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HOW CAR DEALERS ADJUST PRICES TO REACH THE PRODUCT EFFICIENCY FRONTIER IN THE SPANISH AUTOMOBILE MARKET

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Abstract

This paper investigates the relationship between the dynamics of price discounts at the dealership level and product efficiency in the Spanish auto market. Using Data Envelopment Analysis (DEA), product efficiency scores are estimated for 2,092 different vehicles commercialized during 2010, using an innovative database that accounts for more than 75 technical attributes of each model. By alternating official and discounted prices on the DEA specification, we are able to propose a measure of competitive improvement in the retailing stage. We also introduce a decomposition of this measure into two indexes that account for the "commercial effort" made by the dealer and the "intensification of competition" that results from the discounting efforts of the other dealers. Finally, we explore the importance of a number of drivers of dealer discounts. As expected, the results confirm the existence of an inverse relationship between product efficiency and dealer discount. Also as expected, discounts are significantly larger for generalist brands, aged models and gasoline engines.

Keywords: product efficiency, DEA, automobile, dealership, discount, Spain

1. **INTRODUCTION**

Business competitive analysis is concerned with the ability of competitors to deliver products with a similar or superior product/price relationship in the marketplace, which are produced at a similar or lower cost. Competitive advantage exists when the firm either offers more value for a given price (product differentiation) or when costs are lower for a similar product. Price is the variable that splits the value created between the firm and the customer. While the difference between price and cost is what provides a profit margin for the firm, the difference between the value of the product and its price is what provides the rational reason for a customer to purchase. Price setting is critical, as no competitive advantage can emerge if customers do not purchase the product. If the price is just too high for the merits of the product, sales (and profits) will tend to be low. Alternatively, if the price is too low for the merits of the product, sales will be high, but margins will be unreasonably low. The right price is the one that reflects appropriately the merits of the product in the marketplace.

There is a growing body of literature aimed at evaluating the relative merits of competing products on the basis of product attributes and prices. This line of research can be traced back to the seminal work of Lancaster (1966) who described a product as a combination of attributes or a vector in the quality-price space. This representation allowed the construction of a theoretical frontier with the highest quality/price ratio attainable. The competitiveness or appeal of a product could then be approximated by the distance of the product vector to the frontier of *best-buy* products. Most customers are not attracted to buy either the highest quality or the lowest price product. Instead, products with the best quality/price relation will be favored by the bulk of the market, since prospective customers will seek to maximize that ratio (Rust and Oliver, 1994). Product efficiency, as measured by comparison with the *best-buy* frontier, can then be considered as an indicator of the relative (to the frontier) customer perceived value, or the value received for the money paid (Bauer et al., 2002; Smirlis et al., 2004).

The estimation of customer perceived value is an important research topic in business strategy and marketing (Zeithaml, 1988; Dodds et al., 1991; Holbrook, 1994). The traditional approach was to use bi-dimensional maps of perceived value (Brayman, 1996; Gale, 1994). This methodology requires listing the relevant attributes of the product, asking well-informed consumers to evaluate those attributes for a given product and then to weight the importance of each of the attributes. The information is then combined into a composite indicator of relative quality-performance that can be compared to the relative price of the product. While this approach is quite straightforward, it also introduces obvious biases in product assessment, since subjective evaluation will vary as a function of variables such as age or income (Bolton and Drew, 1991).

