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THE EFFECT OF MARKETING SPENDING ON
SALES IN THE PREMIUM CAR SEGMENT:
NEW EVIDENCE FROM GERMANY

JESUS CRESPO CUARESMA AND MATTHIAS STOECKL

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ECONOMICS AND FINANCE

The Effect of Marketing Spending on Sales in the Premium Car Segment: New Evidence from Germany

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Abstract

This paper assesses empirically the relationship between marketing expenditures and sales in the premium car segment in Germany. We employ a new data-set which contains model-specific data on sales (i.e. registrations), restyling activities and marketing expenditures at a monthly basis for the years 1998 to 2007. The richness of our data in the time dimension allows for a systematic modeling of product life cycle effects which have been partly ignored in the existing empirical literature. We find a robust positive marketing-sales relationship, even after common characteristics of the product life cycle have been taken into account. Furthermore, our results indicate that the launching of a new model, face lifts and customized packages appear to exert a positive and sizeable effect on sales in the German premium car segment.

Keywords: Marketing expenditure; panel data models; automobile industry; premium car segment; automotive restyling

JEL codes: D43, M31, M37

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1 Introduction

After several decades of research in marketing dynamics, the impact of marketing efforts on performance metrics such as revenues (e.g. Srinivasan, Pauwels, Hanssens and Dekimpe 2004), sales (e.g. Dekimpe and Hanssens 1995; Lee, Shin and Chung 1996; Duffy 1999; Elliott 2001; Yiannaka, Giannakas and Tran 2002; Ouyang, Zhou and Zhou 2002; Zhou, Zhou and Ouyang 2003), profits (e.g. Abraham and Lodish 1990; Graham and Frankenberger 2000; Notta and Oustapassidis 2001), or firm value (Green, Stark and Thomas 1996; Srivastava, Tasadduq and Fahey 1998; Core, Guay and Buskirk 2003; Han and Manry 2004; Pauwels, Silva-Risso, Srinivasan and Hanssens 2004; Singh, Faircloth and Nejadmalayeri 2005, among others) still remains ambiguous (Bagwell 2007 and Shah and Akbar 2008 provide recent reviews). In this context, Shah and Akbar (2008), for instance, argue that "*[t]he studies of advertising and sales are often questionable on the grounds of ignoring the simultaneous bias problem, and the autocorrelation issues, typical of lagged models used in estimating the intangible advertising asset. One of the most common problems in implementing lagged models is the lack of advertising data availability. There are also problems related to the auto-correlation in successive observations*" (Shah and Akbar, 2008, p. 305).

This paper engages with this debate by analyzing the relationship between marketing expenditures and sales in the German premium automobile market. The automobile industry is well suited to conduct such an analysis for several reasons. Besides visibility and macroeconomic importance (see e.g. the figures reported in Tardiff 1998 and Pauwels et al. 2004 for the US market), it is further characterized by a high degree of product innovations and advertising intensity (Menge 1962, Sherman and Hoffer 1971, White 2001). New products and marketing actions are perceived as crucial in generating future profitability (Cooper 1984, Chaney, Devinney and Winer 1991), rising revenues (Nijs, Dekimpe, Steenkamp and Hanssens 2001) and are seen as drivers of firm growth (Cohen, Eliashberg and Ho 1997), although failure rates are rather high (McMath and Forbes 1998) and marketing efforts are found to rarely have persistent positive effects on sales figures (Dekimpe, Hanssens and Silva-Risso 1999, Srinivasan, Leszczyc and Bass 2000, Pauwels, Hanssens and Siddarth 2002, Pauwels et al. 2004).

This article expands the existing literature in several ways. First, we employ a new unique panel data-set which comprises detailed information on sales (i.e. registrations) and advertising expenditures for the premium car segment in Germany in order to identify the advertising-sales relationship. In particular, this data-set contains model-specific monthly sales and marketing data for 30 car models of the four dominant premium car producers in Germany (Audi, BMW, Mercedes and Porsche) covering a ten year period at a monthly frequency (January 1998 - December 2007).¹ To the best of our knowledge, this data-set is the most comprehensive one

¹These four premium car producers control a cumulative market share of around 90 percent over the sample period. Section 2 presents a detailed description of the data-set.

used hitherto for analyzing the impact of marketing on sales in this important subdivision of the automobile industry.

The richness of the data-set enables us to employ panel data methods to quantify the sales-marketing relationship and identify short and long-run effects of marketing on performance (see, e.g., Pauwels, Currim, Dekimpe, Hanssens, Mizik and Naik 2004 and Leeflang, Bijmolt, van Doorn, Hanssens, van Heerde, Verhoef and Wieringa 2009 and the references therein). In addition, the large time dimension of the data-set allows us to efficiently assess potential problems arising from endogeneity (simultaneity bias between sales and advertising) and auto-correlation which have often been discussed in the previous literature (Willis and Rogers 1998, Shugan 2004, Chenhall and Moers 2007). Finally, the structure of the data permits to depict product life cycle dynamics and to include marketing action of competing firms (Naik, Prasad and Sethi 2008) in the econometric specification.

In order to estimate the effect of marketing measures more precisely, we enrich our data by including information on restyling activities which are introduced during the product life cycle of a car.² The aim of such product improvements is to strengthen sales, thereby decelerating the downswing of sales during the saturation phase of the product life cycle. We therefore extend the basic advertising-sales model by explicitly controlling for these activities.³ This approach facilitates the identification of the marketing-sales conjunction, since such restyling activities usually coincide with marketing campaigns (Dekimpe and Hanssens 1999, Pauwels 2004).

In line with previous research, we report a positive marketing-sales relation even after including an error term structure including model-fixed and time-fixed effects, as well as product life cycle specific trends. Furthermore, restyling activities (i.e. the introduction of a new model, face lifts and customized packages) exert a positive and sizeable impact on sales compared to marketing expenditures. Finally, we observe a high degree of persistence in monthly sales figures over time whereof a substantial part can be explained by product life cycle dynamics.

