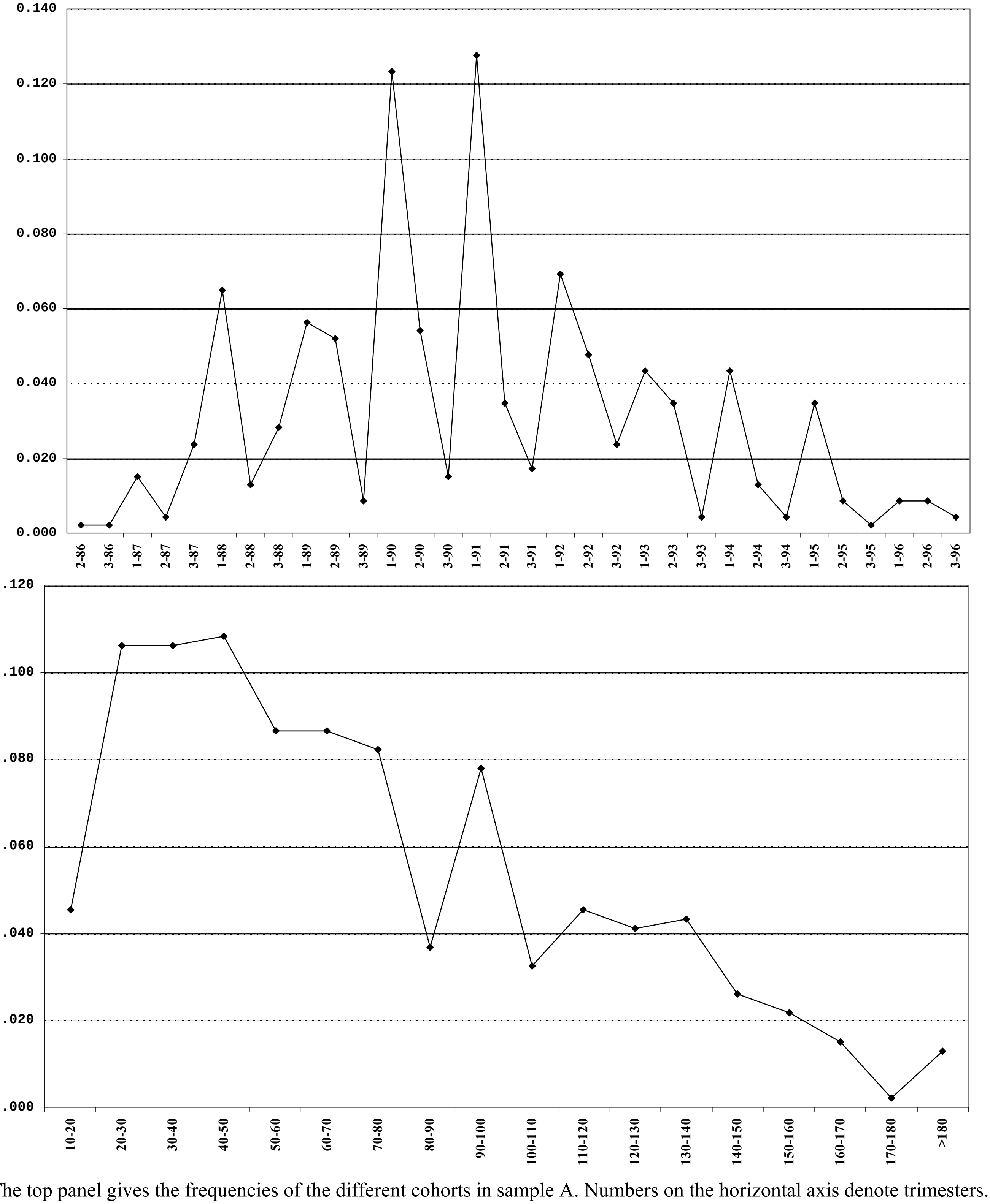
[a]# of observations: 462.
[b]The value of the Dutch Guilder varied between US$ 0.47 and US$ 0.62 during the sample period.
[c]Year of sale minus cohort year.
[d]Strictly speaking: the year in which the car is advertised

Table 4. *Sample B: sample statistics.*[a]

Variable	mean	st. dev.	min.	max.
Price (Dfl.[b])	37168	14895	13950	121745
Age in months	30.8	10.5	2	48
Age in years[c]	1.90	0.828	0	3
# kilometers driven (x0.001)	49.6	30.0	1.5	207
100,000 kilometers or more	0.063			
Engine volume (liters)	1.88	0.259	1.6	2.8
Automatic transmission	0.104			
Cohort 1997	0.182			
Cohort 1998	0.293			
Cohort 1999	0.293			
Cohort 2000	0.114			
Cohort 1st quarter	0.429			
Cohort 2nd quarter	0.257			
Cohort 3rd quarter	0.199			
Cohort 4th quarter	0.115			
Nissan Primera	0.537			
Peugeot 406	0.332			
Audi A6	0.131			
New plate (cohort after May 1999)	0.167			

