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Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstr. 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
Hohenzollernstr. 1-3, 45128 Essen, Germany

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Alex Kihm and Colin Vance[1]

The Determinants of Equity Transmission Between the New and Used Car Markets – A Hedonic Analysis

Abstract

Drawing on a data set containing 371,082 observations on new and used cars from 2008, this study employs a hedonic model to estimate the determinants of prices in the primary and secondary car markets in Germany. We are specifically interested in identifying those vehicle attributes that are responsible for retaining the car's value in the used car market. Beyond parameterizing the influence of technical features and brand name on the retail price, our model simultaneously generates a corresponding set of parameter estimates for the used car price, thereby allowing us to formally compare their magnitudes across the two markets. This comparison reveals that fuel consumption, in particular, is an important determinant of the price, one whose impact is higher in magnitude in the used car market than in the new car market. Large heterogeneity in how cars hold their investment value is also seen to depend on body type and brand/model name.

JEL Classification: M31, R41

Keywords: retail prices; used car prices; hedonic model; Germany

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1 Alex Kihm, Deutsches Zentrum für Luft- und Raumfahrt, Berlin; Colin Vance, Jacobs University Bremen and RWI. – All correspondence to: Colin Vance, RWI, Hohenzollernstr. 1-3, 45128 Essen, Germany, e-mail: colin.vance@rwi-essen.de

Introduction

Europe's ongoing economic crisis has taken a heavy toll on the automobile industry. In the first half of 2013, the demand for new passenger cars in the European Union (EU) tumbled by 6.6% from a year earlier to 6.2 million new passenger vehicles (ACEA 2013). This drop marked the continuation of a downward trend that began in 2007, when annual sales peaked at nearly 16 million vehicles (Jolly 2013). With prospects for a quick recovery bleak, auto manufacturers are shifting attention to the second-hand market, using leasing options and fast track loans to attract buyers who could otherwise not afford the models on offer. This shift in marketing is particularly evident in Germany, where used car sales climbed by over 14% between 2009 and 2012, reaching a volume just over double that of new car sales (Kraftfahrt-Bundesamt 2013).

In this context, identifying the determinants of prices for new and used cars assumes increasing relevance, both from a business and from a policy perspective. For auto manufacturers, the effects of brand or model name and technical characteristics are especially important since the ability of brands to maintain their residual values in the second-hand market has an immediate bearing on the choices of car purchasers in the primary market. For policy makers, a key question regards the contribution of fuel economy to the car price given the European Union's current legislation mandating increased efficiency of new cars as a means to reduce CO_2 in the transport sector (Frondel et al. 2011). To the extent that car purchasers are turning increasingly to the secondary market, the effectiveness of this legislation, which does not apply to used cars, may be undermined.

Cross-cutting these issues is the more basic question of how equity is transmitted between the new and used car markets. In the case of the used car market, if fixed depreciation rates based only on age (and sometimes also mileage) are assumed, as in Feng, Fullerton, and Gan (2013) and many other similar models, this implies that the difference in resale values of two different cars of the same age and wear depends solely on the difference of their retail prices, an assumption that has largely escaped empirical scrutiny.

Indeed, despite the existence of a large body of literature addressing the determinants of car prices, little work has been done that simultaneously analyzes how price formation differs in the new and used car markets or how brand equity is carried over between them. The aim of the present paper is to address these issues by drawing on data from the German market in 2008 that includes the prices of both new and used cars as well as their key attributes, including age, mileage, and technical features. Specifically, we employ a hedonic price regression, which models products as multidimensional packages of characteristics based on observable market prices (Rosen 1974). The paper thereby builds on a long line of studies (e.g. Griliches 1971; Cowling & Cubbin 1972; Murray & Sarantis 1999) that have used the hedonic method to model car prices.

The majority of these studies focuses on prices in the new car market (e.g. Rosen 1974; Ohta & Griliches 1976; Uri 1988; Andersson 2005; Baltas & Saridakis 2010), with a smaller number addressing used cars (e.g. Goodman 1983; Matt et al. 2008). This paper couples these foci and pursues two primary aims: First, with reference to the new car market, we explore the extent to which our results are consistent with those of Baltas and Saridakis (2010) in their study of the Greek car market, focusing particularly on the influence of branding. Second, we expand the model to capture the determinants of price formation in the used car market. To this end, the model is specified to allow for differential effects of the vehicle attributes on price according to whether the car is new or used. We can thereby formally test the hypothesis that the consumer valuation of attributes such as fuel efficiency and brand is the same in the new and used car markets. Moreover, the model controls for the effect of the retail price when modeling the price of the vehicle in the second hand market. In doing so, we show that the explanatory variables can be interpreted in terms of their influence on maintaining the vehicle's value following its shift into the secondary market. Finally, by including dummies for sub-models in the specification, we test the hypothesis that consumers differentiate beyond the level of the car model.