The remainder of the paper is organized as follows. Section 2 describes the data and presents some descriptive statistics. Section 3 describes the pattern of restyling activities and the development of sales over the product life-cycle of a model. Section 4 introduces the econometric specification and discusses the empirical results. Section 5 concludes and provides suggestions for future research.

²Such activities include styling as well as technological changes. Section 3 describes these changes in more detail.

³Sherman and Hoffer (1971), Hoffer and Reilly (1984), Millner and Hoffer (1993) and Kwoka (1993, 1996), have studied the impact of restyling activities on sales. Although they unanimously report the expected positive effect of automotive restyling on sales, their result should be interpreted with caution for several reasons. They exclusively rely on aggregated data for the US car market (i.e. quarterly or annual sales and advertising data). Consequently, they have only a few observations for each model and, therefore, small sample sizes. Furthermore, they neglect endogeneity and auto-correlation.

2 Marketing and sales in the German premium car segment

We rely on a data-set which contains model specific sales (i.e. registrations) and advertising data for the German premium car segment to empirically quantify the advertising-sales relationship.⁴ The basic sample comprises advertising expenditures⁵ and the number of cars registered (which is our available proxy for cars sold) for 30 car models manufactured by Audi, BMW, Mercedes and Porsche. Additionally, we enrich our basic data-set by including information on product improvements and restyling activities.⁶ Specifically, we focus on the five most important make-overs including the market introduction of a model, face lifts of existing models, the introduction of new engines, customized packages and editions. In short, make-overs differ with respect to volume and affected parts.⁷ All data are available at a monthly frequency. The final sample encompasses a ten-year period ranging from January 1998 to December 2007, leaving us with a possible maximum of 120 observations per model.⁸

Table 1 reports the summary statistics of our data-set in terms of sample composition. Column 1 and 2 contain the company and the name of the corresponding model. If several types of one model exist (e.g. BMW 3 Estate and BMW 3 Sedan), we treat these types as separate models (see column 3).⁹ This distinction is of importance as, e.g., estate and sedan versions typically follow a temporally-shifted product life cycle. For instance, the latest version of the Mercedes C-Class sedan has been introduced in June 2000, whereas the estate version was not available in stores until January 2001.¹⁰ Furthermore, the shift of product life cycles causes marketing activities and product improvements to temporally differ substantially between all available versions of one model. This observation supports the separation of different versions (e.g. sedan/estate and coupe/convertible) and also supports the assumption that these versions are treated as separate models by the car manufacturers.

⁴For a detailed description of the difference between premium and volume car producers see, e.g., Allsopp (2005) and Parment (2008).

⁵Advertising expenses include all financial expenditures for television, print media, Internet, radio, cinema, mailings and advertising campaigns for one specific model. This variable does not encompass general advertising expenses (e.g. television campaign to improve the image of the entire company).

⁶We do so by "flagging" (i.e. constructing a [0/1] variable which indicates the date of the corresponding product measure with a value of 1) the month when the respective product measure was introduced.

⁷In section 3 we elaborate on the characteristics of a typical product life cycle focusing on one specific car model. In this context, we also discuss the product improvements mentioned above and their magnitude in more detail.

⁸Furthermore, we enrich the data-set with information on model-specific physical characteristics, like horse power, price for the basic version of a model, average consumption per hundred kilometers and maximum speed. As this data only plays a minor role in the robustness section, we refer the reader to section 4 for further details.

⁹Usually, marketing campaigns either focus on the image of the whole company or on one specific model. Accordingly, if a marketing campaign for a model does not promote a specific version of it, we allocate marketing expenditures on a pro-rata basis on all existing versions.

¹⁰On average, the market introduction for estate versions lies one year ahead.

Table 1: Sample Composition

Company	Model	Type	Class	Start	End	no. MI	Obs.
Audi	A2		Compact	May 00	May 05	1	61
Audi	A3		Compact	Jan 98	Dec 07	2	120
Audi	A4	Estate	Middle Class	Jan 98	Dec 07	2	120
Audi	A4	Sedan	Middle Class	Jan 98	Dec 07	3	120
Audi	A6	Estate	Upper M. Class	Jan 98	Dec 07	2	120
Audi	A6	Sedan	Upper M. Class	Jan 98	Dec 07	2	120
Audi	A8		Luxury	Jan 98	Dec 07	2	120
BMW	1		Compact	May 04	Dec 07	1	44
BMW	3	Coupe	Middle Class	Jan 98	Dec 07	2	120
BMW	3	Sedan	Middle Class	Jan 98	Dec 07	2	120
BMW	3	Estate	Middle Class	Jan 98	Dec 07	2	120
BMW	5	Sedan	Upper M. Class	Jan 98	Dec 07	2	120
BMW	5	Estate	Upper M. Class	Jan 98	Dec 07	2	120
BMW	6	Convertible	Upper M. Class	Dec 03	Dec 07	1	49
BMW	6	Coupe	Upper M. Class	Sep 03	Dec 07	1	52
BMW	7		Luxury	Jan 98	Dec 07	2	120
BMW	X3		Middle Class	Nov 03	Dec 07	1	50
BMW	X5		Upper M. Class	Apr 00	Dec 07	2	93
BMW	Z3		Middle Class	Jan 98	Dec 02	1	60
BMW	Z4	Coupe	Middle Class	Mar 06	Dec 07	1	22
BMW	Z4	Roadster	Middle Class	Jan 03	Dec 07	1	60
Mercedes	A Class		Compact	Jan 98	Dec 07	2	120
Mercedes	B Class		Compact	Mar 05	Dec 07	1	34
Mercedes	C Class	Estate	Middle Class	Jan 98	Dec 07	2	120
Mercedes	C Class	Sedan	Middle Class	Jan 98	Dec 07	2	120
Mercedes	E Class	Estate	Upper M. Class	Jan 98	Dec 07	2	120
Mercedes	E Class	Sedan	Upper M. Class	Jan 98	Dec 07	2	120
Mercedes	S Class		Luxury	Jan 98	Dec 07	2	120
Porsche	911	Convertible	Luxury	Jan 98	Jan 06	1	97
Porsche	911	Coupe	Luxury	Jan 98	Jun 07	2	114