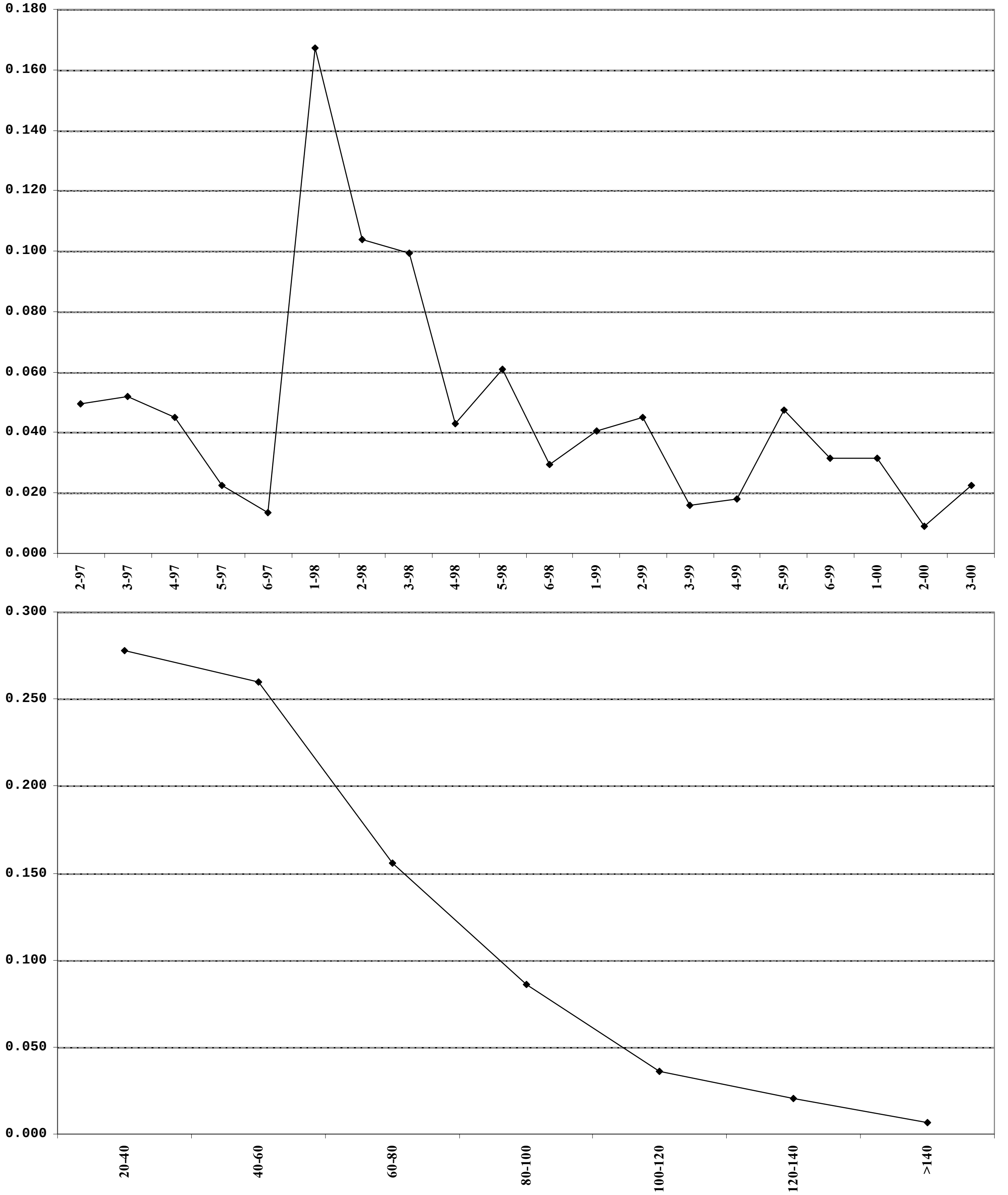
[a]Time of advertising: first two weeks of 2001; # of observations: 443.
[b]The value of the Dutch Guilder was approximately US$ 0.43 at the time of advertising.
[c]2000 minus cohort year.

Figure 3. Sample A, cohort and kilometer frequencies.



The top panel gives the frequencies of the different cohorts in sample A. Numbers on the horizontal axis denote trimesters. For example, 2-92 refers to the period May-August 1992. The bottom panel gives the frequencies of the different kilometer intervals in sample A.

Figure 4. Sample B, cohort and kilometer frequencies.



The top panel gives the frequencies of the different cohorts in sample B. Numbers on the horizontal axis denote two-month periods. For example, 2-92 refers to the period March-April 1992. The bottom panel gives the frequency of the different kilometer intervals in sample B.