The remainder of the paper is structured as follows. The next section presents the empirical methodology followed by a presentation of the data in the third section. The fourth section catalogues and interprets the results. The final section concludes.

Methodology

As summarized in the papers of Aaker (1996) and Keller and Lehmann (2014), the growing importance of branding as a management objective has encouraged the development of various techniques to measure brand equity. Aaker (1996) proposes a set of ten measures that can be referenced for tracking how a brand can be differentiated from its competitors, one of which is the price premium. Our empirical approach focuses on this measure and tracts closely along the lines of a recent paper by Baltas & Saridakis (2010) , who analyze the list pricing of new cars from the Greek market in a hedonic regression model that includes technical characteristics as well as dummy variables indicating each brand (we henceforth call this paper B&S to ease reading). The included dummies comprise both pure brand (e.g. "Mercedes") and model (e.g. "E-class") effects. So specified, the model allows for the estimation of the price premium of each brand, which, as Aaker (1996: 107) has noted, "may be the best single measure of brand equity available" given that virtually any determinant of brand equity is also a determinant of the price premium.

The results of B&S indicate a strong influence of model-wise brand equity on retail prices, a finding that they conclude should be further explored in a comparable analysis of the second-hand market. We take up this lead by estimating a model of a log-transformed price as the dependent variable and a virtually identical suite of untransformed explanatory variables as used by B&S: $\ln(p) = \sum_k \beta_k * x_k$ (see Ohta (1976) for details of this specification and Triplett (2004) for an excellent overview of the hedonic method more generally). This yields a simple log-linear hedonic pricing model, indicating the effects of the predictors on the relative resale price. Analogous to B&S, our predictors, x_i, include technical characteristics of the car as well as brand and model dummies.

The present analysis diverges from that of B&S by virtue of a dataset that includes observations on both new and used cars, thereby affording an opportunity to identify differences in the effects of the explanatory variables between the primary and secondary market. The data is stacked into two sets of observations, with one set corresponding to the new cars and the other to the used cars. The dependent variable, $\ln(p)$, consequently corresponds to either the retail price or the used car price depending on whether the observation is a new or used car. Both sets of data have the same variables measuring the technical attributes of the car, but the used car observations have three additional variables measuring the age of the car, its mileage, and its price as a new car. The values for these variables are set to zero for observations corresponding to the new cars by interacting them with a dummy variable, *Used*, which equals one if the observation corresponds to a used car and zero otherwise. We also interact this dummy with the technical attributes. From this data set, two principle models are specified, the first of which is:

$$\ln(p) = \beta_0 + \beta_{Used} * Used + \beta_{Age} * Age * Used + \beta_{Mileage} * Mileage * Used + \sum_k \beta_k * x_k + \sum_k \delta_k * x_k * Used \quad (1)$$

where x is a vector of variables comprising speed, engine capacity, horse power and fuel consumption. The coefficients generated from Model 1 are identical to those that would be generated were we to split the data and estimate two separate models on new and used car prices. The advantage of pooling is that we can readily conduct hypothesis tests of whether the technical attributes have the same impact across new- and used cars by testing for the statistical significance of the interaction effect δ_k. The null hypothesis is that there are no such differences, $H_o: \delta_k = 0$.

In a subsequent step, we split the data and estimate two separate models on new and used car prices, labeled as Model 1a and 1b, respectively. While these models are computationally equivalent to Model 1, estimating them separately facilitates comparison with the final model presented, Model 2. Like Model 1b, Model 2 is limited to the sample of used cars but is distinguished by the inclusion of the retail price (*Retail pr*) as a regressor:

$$\ln(p) = \beta_0 + \beta_{Retail\ pr} * Retail\ pr + \beta_{Age} * Age + \beta_{Mileage} * Mileage + \sum_k \beta_k * x_k \quad (2)$$

The inclusion of the retail price imparts an important distinction in the interpretation of the coefficients. If not included, as in Model 1b, the coefficient estimates indicate the direct value of the car's characteristics and brand assuming that these features have no bearing on the depreciation of the car. Conversely, if the retail price is included as a regressor, the coefficient estimates on the technical attributes instead indicate the extent to which these attributes maintain the value on the initial investment.