Notes: "MI" denotes market introduction. Sample size $n = 2,896$

We assign each model into one of four size classes (compact, middle, upper middle and luxury class, see column 4) relying on the classification made available by the companies themselves. However, by grouping all models according to important size-related characteristics like price, horse power and average consumption we arrive at virtually the same classification of models.¹¹ This supports the conclusion that the members of the self-declared size classes are indeed very homogeneous within each one of the groups.¹²

The remaining columns in Table 1 provide selected information about the sample coverage of each model in our data-set. Column 5 and 6 contain the date (month) of the first and the last observation, respectively (i.e. there are no missing sales and advertising data during this

¹¹Table A.1 in the appendix displays summary statistics concerning some important car characteristics (e.g. average consumption per 100 km, maximum speed and the like) and the number of observations for each size class.

¹²In a robustness test (not reported in the paper), we include class fixed effects based on this classification and model specific characteristics as displayed in Table A.1 in the appendix in our econometric specification. The results are qualitatively and quantitatively comparable to the ones reported and are available from the authors upon request.

time span). We observe full coverage for the entire sample period (implying that the number of observations equals 120) for 18 out of 30 models.¹³ Thus, the structure of our data-set is best described as an unbalanced panel data-set.

Next, we take a closer look at the 12 car models for which we do not have full sample coverage. This will bring some first fruitful insights in the product life cycle of premium cars. Models with initial observations after January 1998 usually do not have a direct or comparable predecessor. We classify these models as newcomers. The date of the first observation then indicates the beginning of the first product life cycle (PLC; i.e. market introduction).¹⁴ This group consists of nine models and only the BMW X5 has a direct successor in our sample period.¹⁵ In addition, our data-set encompasses four models with the last observation available before December 2007. This concerns cars produced by Audi, BMW and Porsche. Let us illustrate the underlying patterns in more detail. First, the Audi A2 suffered from very low sales figures and, therefore, production was stopped. Since Audi does not plan a direct successor for the A2, the A3 will remain the only Audi model in the compact class.¹⁶ The BMW Z3 has been replaced by its successor, the BMW Z4. We classify these two cars as separate models due to significant differences in several important aspects. Size and power are among the most decisive ones. This diversification is supported by the relabeling implemented by BMW (from Z3 to Z4). Third, for the two Porsche models (911 Convertible and Coupe) we simply have no advertising data beyond the reported end dates.

Column 7 of Table 1 displays the number of market introductions for each model during our sample period.¹⁷ In the empirical analysis below, we refer to a product life cycle as the time period between two market introductions. On average, a product life cycle lasts between six and eight years depending on the sales record of a model. This is in line with stylized facts known from the car industry. Therefore, we expect to observe, on average, two market launches for each model in our sample period. Indeed, this is the case for 19 cars. With three market introductions, Audi's A4 lies in the upper bound of this scale.

For the results of our empirical analysis to allow for valid statements about the impact of advertising on sales in the premium car market, our sample would have to cover a significant share of the respective market. In this context, the cumulative market share, which is covered by the four premium car producers in our sample, serves as the main variable of interest. Figure 1 displays the development of market shares for the entire premium car segment for the years

¹³Column 8 provides the corresponding number of observations for each model used in the empirical section. In total, our sample consists of 2,896 model-month observations.

¹⁴Since the dependent variable in our specification represents the number of registrations, the starting date indicates the date when the first units were sold. This usually does not directly coincide with the official market introduction (i.e. the date the company announces the market launch). However, these two dates do not tend to exhibit big differences.

¹⁵The new BMW X5 was launched in Germany in January 2007.

¹⁶In the autumn of 2010, Audi launched a new compact class model introducing the new Audi A1.

¹⁷In section 3 we elaborate on the characteristics of a market introduction.

2000 to 2008.¹⁸ Apart from Audi, BMW, Mercedes and Porsche, we display the cumulative market share of all other premium car producers.¹⁹

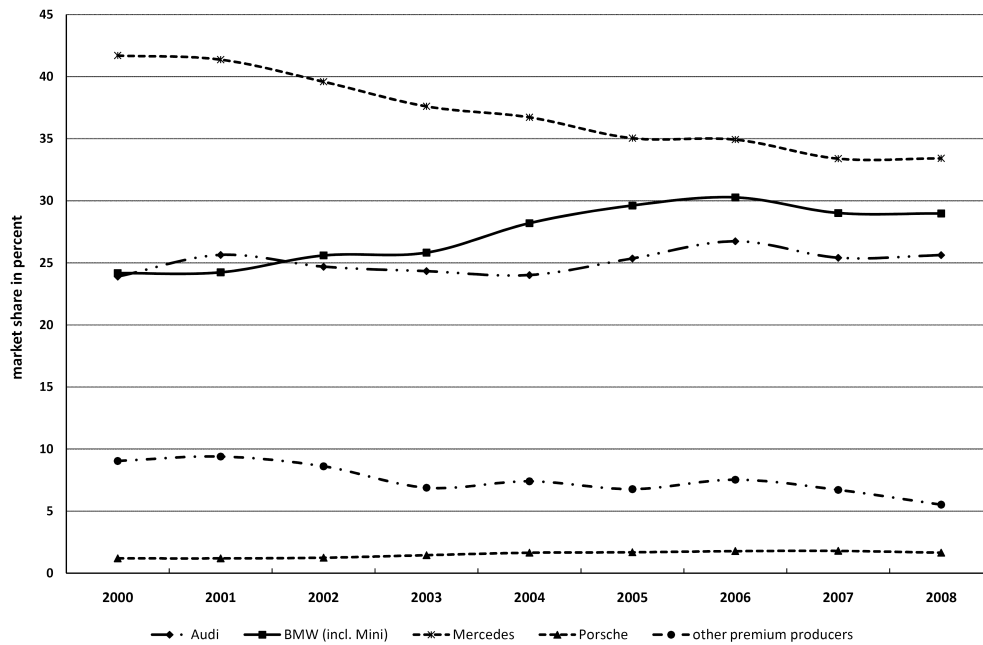


Figure 1: Market shares in the premium car segment²⁰

In short, all other premium car producers combine a constantly small market share and even witness a decline in market shares from nearly ten percent in 2000 to slightly above five percent in 2008. In turn, the market share of the four companies under investigation does not fall below 90 percent within the period under consideration. Although this pattern is quite stable, there have been considerable shifts in market shares among these four companies. Mercedes lost around eight to ten percent in market shares to Audi and BMW,²¹ whereas the market share of Porsche lies notably stable at around two percent.²²