To avoid these biases, other approaches have relied on objective methods to weight the (measurable) attributes of the product into a product efficiency ratio that approximates customer value. Non-parametric frontier techniques, such as Data Envelopment Analysis (DEA), are being increasingly used in the literature to make these comparisons. DEA is a frontier tool that has been extensively used to measure efficiency in production by comparing input-output vectors with an empirically constructed best-practice frontier (see Liu et al. 2013a,b for recent surveys of DEA applications). The adaptation of the DEA framework to the estimation of the product efficiency was first proposed by Kamakura et al. (1988). They applied this tool to measure product efficiency in several markets, including automobiles. The DEA framework was able to generate a set of weights for the attributes of each product which maximized the efficiency score of that product (i.e., a benefit of the doubt evaluation). After this pioneering work, many authors have applied this technique to different sectors such as computer printers (Doyle and Green, 1991), notebooks (Fernández-Castro and Smith, 1996), numerical control machines (Sun, 2002), mobile phones (Smirlis et al., 2004; Lee et al., 2005), computer printers (Seiford and Zhu, 2003), digital cameras (Chumpitaz et al., 2010) and, most notably, automobiles. To our knowledge, the DEA approach has been applied to evaluate the product efficiency of automobiles by Papagapiou et al. (1997), Papachristodoulou (1997), Fernández-Castro and Doldán (2002), Fernández-Castro and Smith (2002), Bauer et al. (2002), Staat and Hammerschmidt (2005), Oh et al. (2010), Choi and Oh (2010) and, more recently, Hwang et al. (2013) and González et al. (2013). Within the automobile industry other papers have focused exclusively in evaluating specific issues, such as the environmental impact of the car models (Kortelainen and Kuosmanen, 2007; Chen et al., 2012; Voltes-Dorta et al., 2013; Hampf, 2013).

In this paper, we build on previous literature to evaluate product efficiency in the Spanish automobile market. In doing so, we pay special attention to overcoming some of the most common empirical limitations of previous research for at least three concerns. A first aspect that has been largely overlooked in previous studies is the fact that car dealers usually make significant price adjustments, cutting the model's official price in order to boost sales. Using the official price list may be right for comparing computer printers, but will most likely be misleading for comparing automobiles, as some dealers make significant discounts which are not registered in the official price list. As a consequence, real market prices can be markedly different from official ones. Our empirical application will use both official prices and discounted prices for all the models analyzed. The comparison of product efficiency scores under official and discounted prices will indicate how effective car dealers are in adjusting real prices in order to reach the *best-buy* frontier.

The second limiting aspect of previous literature that will be addressed in this paper is the focus on a narrow piece of the market. The number of models and versions included in empirical analyses is usually very small, relative to the actual extent of the market. To overcome this limitation, in this paper we have collected data on 2,092 different versions of 103 different models belonging to 25 different brands. Using a large sample is very useful in order to provide a closer approximation of the real underlying frontier when using non-parametric frontier methods. The frontier is not estimated as a parametric function but as an envelope of the data observed. If few data are available, the (envelope) frontier may be an unreasonably imperfect representation of the actual market frontier. The third limiting aspect of previous research that will be addressed in this paper is the number of attributes considered in measuring product efficiency. In general terms, previous research has been limited to a few visible and objective attributes of the car, without a consensus about which variables should be used. While some papers rely on attributes such as horse power, size and fuel efficiency (e.g. Oh et al., 2010), other papers evaluate product efficiency on the basis of horse power, safety and equipment (e.g. Staat and Hammerschmidt, 2005). Horse power is the only variable that appears consistently in the literature reviewed. In this paper we combine information on more than 75 attributes which account (in the same DEA model) for most of the car features that have been used in previous research and even add a new variable on car reliability.

In order to achieve these goals, this paper builds on a previous research carried by the authors in which a preliminary analysis of product efficiency in the Spanish auto market was done (González et al., 2013). Here we considerably extend the sample and number of attributes considered and we put the focus on the comparison between the estimates of product efficiency using the official price and using the discounted price. This comparison will bring new insights to the analysis of the competitive dynamics at the dealership level. In particular, we will test some hypothesis related to these dynamics as presented in the next section.

2. HYPOTHESES

Despite the recent liberalization of the European automotive market (Brenkers and Verboven, 2006), the distribution of cars in Spain has remained fundamentally unchanged. Franchising is the dominant mode of governing automobile distribution (Arruñada et al., 2009). Traditional dealers have stable franchise relationships with car manufacturers, which grant exclusive territories and impose commercial conditions and sale quotas (Vázquez, 2000). The market is a differentiated oligopoly in which different brands compete with differentiated models that appeal to segmented customers. In such a scenario, market prices should adjust to reflect the relative merits of each product.