This distinction can be best understood in the following rearrangement of Equation (2):

$$\begin{aligned} &\ln(p) = \beta_{Retail\ pr} * \ln(Retail\ pr) + \boldsymbol{x}^{\boldsymbol{T}}\boldsymbol{\beta} \\ &\Leftrightarrow \ln(p) - \beta_{Retail\ pr} * \ln(Retail\ pr) = \boldsymbol{x}^{\boldsymbol{T}}\boldsymbol{\beta} \\ &\Leftrightarrow \ln\left(\frac{p}{Retail\ pr^{\beta_{Retail\ pr}}}\right) = \boldsymbol{x}^{\boldsymbol{T}}\boldsymbol{\beta} \\ &\Leftrightarrow \frac{p}{Retail\ pr^{\beta_{Retail\ pr}}} = \exp(\boldsymbol{x}^{\boldsymbol{T}}\boldsymbol{\beta}) \end{aligned} \quad (3)$$

where the vector $\boldsymbol{x}$ includes all the aforementioned explanatory variables except the retail price, $\boldsymbol{T}$ denotes the transpose of vector $\boldsymbol{x}$, and $\boldsymbol{\beta}$ is a parameter vector. The left hand side of equation (3), containing the ratio of the used car price to the retail price, can be interpreted as a measure of the used car's value retention. Alternatively put, the coefficients $\boldsymbol{\beta}$ can be interpreted as measuring the effect of the explanatory variables in maintaining the car's value in the used car market, with positive values indicating that the variable reduces depreciation and negative values indicating that the variable increases it.

Including the retail price as a regressor in Model 2 gives rise to the following null hypothesis: To the extent that the retail price incorporates all the facets of automobile quality, which is a basic premise of hedonic price analysis, its inclusion in a regression on the used car price should render the effects of the other technical attributes in the regression statistically insignificant. Was this not the case, it would suggest that the relative impact of the statistically significant attributes on the car's value changes when the car moves from the primary to the second-hand market.

Data

We gathered the data on new and used cars ("ADAC Autokosten") from the German automobile club ADAC for the year 2008. ADAC draws on data from the German automobile trust (DAT), a well-renowned source for used car market prices. These prices can be understood as the German equivalent to the widely referenced "Blue Book" or "Red Book" values, which have served as the basis for many analyses of the used car market in the US (Wykoff 1970; Wykoff 1973; Goodman 1983; Buehler 2010). A detailed explanation (ADAC Fahrzeugtechnik 2013) explains how these second-hand values are generated based on observed market prices, equipment levels and model generations.

To extract the data from the ADAC databank, we developed a script that browses by mouse 293 different car models in different body types, 8 age categories and 34 mileage categories and stored the information in a separate database. This resulted in a cross-sectional dataset that contains a total of 365,704 observations on used cars and 5,378 observations on new cars from 2008, yielding comprehensive and balanced coverage of each market. While this approach has some expenses in terms of time and programming effort, it is a promising source of large-scale and high-quality data at low monetary expenses, which are often burdensome in this field.

Table 1 presents the descriptive statistics of the variables used in the model. Note that unlike the data of B&S, no information about airbags, alloy wheels, air conditioning, ESP-TCS or leather interior was available. This omission is a potential source of bias and should be borne in mind when drawing comparisons. To gauge the implications, we explored capturing these features through segment dummies, but found this to have only negligible effects on the coefficients of interest. It is also noted that the inclusion of the retail price as a regressor in the model of the used car price (Model 2) is likely to pick up some of the influence of unobserved features. We therefore opted to exclude the dummies to maintain comparability with B&S, who also did not use such dummies.