In summary, the data-set at hand covers the key producers and, in large part, the relevant models of the premium car market in Germany, although our sample does not cover the entire product line of the four companies.²³ In the next section we take a closer look at the specific characteristics of the product life cycle in the premium auto market. Additionally, we examine the most important restyling activities and their timing over the life span of a representative car model.

¹⁸Including the years 1998 and 1999 does not alter the picture.

¹⁹This group encompasses the following brands: Alfa Romeo, Acura (Honda), Cadillac, Lincoln, Infiniti (Nissan), Jaguar, Landrover, Lexus (Toyota), Saab and Volvo.

²⁰Source: http://www.kbashop.de/wcsstore/KBA/Attachment/Kostenlose_Produnkte/n_marken_2008.pdf

²¹The cumulative sales figures for BMW include the sales of "Mini".

²²In a robustness test not reported in any table, we excluded Porsche from our sample to control for a possible outlier bias. The results stay the same.

²³The cars included usually represent the top-sellers of each company and are responsible for a major share of cumulative annual sales. Total sales of Audi, for instance, sum up to around 221.000 units in 2007 in our data-set, which makes up 88 percent of Audi's total annual sales.

3 Automotive restyling and the product life cycle in the premium car segment

In this section we describe the sales development and the timing of restyling activities over a car's life. We conduct this exercise in two steps. In step one, we analyze the main properties of the product life cycle in the premium car segment. Step two continues with a description of the restyling activities and their timing during the product life cycle. Throughout this section we pursue an exclusively descriptive approach.²⁴

Product life cycle: Sales of durable goods typically follow a certain pattern over time which is referred to as the product life cycle. Accordingly, at the beginning of the product life cycle sales first increase, reach a peak after a while and afterwards continue to decline until the product is replaced by a successor. To analyze the product life cycle in the premium car segment we proceed as follows.

First, we group all car models according to their class and type rating. One group, for example, consists of all middle class estate cars. This approach yields clusters of around three cars on average (see Table 1). In the next step, we compare the date of market introduction of each model in every single cluster. This exercise refines the aforementioned classification which, by then, contains subgroups of cars with overlapping life cycles. This ensures the identification of direct competitors in our clusters. In a next step, we abstract from any time dimension by normalizing the month of the market launch to zero. This procedure facilitates the comparison of product life cycles of direct competitors. Finally, we draw a graph, which is based on actual sales figures, containing a life cycle for each model in every group. To reduce the volatility in monthly sales figures, we apply a flexible smoothing algorithm.²⁵ We discuss the results of these steps by selecting one specific group. This will be without loss of generality as the results for all other groups are very similar.

Figure 2 displays the product life cycle for upper middle class sedan cars (i.e. BMW 5 Sedan, Audi A6 Sedan and Mercedes E Sedan) in terms of registrations per month. The x-axis represents the time axis scaled by years since market introduction (e.g. T2 indicates the end of the second and the start of the third year after market introduction).²⁶ In general, the graphs map the common product life cycles for durable goods very well (see e.g. Kwoka 1996 and Moral and Jaumandreu 2007, among others). Sales figures experience a sharp rise in the first year after market introduction (growth phase). Soon after a short maturity and saturation phase

²⁴In the empirical section we further pay attention on the correct econometric modeling of the product life cycle and the restyling activities. See Section 4 for further details.

²⁵The smoothing algorithm is based on the slope parameters estimated by locally weighted regressions. We choose a small bandwidth (0.20) to allow the smoothed curve to flexibly follow the movements in sales but not to become too volatile.

²⁶The figure look very similar if we use market shares instead.

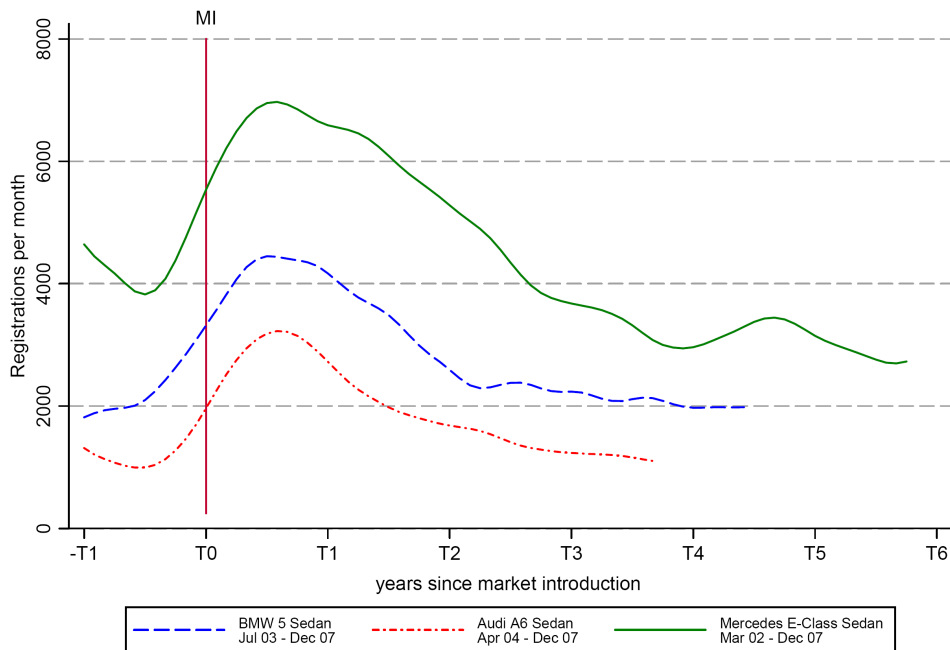


Figure 2: Life Cycle Comparison: Upper middle class

the trend reverts and monthly sales start to decline rapidly until the end of the product life cycle or the introduction of a follow-up model.