However, price setting in this sector occurs in two stages. First, manufacturers determine official (listed) prices for each model's version, as well as the prices for the extra equipment and auto parts. In doing so, the manufacturer takes into account the information about competing products and its own positioning strategy in the marketplace. Manufacturers also establish the transfer prices at which vehicles are sold to dealers. In a second stage, dealers have considerable discretion (as compared to other activities) to adjust the final price of each deal according to market circumstances. In this process, the dealer is able to incorporate local information about market dynamics, adjusting final prices to the comparative merits of the model, taking into account the offers of competing brands. Because of the franchise structure of the manufacturer-dealer relationship, the dealer has every incentive to set prices in a way that maximizes its own profit. This may produce double marginalization problems, since the dealer would take the transfer price as the unit cost, with the effect of reducing sales volumes below the level that would maximize the manufacturer's profit. In order to avoid double marginalization problems, manufacturers establish sales targets to dealers (Vázquez, 2000), which are then rewarded with discounts in the transfer price of the vehicles when targets are met. Dealer discounts are one of the most important instruments through which dealers are able to meet sales targets.

To establish sales targets, the manufacturer uses demand prospects which do not always reflect the real situation of the market, since competing products may be more attractive than initially expected. However, if the market works efficiently at the dealership level, then the magnitude of discounts should be inversely related to the actual relative merits of each product (i.e., product efficiency). In other words, if a car model has more valuable features than competing products and is offered at a similar price, then the dealer will not need to give large discounts in order to meet sales targets. In contrast, when the features of a model are inferior to competing products of similar price, then the dealer would need to adjust the price significantly in order to balance the product/price ratio to a competitive level.

Hypothesis 1: the magnitude of dealer discounts would be inversely related to product efficiency.

The automobile market is highly segmented. The main segmentation variables are car size and brand image. Following the proposal of the EEC (1999) regarding car size, the market can be segmented into A-Mini (e.g.: Smart, Mini), B-Small or Subcompact (e.g.: VW Polo, Opel Corsa), C-Medium or Compact (e.g.: VW Golf, Seat León), D-Large (e.g.: BMW 3 series, Mercedes C-Class), E-Executive (e.g.: BMW 5 series, Volvo S80), F-Luxury (e.g.: Audi A8, BMW 7 series) and M-Multi Purpose Vehicle (e.g.: Ford B-Max, Renault Scenic). Regarding brand image there is a broad division between generalist brands (Ford, Peugeot, Seat, Opel, etc.), which appeal to the average customer, and premium brands (BMW, Mercedes, Audi), which appeal to high income customers. In between, we find brands that can be considered as "semi-premium" as they stay a step ahead of generalists on the basis of reliability (Toyota, Honda, Mazda), sportiveness (Alfa Romeo, Mitsubishi), elegance (Lancia, Saab), safety (Volvo) or balance (VW). The competitive dynamics within the different segments may be markedly different.

According to Shudir (2001), pricing behavior should be more aggressive in the entry level of smaller car segments (A and B), while it would be more cooperative in the larger car segments (D, E, F and M). The rationale for this hypothesis is that most customers in the small car segments are young buyers making their first purchase. These customers tend to be extremely sensitive to price. There is also an immense motivation for brands to aggressively compete for these young customers, since in the long run they may become brand-loyal customers who repeat purchases within the same brand (Crawford, 2008). In contrast, buyers in the larger segments are usually older and more loyal to their previous car brand which, in turn, relaxes price competition in the market. However, given these incentives the manufacturer will also try to compete for this entry level customers. Therefore, the competitive pressure may be already incorporated in the official price.

Additionally, generalist brands should face stronger competitive pressures, since brand image will not be enough to significantly differentiate their models. In contrast, premium brands may price more cooperatively.

Hypothesis 2: the magnitude of dealer discounts would be larger within the generalist segments and lower in the semi-premium and premium segments.

Another variable that deeply drives demand in the automobile market is the newness of the model (Kwoka, 1993; Train and Winston, 2007). For this reason, manufacturers have shortened the life cycles of each model to an average of around six years and, usually, introduce a restyling when the model has been three years in the market. Korenok et al. (2010) show that the demand increase obtained from a restyling is 10 times greater than the increase that will be obtained from a 10% price discount. Therefore, both variables should be inversely related.

Hypothesis 3: the magnitude of dealer discounts would increase as the model ages in the market.

Hypothesis 4: the magnitude of dealer discounts would be lower for new models (those launched during the year).