Table 1: Descriptive statistics

Variable	Unit	Mean	Std. Dev.	Min	Max
Retail price	€	33,322	17,451	8,930	222,519
Resale price	€	16,228	9,476	535	144,609
Age	Years	2.57	1.24	0.00	5.00
Mileage	1000 km	69.09	43.87	0.00	157.50
Speed	km/h	199.67	29.34	132.00	329.00
Engine capacity	Liter	2.12	0.77	0.80	6.21
Horse power	HP	153.57	70.92	44.00	603.00
Fuel consumption	l/100km	7.34	1.95	3.30	16.50
Used car	yes/no	365,704 yes and 5,378 no (new)			
Brand/model	Dummies for all 293 car model names				

Results and discussion

Alongside the results from B&S for comparison, Table 2 presents the coefficient estimates from the model given by Equation 1. The p-values presented in the table are calculated from robust clustered standard errors, with the clusters defined by the car model. The associated estimates of the standard errors thereby account for both heteroskedasticity and non-independence of the error term. To assess whether high multicollinearity afflicts the estimates of the standard errors, we calculated the condition number, a diagnostic tool suggested by Belsley, Kuh, and Welsch (1980). This measure indicates how close a data matrix **X** is to being singular, whereby a higher value indicates a greater likelihood of multicollinearity problems. The calculated condition number here is 22.4, well below the threshold of 30 suggested by Belsley, Kuh, and Welsch (1980) to warrant concerns about multicollinearity.

Turning to the coefficient estimates presented in Table 2, we see that with the exception of speed, the new car coefficients on the technical attributes – engine capacity, horsepower, and fuel consumption – track closely in magnitude with those of B&S. That our estimate for speed, at 0.0007, is only about a third of the magnitude suggests that this feature is valued more highly in the Greek than in the German market, possibly reflecting the more limited heterogeneity of top speed among cars in Germany.

With respect to the question of value retention, the controls for the age and mileage of used cars in Model 1 both have the expected signs and are statistically significant. Each additional year decreases the price of the used car by 7.4%, while each 1,000 kilometers driven decreases its price by 0.3%. The used car dummy indicates that used cars are, on average 7.3% ($e^{-0.0762}$-1), cheaper than new cars. Nevertheless, this attribute does not significantly alter the effect of most of the technical attributes in the model. Specifically, the effects of speed, engine capacity and horsepower on the car price are roughly the same in the secondary and primary markets, as is evidenced by the small magnitudes and statistical insignificance of the interaction effects. The one discrepancy is seen for the variable fuel consumption. While the coefficient on this variable for the case of new cars is similar to B&S, the estimate of the interaction effect indicates a stronger effect of fuel consumption on the used car price. Specifically, the estimates suggest that a unit increase in fuel consumption reduces the used car price by about 6%, compared with a reduction of 2.3% in the new car market. Indeed, this is the only coefficient in Model 1 whose magnitude varies significantly between the new and used car markets, suggesting that the relative willingness to pay for fuel efficiency is higher in the secondary car market than in the primary market.

Table 2: Determinants of logged prices for new and used cars

	B&S	Model 1
Used		-0.0762
		(0.044)
Used*Age		-0.0744
		(0.000)
Used*Mileage		-0.0031
		(0.000)
Speed	0.003	0.0007
	(0.000)	(0.025)
Used*Speed		-0.00002
		(0.926)
Engine capacity	0.081	0.0500
	(0.000)	(0.000)
Used*Engine capacity		0.0090
		(0.100)
Horse power	0.002	0.0024
	(0.000)	(0.000)
Used*Horse power		0.0001
		(0.150)
Fuel consumption	-0.018	-0.0232
	(0.000)	(0.000)
Used*Fuel consumption		-0.0381
		(0.000)
Constant	8.990	9.6855
	(n/a)	(0.000)
R^2	0.99	0.94
Number of observations	921	371082

P-values in parentheses. Car model dummies are included, but not reported.

Having examined how the effects of technical attributes on price formation vary between the primary and secondary car markets, we now focus on the latter market, and specifically on the question of the extent to which these attributes bear on the value retention of the car. To this end, Table 3 presents three hedonic regressions of the car price. The first two columns present estimates from separating the data by new and used cars, thereby replicating the estimates produced from Model 1 using the interaction terms. The final model in Table 3, Model 2, is limited to used cars and distinguished by the inclusion of the logged retail price as a control variable. In interpreting the magnitude of this estimate, a useful reference point is a coefficient one, which would be indicative of a proportional transfer in value from the primary to the secondary car market. The obtained estimate is around 1.199, which a t-test (not presented) reveals to be significantly higher than one. This suggests that increases in the retail price disproportionately increase the residual value: a 10% higher retail price, for example, leads to a roughly 12% higher used car resale price. One possible explanation is that better-equipped cars keep more of their value (for example, air conditioning can be a must-have feature to maintain high residual values).