The existing literature offers several competing theories to explain the existence of this specific sales pattern. Product diffusion models present a potential explanation based on the fact that the customer base (all potential buyers) for a product consists of innovators and imitators. Usually, imitators by far exceed the number of innovators but innovators spread the word about a new product and endorse imitators to buy. This process explains raising sales shortly after market introduction. Later on, however, sales start to decrease as the number of potential buyers (imitators) is exploited (see e.g. Kwoka 1996, among others, for a formal description of a characteristic product diffusion model).

A second theory interprets the reported pattern as a result of a high degree of owner loyalty. Accordingly, customers who previously bought the predecessor of a product are more likely to buy the successor as well. Owner loyalty is particularly developed in the premium car market (Power and Associates 1991). If customers replace old versions immediately after the market introduction of a follow-up, model sales figures certainly increase. Power and Associates (1991), for instance, report that owner loyalty in the US market for luxury makes (e.g. Mercedes, Cadillac, Lincoln) equals 75 percent. This means, that 75 percent of all buyers who, for example, bought a Mercedes in the past, will buy a Mercedes again. Consequently, marketing campaigns for products with high owner loyalty rarely provide customers with detailed product information. Instead, they only tend to mention a price for the basic version, are markedly image-oriented and focus on prestige. Furthermore, advertising solely aims at informing poten-

tial buyers about recent changes in the product line-up. This is exactly what we tend to see in car advertisements.²⁷

In summary, all three product life cycles look astoundingly similar. The shape (i.e. the height and the length) of the product life cycle depends on the popularity of the specific model. Most importantly, these results provide us with some first insights on how to model the product life cycle in the empirical section. Based on Figure 2, it appears obvious that controlling for (eventually model-specific) product life cycle trends is necessary when identifying the effect of marketing measures on sales. Additionally, the evidence presented here provides us with a rationale for why car manufacturers engage in restyling activities during the product life cycle.

Restyling Activities: Car producers maintain large R&D departments and design divisions to keep pace with changing trends and technological progress. In a highly competitive industry like the premium car segment, it is crucial for the success and survival of a company to make customers benefit from innovations and improvements. Consequently, car producers constantly change and update their product line-up to attract new customers and to keep existing customers satisfied although production and development costs are considerable (Pauwels et al. 2004).

In general, restyling activities²⁸ are targeted to increase sales. Accordingly, the effect of marketing activities can not be estimated neatly as restyling activities coincide with marketing campaigns. We thus enrich our data-set with information about the restyling activities conducted for every model. In the following, we describe the five most important restyling activities, ranked according to their volume. We then examine the timing of restyling activities over the product life cycle in more detail.

The largest restyling activity, which also includes the highest degree of technological progress, is the market introduction (MI) of a new model. The high degree of innovation is especially apparent in the case of newcomers; car models that do not have a direct predecessor (e.g., Audi A2 or BMW 1). In this case, the market introduction features a completely new body design and platform with a resized wheelbase and a change in length, width and height of the body. Additionally, newly developed engines, new transmission technologies and drive systems are introduced. The interior design is subject to a substantial redesign, which encompasses the dashboard, the upholstery and the steering wheel. Of course, a market introduction is the most expensive restyling activity due to the scale of conducted measures. All other product improvements consist of relatively minor changes, build on existing platforms and designs and

²⁷An evaluation concerning which one of the theories put forward above is backed up by our data for the premium car market is beyond the scope of this paper.

²⁸The term "restyling activities" includes design as well as technological changes and improvements. The terms "product improvement" and "product changes" are treated as interchangeable.

modify only specific parts. Out of this group, we include four product innovations.²⁹ After the market introduction, the face lift (FL) represents the most extensive restyling measure. Thereby, the focus clearly lies on a redesign of the chassis. The make-over affects the radiator grill, rear and front lamps, fenders and bumpers. In some cases, a face lift is accompanied by the introduction of new engine types.

The remaining three restyling activities (editions, packages and new engine versions) are associated with significantly lower costs. There is no clear distinction between the first two as they share some common features. One of these, for instance, is that optional devices (air conditioning, xenon headlights, park distance control, rain-sensing windshield wipers, stability control system, fog lights, ...) become standard equipment. Comparably, editions (ED) and the introduction of new engine versions are similar as well, as the main focus of editions lies on the introduction of new engine versions. These new versions differ with respect to physical characteristics (e.g. cylinder capacity), fuel system (petrol or diesel) or transmission systems. Editions usually also comprise minor changes in appearance (e.g. new grill or lamps). Finally, the smallest restyling measure is the introduction of packages (PA), which are geared to the needs of specific target groups. One exceptionally popular package is the sport package. This, for instance, encompasses a sportive steering wheel and shift knob. Additionally, designer rims, a lowered chassis and a hard suspension set up stress the sportive character. Further examples for packages are lifestyle and luxury packages.

Our classification is similar to Kwoka (1993) and Millner and Hoffer (1993), although we do not use an ordinal scaled variable to classify the restyling activities according to their magnitude. Instead, we include in our model dummy variables for each measure (thus a total of five dummies) which mark the date of the corresponding product improvement. This enables each restyling activity to exert an individual impact on sales without having to impose a particular functional relationship between the effects of the different activities, as would be the case if a single scaled variable was included.³⁰

For the sake of clarity, we focus on one model (i.e. BMW 5 Sedan). In Figure 3 we show two complete product life cycles.³¹ The life cycle curve is constructed as in Figure 2, although we use a smaller bandwidth (0.15) to allow for more flexibility in capturing short-run dynamics. Furthermore, we use a real-time scaled x-axis and actual sales figures are plotted as gray dots. We mark the date of product improvements as dashed vertical lines.