Finally, the discount policy may also be conditioned by the type of fuel used by the car: gasoline or diesel. While the bulk of demand in America and Japan is for gasoline models, diesel models represented about 50% of the market in Europe by 2010 (source: European Automobile Manufacturing Association). Diesel engines are more in demand in Europe because they attain better fuel economy than their gasoline counterparts, and oil prices are significantly higher in Europe. Dieselization is especially notable in Spain, with about 70% of the market (source: European Automobile Manufacturing Association). Given the preference for diesel cars in this market, dealers would tend to offer greater discounts for gasoline models, whose demand would be more elastic.

Hypothesis 5: the magnitude of dealer discounts would be higher for gasoline models than for diesel models.

3. ESTIMATION OF PRODUCT EFFICIENCY

In order to obtain an index of product efficiency for each model's version, we estimated a DEA *best-buy* frontier[1]. This frontier is obtained from the comparison of data on the attributes of all the models included in the sample. These attributes can be characterized as inputs and outputs. The inputs are the car features that the customer would like to minimize because they reduce perceived value (e.g., price, fuel consumption, etc.). In turn, the outputs are the features that the customer wants to maximize because they contribute to increase perceived value (e.g., horse power, equipment, etc.). In this research we will only consider one input: *price*. The rest of the cars' features have been measured in such a way as to enter them as outputs into the DEA program (i.e., more is better). The outputs included in our DEA model are: *ecology, fuel consumption, real horse power, maximum speed, acceleration, volume, boot space, safety, reliability and standard equipment*. These variables are precisely explained in Section 4.

Therefore, we propose a model with one input and ten outputs to construct the *best-buy* frontier. Cars located on the frontier can be considered as *best-buys* since they offer a unique combination of attributes (input and outputs), i.e. one that cannot be beaten by any other product that is currently available in the market in terms of perceived value. This idea links to the view that customers don't purchase products but bundles of attributes (Lancaster, 1966). In order to establish how to value the different attributes of the cars, we followed the original DEA formulation of Charnes et al. (1978). The DEA program finds the maximum radial contraction in the inputs (input orientation) or the maximum radial expansion in the outputs (output orientation) that is feasible. The data available and the assumptions in the DEA formulation jointly determine which input-output combinations are considered to be feasible.

[1] A recent review of the issues to take into account when performing a DEA analysis can be found in Cook et al. (2014). A different (parametric) approach is the estimation of stochastic frontiers (see Álvarez and Arias, 2014 for a recent overview).

Convexity is a controversial assumption in DEA. In the context of product efficiency estimation, Fernandez and Smith (2002), Lee et al. (2005) and, more recently, Chumpitaz et al. (2010) argue for dropping the convexity assumption and follow the Free Disposal Hull (FDH) non-convex model originally proposed by Deprins et al. (1984). The main argument favoring FDH is the impossibility of assuming that any convex combination of product bundles actually observed in the market could be feasible to produce or to be found in the marketplace. While recognizing the possible technical infeasibility of many of these combinations, we believe that convexity remains an appropriate assumption for hedonic price estimation. As shown by Thrall (1999), FDH efficient products which are not DEA efficient, can be hardly rationalized in terms of utility maximization for any set of weights (values) that consumers may assign to the different characteristics[2]. While FDH will still provide valid estimates from the viewpoint of technical efficiency, as shown by Cherchye et al. (2001), convex DEA seems reasonable from a utility maximization perspective.

Our main interest in the DEA formulation lies in knowing what the right price for each bundle of attributes is (one that corresponds to the utility associated to that bundle). This can be done by adapting the DEA setting to the case of a single input. We followed this approach by converting to outputs all the features that would be naturally considered as inputs (fuel consumption, CO_2 emissions, etc.) during the elaboration of the database. Therefore, our model will seek to find the minimum price associated with each existing bundle of outputs in the market. The variable returns to scale (VRS) multiplier DEA model (the dual of the envelope model) with an input orientation can be written as:

[2] Thrall (1999) is concerned with a production efficiency setting and, therefore, shows how FDH efficient production processes may be inconsistent with profit maximization. The arguments can be extended to product efficiency and utility maximization.