Table 3: Implications of controlling for the retail price on the used car price

	Models 1a and 1b		Model 2
	New cars	Used cars	Used cars
Ln(Retail price)			1.1990
			(0.000)
Mileage		-0.0031	-0.0031
		(0.000)	(0.000)
Age		-0.0744	-0.0744
		(0.000)	(0.000)
Speed	0.0007	0.0007	0.0002
	(0.029)	(0.127)	(0.390)
Engine capacity	0.0500	0.0590	-0.0009
	(0.000)	(0.000)	(0.855)
Horse power	0.0024	0.0025	-0.0003
	(0.000)	(0.000)	(0.003)
Fuel consumption	-0.0232	-0.0613	-0.0335
	(0.000)	(0.000)	(0.000)
Constant	9.6855	9.6093	-2.0036
	(0.000)	(0.000)	(0.000)
R^2	0.96	0.94	0.97
Number of observations	5378	365704	365704

P-values in parentheses. Car model dummies are presented below (Table 3A).

Beyond slightly improving the explained variance of the model, with an R^2 reaching 0.97, the inclusion of the retail price in Model 2 confirms the hypothesis that some, though not all, of the technical attributes are rendered statistically insignificant. The estimates for speed and engine capacity, for example, are statistically indistinguishable from zero, and the estimate for horse power, which has an unexpected negative sign and is statistically significant, has a magnitude very close to zero. The only coefficient to retain a sizeable magnitude is fuel consumption, albeit reduced by almost half relative to Model 1b. Specifically, evaluated at the means of the sample, the estimates from Model 1a and 1b suggest that the hedonic price of one liter less of fuel consumption per 100km is approximately 579 € for new cars and 813 € for used ones (calculated from the difference in predictions between a car with the mean values from Table 1 and a car with one liter less of fuel consumption). When controlling for the retail price in Model 2, the value ascribed to saving a liter of fuel consumption per 100km is still around 623 €, underlining the high valuation of this attribute in the used car market.

One way to further assess the value of fuel efficiency is to calculate the break-even distance after which the investment in efficiency is paid off. This calculation has the advantage of being invariant to exchange rates and inflation, and thus can be compared with other results in the literature irrespective of time or place and even of the change in efficiency. At a current fuel price of about 1.30 €/liter, the break-even distance for one liter less fuel consumption per 100 km is 62,540 km (=(813 €/1.30 €)*100) for an investment of 813 € and 47,956 km for an investment of 623 €. These values appear quite realistic; most used car buyers can be expected to drive their cars beyond that point. For comparison, Goodman (1983) estimated a willingness-to-pay of 325 $\$_{1983}$ for improving efficiency from 15.6 to 20 MPG. The resulting break-even distance of 61,800 km at 0.60 $\$_{1983}$/gal (=[325/((.6/15.6)-(.6/20))]*1.609) falls within the range of that estimated in the present study.

Table 3A is a continuation of Table 3 and presents the retail prices and coefficient estimates for those cars present in both B&S and our data, with the Volkswagen Golf as the reference category. Although our specification differentiates not only the official model names (like BMW 5) but also their sub-models, a comparison between the coefficient estimates for the new car markets with those of B&S shows a tight correspondence. With few exceptions, the coefficients have the same sign and are of a similar magnitude. Furthermore, the price premium for each model is similar between the new and the used car markets when not controlling for the retail price: The mean absolute difference in the premium is about 16 percentage points.

The inclusion of the retail price in Model 2 completely alters this pattern, increasing the equity of some car models relative to Model 1 and decreasing it for others. The mean absolute difference in the price premium between Model 1 and 2 jumps to about 44 percentage points. This "value conservation" perspective reveals the fact that the investment in some cars depreciates more than in others. Intuitively, one would expect the value conservation to be weaker for luxury cars, for which the market is generally smaller while the total investment sums are very high. Two car models that confirm this expectation are the BMW 6 Cabrio and the Mercedes CL Coupe, whose coefficients decrease by over 100% when controlling for the retail price.