With the exception of face lifts, which are usually introduced in the middle of a product life cycle, the timing of other product improvements does not seem to follow a certain pattern in time. Surprisingly, besides the apparently positive effect of a market introduction, all other

²⁹Although, a wide variety of other product measures exists, the focus in this paper is on the five associated with the highest costs.

³⁰We refer to section 4 for further details on the econometric setting.

³¹Sales data for this model are available from January 1995 onwards. Advertising data, however, are only available since January 1998.

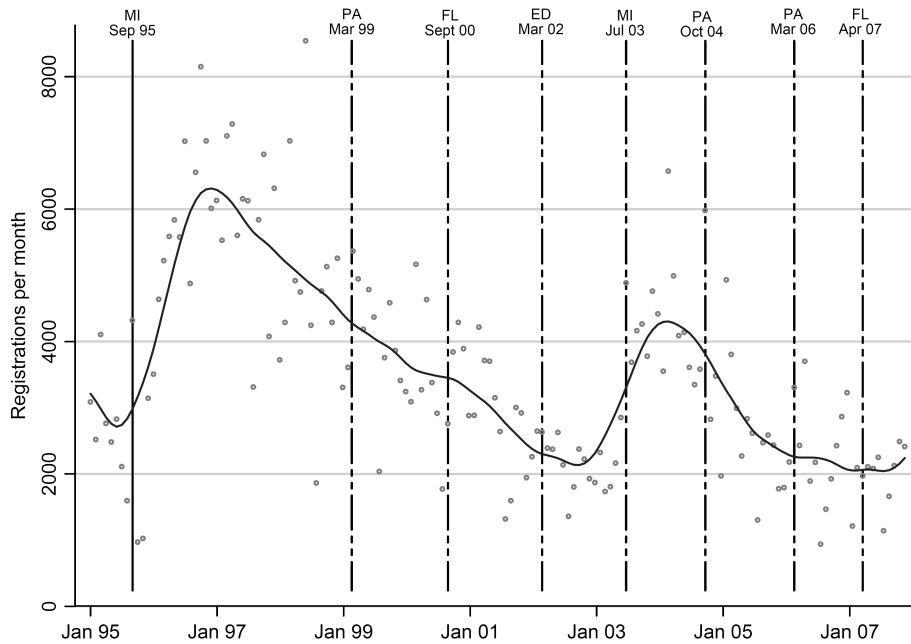


Figure 3: Sales and product innovations over the life cycle: BMW 5 Sedan

restyling activities leave sales figures virtually unchanged (at least in this graphical representation). The identification of positive effects of restyling activities, however, needs to be carried out in the framework of a fully-specified econometric model, as will be done in the following section.

In summary, this section stresses the importance of controlling for the product life cycle and restyling activities to identify the advertising-sales relationship. This is especially apparent for restyling activities as they are accompanied by marketing campaigns to inform the customer.

4 Empirical analysis: Quantifying the effects of marketing expenditures on sales in the German premium car segment

Our aim is to evaluate empirically the effect of media expenditures on sales in the premium car sector. We start by analyzing the time series properties of the main variables of our panel data-set using panel unit root tests. In particular, we apply the Levin-Lin-Chu test (Levin, Lin and Chu 2002) and the Im-Pesaran-Shin test (Im, Pesaran and Shin 2003) to the central variables in our model (logged sales and media spending).³² All variables strongly reject the null hypothesis of a common unit root, independently of the test used.³³ We thus proceed by

³²More precisely, we add the value of one to each of the two variables to avoid losing observations with zero sales or media spending. The results are robust to this transformation.

³³Detailed test results are available from the authors upon request.

formulating our model using the (log) levels of the variables instead of their growth rates. We use the following general autoregressive distributed lags (ARDL) specification,

$$s_{it} = \phi s_{it-j} + \lambda_0 m_{it} + \lambda_1 m_{it-1} + \theta_0 m_{it}^* + \theta_1 m_{it-1}^* + \sum_{j=1}^5 \beta_j x_j + \varepsilon_{it}, \quad (1)$$

where s_{it} represents (log) sales of type i in period t , m_{it} is the log of media expenditures and m_{it}^* refers to logged media expenditures of rival companies.³⁴ We deflate all monetary values to represent real values to ensure comparability over time. In addition, our specification also includes five different binary variables which represent product measures (x_j , $j = 1, \dots, 5$): introduction of a model, face lifts of existing models, the introduction of new engines, customized packages and editions.

Our assumptions concerning the error term ε_{it} play a particularly important role in order to identify the effect of marketing measures on sales. We assume that the structure of the error term is of the following form:

$$\varepsilon_{it} = \mu_i + \rho_1(t) + \rho_{2i}(t) + \nu_{it}; \quad \nu_{it} \sim \mathbf{NID}(0, \sigma^2). \quad (2)$$

The term μ_i represents the model fixed effect, which ensures that time-invariant unobservable variables affecting the differences in sales levels across models are accounted for. We assess the time shocks which are common to all models using the functions $\rho_1(t)$ and $\rho_{2i}(t)$. These functions control for global shocks affecting all models at the same time. We specify $\rho_1(t)$ as global shocks which affect all models in a given month, so that $\rho_1(t) = \sum_r \rho_r I(\text{observation } t \text{ is in month } r)$, where $I(\cdot)$ is an indicator function taking value one if the argument is true and zero otherwise. On the other hand, $\rho_{2i}(t)$ is used to account for the common features of the product cycle across models. By controlling for these common product cycle effects we ensure that inference on the potential effects of marketing measures are based on differences in the timing and size of such measures after taking into account the product cycle in which that particular model is. We specify $\rho_{2i}(t)$ as a linear trend for each product life cycle observed in the data,

$$\rho_{2i}(t) = \sum_{c=0}^4 \rho_{2c} t I(\text{observation } t \text{ of model } i \text{ is in product cycle } c). \quad (3)$$

Such a relatively complex fixed-effects structure ensures that the effects we estimate are not exclusively driven by the dynamics that constitute the common stylized facts of the product cycle described above.