Not all luxury cars, however, display this pattern. For example, the difference between Mercedes S and VW Phaeton, which are both from the same luxury segment, underlines the dependency of value conservation on a more general brand image within the segment. Both show new-car coefficients of about 0.8, but their used car coefficients in Model 1b differ. While the VW Phaeton drops to 0.6, the Mercedes S is seen to hold its value as a used car with a coefficient that remains at about 0.8. This is also reflected in the value conservation perspective in Model 2: the Mercedes S maintains a much higher coefficient than the VW Phaeton, though both lose value relative to the Volkswagen Golf. That said, some very expensive luxury cars like the Mercedes G SUV actually obtain a positive coefficient relative to the Golf despite controlling for their high retail price. These patterns highlight that blanket statements concerning the consumer valuation of particular brands and segments are unwarranted.

The same observation applies to sub-models (body types). The coefficient differences between multiple body types of the same car model support the hypothesis that the consumer distinguishes the valuation of used cars not only by technical attributes and models, but even further between the different sub-models. As B&S state, the aim of sub-branding – even in the third order presented here – is to target different segments of customers. One can easily imagine the different needs of people buying a sedan compared to those buying a convertible of the same car model. In this regard, an interesting pattern is revealed by the coefficient differences between sedan and estate body types on the used car market, which are larger than for the new car versions of these body types. For example, a new Mercedes C estate is (ceteris paribus) 46% ($e^{0.377} - 1$) more expensive than the reference VW Golf, while the corresponding new sedan shows a price premium of 38% ($e^{0.323} - 1$), resulting in an 8 percentage point difference between sedan and estate. This difference for the respective used cars increases to 12 percentage points ($e^{0.521} - e^{0.449}$). The used estate versions of BMW 3 and 5, Mercedes C and E, Peugeot 407, Toyota Avensis and VW Passat all show a higher difference in terms of price premium to their sedan counterparts than on the new car market. In fact, almost all estates outperform the respective sedans in maintaining their value (except BMW 3, where the difference is close to zero). We can conclude that used car buyers apparently value estates more than new car buyers do, suggesting a difference between the two types of customers.

Table 3A: Illustrative model effects (relative to VW Golf hatch)

Brand/Model		Body Type	Retail Price	B&S	Model 1a (new)	Model 1b (used)	Model 2 (used)
BMW	1	Hatch	29250	0.132	0.054	0.050	-0.014
		Cabrio	37025	(all)	0.250	0.320	0.020
		Coupé	35300		0.113	0.129	*-0.006*
	3	Sedan	42969	0.293	0.237	0.257	-0.028
		Cabrio	52579	(all)	0.451	0.553	*0.012*
		Coupé	43914		0.297	0.357	*0.001*
		Estate	41036		0.265	0.288	-0.030
	5	Sedan	53563	0.491	0.474	0.450	-0.119
		Estate	54651	(all)	0.530	0.554	-0.081
	6	Coupé	82183	0.764	0.657	0.719	-0.069
		Cabrio	90283	(all)	0.765	0.899	*-0.019*
	7	Sedan	85050	0.804	0.743	0.686	-0.204
	X3	SUV	46562	0.526	0.450	0.614	0.074
	X5	SUV	59850	0.757	0.521	0.732	0.108
	Z4	Coupé	46033	0.359	0.280	0.399	0.063
		Cabrio	40518	(all)	0.304	0.462	0.098
	Mean		52548	0.516	0.399	0.467	-0.012
	Standard deviation		18295	0.246	0.210	0.232	0.081
Citroen	Berlingo	Minivan	15475	-0.023	-0.248	-0.401	-0.104
	C1	Hatch	12116	-0.547	-0.502	-0.864	-0.263
	C2	Hatch	15669	-0.327	-0.284	-0.569	-0.229
	C3	Hatch	17968	-0.292	-0.150	-0.453	-0.274
		Cabrio	22390	-0.051	0.077	-0.112	-0.205
	C4	Hatch	23605	-0.177	0.013	-0.196	-0.212
		Coupé	22789	(all)	-0.012	-0.224	-0.209
		Minivan	28605	0.061	0.210	0.189	-0.063
	C8	Maxivan	35802	0.365	0.384	0.314	-0.147
	Mean		21602	-0.124	-0.057	-0.257	-0.189
	Standard deviation		7354	0.278	0.271	0.367	0.071
Kia	Magentis	Sedan	26266	-0.093	0.059	-0.085	-0.156
	Sorento	SUV	40990	0.317	0.299	0.372	*0.013*
	Sportage	SUV	25703	0.203	0.065	0.056	-0.022
	Mean		30986	0.142	0.141	0.115	-0.055
	Standard deviation		8668	0.212	0.137	0.234	0.089
Lada	1117	Estate	9230	-0.736	-0.781	-1.376	-0.440
	1118	Sedan	8930	(all)	-0.814	-1.517	-0.542
	1119	Hatch	8930		-0.814	-1.482	-0.506
	2111	Estate	10890		-0.637	-1.301	-0.536
	4x4	SUV	12367	-0.167	-0.417	-0.777	-0.276
	Mean		10069	-0.452	-0.693	-1.290	-0.460
	Standard deviation		1521	0.402	0.170	0.300	0.111