The average number of observations by car model in our panel is over 60, thus implying that the biases that tend to occur in dynamic panels where the time dimension is very small compared to the cross-section dimension are not expected to play an important role in our specification. This

³⁴ m_{it}^* is defined as the sum of all media expenditures by rival car producers in period t .

implies that we can estimate the specification given by equation (1) using standard least-squares methods (Baltagi 2008).

In Table 2 we present the estimation results for different specifications of the fixed effect terms, as well as different choices of explanatory variables. The first three columns of Table 2 present the estimates from models where we do not include any fixed effect beyond a common intercept, thus specifying ε_{it} as an error term with the standard characteristics assumed in cross-sectional econometric analysis. The estimates for the coefficient of lagged sales indicate that the stochastic process being modeled has a high level of persistence. If we compare the estimates of the autoregressive parameter across models with different time-effect specifications (compare the estimates of columns 1-6 in Table 2 with those of columns 7-9), we can conclude that a large part of sales persistence can be efficiently explained making use of systematic trends within the product cycle common to all models. In column 1-3, the parameter estimates for contemporary domestic and rival media spending reflect a positive association between marketing spending and sales in this model specification. The introduction of dummy variables for product improvements in the model (column 2 and 3) shows significant positive effects for model introduction, customized packages and new engines. On the other hand, the generalization of the model to allow for lagged terms of domestic and rival media spending leads to counteracting effects in rival media spending (positive contemporary versus negative lagged term, of roughly similar size).

Since sales (and media spending) may be systematically affected by common exogenous shocks, we first expand the model by assuming time-fixed effects in the error term. Columns 4, 5 and 6 in Table 2 present the estimates of models with fixed month effects but without model-specific intercepts. In this setting, the positive effect of rival media spending changes its sign and is found to affect domestic sales negatively (although insignificantly), which implies that the effect found in the first three columns was biased by the fact that media spending campaigns tend to be relatively synchronized across companies. The contemporary effect of own media spending, as well as the model introduction effect, still appear significant in this setting. In contrast to columns 1-3, a face lift now exerts a significantly positive effect on sales, whereas the coefficients for the remaining product improvements are insignificantly different from zero.

The specifications in the first six columns of Table 2 exploit differences across models and in time. However, if we intend to evaluate the effect on sales of a given measure for a specific model we should concentrate in effects within model types, thus exploiting exclusively differences in the time dimension to estimate the parameters. In columns 7 to 9 we report the estimates of the specifications including model fixed effects, month fixed effects and product life cycle specific trends. The inclusion of this more sophisticated set of deterministic effects implies that we exploit differences in the deviations from the average product life cycle in order to extract the effect of media expenditures and marketing actions on sales.

Table 2: Regression results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Lagged sales	0.9155*** [0.0112]	0.9268*** [0.0099]	0.9306*** [0.0098]	0.9330*** [0.0110]	0.9417*** [0.0097]	0.9401*** [0.0096]	0.6754*** [0.0308]	0.6931*** [0.0278]	0.6692*** [0.0272]	0.7266*** [0.0263]
Media spending	0.0201*** [0.0031]	0.0158*** [0.0028]	0.0160*** [0.0033]	0.0179*** [0.0030]	0.0139*** [0.0027]	0.0112*** [0.0032]	0.0078*** [0.0024]	0.0064*** [0.0023]	0.0050* [0.0027]	0.0069** [0.0028]
Lagged media spending			0.0010 [0.0030]			0.0034 [0.0029]			0.0011 [0.0026]	0.0034 [0.0027]
Media spending of rivals	0.0588*** [0.0084]	0.0580*** [0.0084]	0.1106*** [0.0096]	-0.0214 [0.0158]	-0.0157 [0.0158]	-0.0097 [0.0159]	-0.0007 [0.0163]	0.0009 [0.0163]	0.0023 [0.0149]	0.0020 [0.0155]
Lagged media spending of rivals			-0.1017*** [0.0104]			-0.0309* [0.0170]		-0.0199 [0.0147]	-0.0199 [0.0147]	-0.0174 [0.0153]
Model introduction		0.6387*** [0.1731]	0.6416*** [0.1708]		0.5935*** [0.1676]	0.5998*** [0.1673]		0.2764** [0.1387]	0.2496* [0.1355]	0.3950*** [0.1400]
Face lift		0.0733 [0.0501]	0.0571 [0.0479]		0.0767* [0.0420]	0.0835** [0.0423]		0.0677* [0.0393]	0.0685* [0.0397]	0.0651* [0.0394]
Customized package		0.1803** [0.0859]	0.1713** [0.0861]		0.0837 [0.0915]	0.0879 [0.0915]		0.1197 [0.0735]	0.1212* [0.0713]	0.1316* [0.0756]
Editions		0.1354 [0.1140]	0.1060 [0.1166]		-0.0333 [0.0914]	-0.0335 [0.0947]		-0.0306 [0.0893]	-0.0437 [0.0908]	-0.0769 [0.0858]
New engines		0.2057*** [0.0588]	0.1776*** [0.0557]		0.0486 [0.0569]	0.0505 [0.0569]		0.0285 [0.0517]	0.0241 [0.0516]	0.0525 [0.0511]
Model fixed effects	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Product cycle trends	No	No	No	No	No	No	Yes	Yes	Yes	No
Observations	2,886	2,886	2,866	2,886	2,886	2,866	2,886	2,886	2,866	2,866
R-squared	0.884	0.890	0.893	0.914	0.918	0.918	0.930	0.931	0.932	0.929

Notes: Dependent variable is $\log(1+\text{sales})$. OLS estimation with White heteroskedasticity-robust standard errors in brackets (in all cases). * (**) [***] stands for statistical significance at the 10% (5%) [1%] level. Coefficients of constant, model- and time-fixed effects as well as product cycle trends not reported.