Table 3A (continued): Illustrative model effects

Brand/Model		Body Type	Retail Price	B&S	Model 1a (new)	Model 1b (used)	Model 2 (used)
Mercedes	A	Hatch	25390	0.207	0.096	0.080	-0.034
	B	Minivan	28581	0.299	0.196	0.222	-0.013
	C	Sedan	39639	0.371	0.323	0.449	0.062
		Estate	41407	(all)	0.377	0.521	0.070
	CLC	Coupé	33382		0.209	0.302	0.052
	CL	Coupé	152225	0.891	0.928	1.004	-0.109
	CLK	Coupé	49216	0.540	0.422	0.546	0.040
		Cabrio	56290	(all)	0.514	0.700	0.084
	CLS	Sedan	72804	0.537	0.562	0.699	*0.026*
	E	Sedan	50842	0.501	0.485	0.514	-0.068
		Estate	53034		0.553	0.620	-0.044
	G	SUV	88862	1.162	0.896	1.191	0.116
		Cabrio	75494	(all)	0.999	1.229	*0.032*
	GL	SUV	82143	0.771	0.789	1.054	0.109
	ML	SUV	68186	0.592	0.570	0.835	0.152
	R	Maxivan	55809	0.618	0.540	0.632	*-0.015*
	S	Sedan	101139	0.807	0.828	0.828	-0.165
	SL	Cabrio	132476	0.912	0.895	0.987	-0.086
	SLK	Cabrio	47628	0.409	0.344	0.486	0.073
	Mean		66029	0.616	0.554	0.679	0.015
	Standard deviation		33864	0.266	0.270	0.319	0.084
Peugeot	1007	Hatch	18067	-0.229	-0.160	-0.339	-0.147
	107	Hatch	11508	-0.522	-0.551	-0.798	-0.137
	206	Hatch	14325	-0.283	-0.353	-0.505	-0.082
	207	Hatch	18300	-0.266	-0.216	-0.306	-0.047
		Cabrio	24211	(all)	0.043	0.093	0.042
		Estate	19234		-0.144	-0.188	-0.015
	407	Sedan	29683	0.074	0.174	0.137	-0.072
		Coupé	35979	(all)	0.303	0.325	-0.038
		Estate	31594		0.233	0.243	-0.037
	607	Sedan	41479	0.284	0.423	0.301	-0.205
	807	Maxivan	35690	0.405	0.383	0.375	-0.084
	Mean		25461	-0.077	0.012	-0.060	-0.075
	Standard deviation		9961	0.338	0.320	0.390	0.069
Skoda	Fabia	Hatch	16806	-0.234	-0.236	-0.420	-0.137
		Estate	16591	(all)	-0.228	-0.348	-0.074
	Superb	Estate	30342	0.111	0.189	0.219	*-0.007*
	Mean		21246	-0.061	-0.092	-0.183	-0.073
	Standard deviation		7877	0.244	0.243	0.350	0.065

Table 3A (continued): Illustrative model effects

Brand/Model		Body Type	Retail Price	B&S	Model 1a (new)	Model 1b (used)	Model 2 (used)
Toyota	Avensis	Sedan	28860	-0.035	0.172	0.165	-0.041
		Estate	29610	(all)	0.200	0.236	*-0.003*
	Aygo	Hatch	12115	-0.542	-0.502	-0.752	-0.150
	Corolla	Hatch	27305	-0.060	0.134	0.115	-0.045
	Land Cruiser	SUV	48055	0.680	0.601	0.729	*0.009*
	Land Cruiser V8	SUV	78767	1.046	0.809	1.044	0.074
	RAV4	SUV	32000	0.420	0.272	0.317	*-0.009*
	Yaris	Hatch	17298	-0.253	-0.202	-0.355	-0.113
	Mean		34251	0.179	0.185	0.187	-0.035
	Standard deviation		20886	0.558	0.413	0.564	0.071
VW	Beetle	Hatch	23067	0.198	0.055	0.020	-0.046
	Eos	Cabrio	34895	0.137	0.275	0.320	*-0.010*
	Fox	Hatch	11927	-0.368	-0.504	-0.629	-0.025
	Golf	Hatch	23634	Base=0	Base=0	Base=0	Base=0
		Estate	24825	(all)	0.081	0.083	-0.014
	Golf Plus	Minivan	25170		0.070	0.046	-0.038
	Jetta	Sedan	25965	-0.006	0.083	0.017	-0.082
	Passat	Sedan	31091	0.076	0.211	0.184	-0.068
		Estate	32415	(all)	0.249	0.288	*-0.011*
	Phaeton	Sedan	90794	0.656	0.840	0.609	-0.398
	Polo	Hatch	17644	-0.263	-0.200	-0.357	-0.117
	Sharan	Maxivan	36138	0.303	0.417	0.363	-0.137
	Touareg	SUV	62959	0.671	0.584	0.779	0.079
	Touran	Minivan	28986	0.104	0.210	0.245	-0.008
	Mean		33536	0.137	0.169	0.141	-0.062
	Standard deviation		20212	0.337	0.323	0.356	0.111

All coefficient estimates are statistically significant at the 5% level or below unless highlighted in italic and grey.

Conclusion

The purchase of a new car is among the largest expenditures incurred by a typical household. To the extent that the return on this investment, partly reflected in the resale value, is an important criterion in choosing a car, private car buyers as well as fleet managers have an interest in identifying those attributes that maintain the car's value across the primary and secondary markets. This paper has attempted to shed light on this issue by employing a hedonic model to estimate the determinants of car prices in Germany. We drew on a large-scale data set comprised of 371,082 observations on both new and used cars from 2008. Exploiting this data structure, we specified the econometric model to allow for testing the equivalence in the effect of the technical attributes of the cars in the primary and secondary markets. We additionally explored the consequences of including a control for the retail price on the estimates of the technical attributes of used cars, testing the null hypothesis that these coefficients are all zero given that the price incorporates all the salient features of car quality. Finally, the estimated model included dummies for 293 car sub-models to test for the existence of model-name premia.

There are four main findings:

1. The impacts of technical features on the car price do not vary substantially between the primary and the secondary car markets, conditional on the retail price not being included as a control variable. The one exception is the coefficient on fuel consumption. This variable is higher in magnitude in the secondary market than in the primary market. We conclude that second-hand buyers place more importance on low fuel consumption than new car buyers.
2. When the retail price is included in the model, the effects of the technical attributes on the used car price are substantially reduced, in most cases approaching zero and/or statistical insignificance, suggesting they have no bearing on the value retention of the car. Again, the central exception is fuel consumption, whose impact continues to be higher in the secondary than in the primary market. Also, the brand equity coefficients reveal a large heterogeneity in value retention between different brand and model names. Differences in resale values of two cars of the same age and mileage thus do not solely depend on the difference in their retail prices; fuel consumption, brand name, and model name also matter.
3. The retail price itself has a coefficient of around 1.2, suggesting that on average a 10% increase in the retail price yields a disproportionate 12% increase in the used car price.
4. Across both the new and used car markets, brand equity is not only reflected on the car model level, but even further by the body type sub-versions of that model.

Taken together, these findings point to the importance of a careful and detailed formulation of car depreciation. From a marketing perspective, we confirm the evidence presented by (Baltas & Saridakis 2010) in support of brand-name premia that derive from model brand equity in the new car market, and additionally show this effect to hold for the secondary market. Our results additionally suggest that fleet managers not underestimate the strong effect of fuel consumption on the resale price of their cars at the end of the first holding period. This effect is stronger in the used car market than in the one for new cars. Hence, fuel efficiency is not perfectly reflected in the retail price and a new car buyer can gain resale value by choosing a more efficient model.

From a policy perspective, the high and significant effect of fuel consumption should provide some reassurance to policy makers concerned with climate protection in the transport sector. Specifically, our results indicate that consumers place a high value on this feature even in the secondary market, which is out of reach of the strict efficiency improvements enacted in 2009 that target the new car market.

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