This new set of fixed effects renders the effect of a market introduction, a face lift and customized packages significant if all relevant variables are included in the model (see column 9). As mentioned above, the estimates of the autoregressive parameter are now systematically lower than in the other models, since a large part of the persistence of sales takes place as part of (common) product life cycle dynamics. In order to assess the role of product cycle dynamics on the effect of marketing expenditure, in column 10 we present the estimates from the full specification (column 9) with fixed model and time effects but without product life cycle deterministic trends. A comparison with the results in column 9 shows that, for instance, the effects of media spending and the introduction of a new model are now somewhat larger in magnitude, which emphasizes the importance of incorporating product life cycle dynamics in the econometric model as otherwise both effects would be overstated. It should be noted that the effect of media spending still appears significant in models where specific intercepts for model types, time-fixed effects and common product cycle effects across all model types are assumed. This result indicates that differences in media spending across models in the German premium car segment are associated with differences in sales beyond those which are implied by the average product life cycle of the product.

Additionally, our different specifications reveal some interesting insights in the advertising-sales relationship. In general (columns 1-10), we observe a significantly positive effect of media spending on sales. However, this effect diminishes rapidly in magnitude after incorporating common product life cycle dynamics. The impact of marketing expenditures on sales, for instance, is reduced by three-quarters between the most basic model (column 1) and our preferred specification (column 9). More precisely, a ten percent increase in media spending raises sales by 0.05 percent in the short run with a corresponding long run effect (given by the ratio of the corresponding parameter estimate and $(1 - \hat{\phi})$) of 0.15 percent. Concerning the effects of product improvements, the introduction of a new model, a face lift and customized packages appear significantly positive related to sales even after including all fixed effects. The coefficients are sizeable compared to the estimated effect of media spending. Apart from the expected quantitatively large sales effect of a market introduction, customized packages, for instance, trigger a direct contemporaneous impact on sales of around 0.12 percent and a long-run effect of around 0.37 percent. The effect of all other product innovations studied (i.e. new editions and engines) are captured by the (deterministic) product life cycle observed for all model types in our sample. We also specified models including quadratic product cycle trends, which may be considered a better choice to trace the sales dynamics along the product life cycle. All the results presented above are left practically unchanged by this generalization.³⁵

In order to ensure that our results are not driven by the particular specification and estimation method used, we performed a battery of robustness checks. A usual concern in the empirical

³⁵Detailed results of models with more complex specifications for product life cycle dynamics are available from the authors upon request.

literature of marketing effects is related to the endogeneity of media spending and sales (see Lambin 1976 and Schmalensee 1972 for seminal references on this issue). We re-estimated the full model in column 9 (our preferred specification) using up to three lags of media spending and rival media spending as instruments for the marketing expenditure variables. The results of the instrumental variables estimation are qualitatively and quantitatively very similar to those obtained using OLS, and the Durbin-Wu-Hausman test delivers a test statistic of 0.14 (p-value = 0.87), which indicates that the least squares method should be preferred.³⁶

The long time series available by model type ensure that the biases which are usually present in dynamic panel data models when the time dimension of the panel is short are not present in our study. We nevertheless also estimated the specifications presented here using dynamic panel methods based on Generalized Method of Moments (GMM) estimation (see Arellano and Bond 1991 and Blundell and Bond 1998 for the most popular estimation methods). The results presented in Table 2 are qualitatively unaffected by the use of dynamic panel data GMM methods.³⁷ In a last robustness check we include the aforementioned car characteristics in our specification as displayed in table A.1, but this leaves the effects of our main variables virtually unchanged and the overwhelming majority of the coefficients of the included variables remains insignificant.

5 Conclusions

There is still a lively debate going on in marketing research about the impact of marketing on sales figures. This paper ties to this debate by assessing the relationship between marketing expenditures and sales in the premium car segment in Germany. We employ a unique panel data-set which comprises sales and advertising data for the German premium car sector at a monthly basis for the years 1998 to 2007. The richness of the data-set in the time-dimension allows to efficiently deal with problems associated with endogeneity and auto-correlation and to incorporate product life cycle dynamics partly ignored in previous research. Furthermore, we extend the data-set by including information about restyling activities typical for the automobile industry.

Our results indicate a positive relation between marketing expenditures and sales, but the magnitude of this effect highly depends upon the inclusion of a deterministic error term structure with model- and time-fixed effects and product life cycle specific trends. Additionally, we find that the introduction of a new model, face lifts and customized packages increase sales, whereas marketing actions of rival companies do not significantly influence domestic sales. Finally, we

³⁶The estimation results are not presented here but are available from the authors upon request.

³⁷The usual instrumentation structure implied by GMM estimation in dynamic panel data, however, proved inadequate for our data-set and standard Sargan tests tended to reject the null hypothesis of instrument adequacy. Detailed results for this robustness check are available from the authors upon request.

observe a high degree of persistence in monthly sales figures over time but a substantial part can be explained by product life cycle dynamics. In summary, these results emphasize the importance of a careful econometric modeling of the advertising-sales relationship.

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Appendix

Table A. 1: Average product characteristics per class

	Compact class	Middle Class	Upper M. Class	Luxury Class
Cylinder capacity (cm ³)	1,503.87	2,023.87	2,381.03	3,187.14
Engine torque (N m)	140.70	196.51	268.69	337.74
Power (in HP)	94.66	142.83	179.26	259.07
Acceleration (0-100 km/h)	11.92	10.18	9.18	7.02
Max speed (km/h)	180.93	209.71	219.69	256.46
Consumption (avg. 100 km)	6.56	8.30	8.54	10.35
Basic weight (kg)	1,140.99	1,410.38	1,618.72	1,647.96
Basic price (EUR)	19,258.65	28,366.41	42,977.46	66,032.93
Observations	379	1,032	914	571

Notes: Source: autoarchiv.net; Sample size $n = 2,896$

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