$$
\begin{aligned}
&\max\ \theta = \sum_{s=1}^{S} u_{s0} y_{s0} + \varepsilon \\
&s.t.: \\
&v_0 p_0 = 1 \\
&\sum_{s=1}^{S} u_{s0} y_{sj} + \varepsilon - v_0 p_j \le 0 \quad , \quad j = 1, \cdots, n \\
&u_{s0}, v_0 \ge 0 \, , \varepsilon \in \Re
\end{aligned}
$$

where y_{s0} is the value of output s for model version 0 and p_0 is its official price. The mathematical program uses the multiplier v_0 to normalize the value of the input to 1 and, then, searches the multipliers u_{s0} that maximize the combined value of the outputs. The parameter ε was added by Banker et al. (1984) to the original DEA basic model to relax the constant returns to scale condition by not restricting to hyperplanes passing through the origin The second restriction imposes that with those weights all the other vehicles must have a net value of less than 0. This constraint defines the *best-buy* frontier and sets a maximum value of 1 for the objective function. If the vehicle under analysis obtains a value 1 it is on the frontier, which means that the program was able to find a set of weights with which there is no other vehicle that offers a preferable bundle of attributes (i.e. more utility). If the value is lower than 1, it means that, even with the most favorable weights possible for the bundle of attributes under analysis, there are better deals in the market. Therefore, the difference between the optimal value of the objective function (i.e., the DEA product efficiency score) and 1, reflects the overprice of each particular car. A price excess which cannot be rationalized on the basis of the value attached to the bundle of attributes included in the car.

Following the VRS model has two advantages in our setting. First, in the context of hedonic pricing, prices are expected to be non-linearly related to characteristics (Ekeland et al., 2004). This non-linearity can be captured by the VRS model. Second, Hollingsworth and Smith (2003) have shown that when data on inputs and outputs represent ratios of other variables (which is our case for many of the variables), the VRS specification is more appropriate.

If some car attributes (outputs) are considered to be more important than others, weight restrictions could be imposed in the DEA program to account for these differences. However, the auto market is extremely segmented on the basis of the differing preferences of different customers, which provide the context for horizontal differentiation based on combining car attributes in different ways. The great variety of models and versions of these models is a reflection of such differences in customer preferences. Not all customers obtain utility from the attributes in the same manner. For instance, some customers are willing to make great sacrifices in all technical car attributes just to make a more ecological purchase. It may therefore be completely rational to provide a vehicle that sacrifices horse power, price, equipment and volume for reduced CO_2 emissions. Such a vehicle can perfectly be a *best-buy* for a given group of customers.

As noted by Bauer et al. (2002: pp. 10-11) "a rationale for choosing a nonparametric technique is the fact that it does not project the observed data into an inflexible scheme of fixed weights…. We consider the idea of a single proper benchmark to be misleading in our context because in that case only one strategy for optimizing products would be assumed in the analysis. Instead, the plethora of different marketing strategic possibilities needs to be considered when evaluating product efficiency. It is in the nature of marketing, that alternative value-creating product concepts (parameter-combinations) exist to serve consumer segments with corresponding preferences". Weight restrictions will rule out many of these rational possibilities unnecessarily. Additionally, weight restrictions can also lead to infeasibility problems (Podinovski and Bouzdine-Chameeva, 2013) and its use to introduce value judgment on DEA has been recently questioned in the literature (Førsund, 2013). Therefore, we believe that the analysis of product efficiency in the auto market makes a strong case for weights flexibility as allowed in the original DEA formulation.

The estimation of DEA scores using official prices will provide an indicator of the product efficiency with which each model is launched by the manufacturer. If, instead of using the official price as the input, we use the discounted price, we will obtain DEA scores reflecting the actual product efficiency that the product effectively yields in the marketplace. This efficiency combines the efforts of both the manufacturer and the dealers. We can compare both scores to obtain an index that quantifies the competitive improvement that is attained as a result of the commercial efforts of distributors. If we label the DEA score of product efficiency with the official price as θ_o and the DEA score of product efficiency with the discounted price as θ_d, the competitive improvement (*CI*) attained through dealer discounts can be measured as:

$$CI = \frac{\theta_d}{\theta_o}$$

If dealer discounts move the model towards the *best-buy* frontier, the *CI* index will be greater than 1, indicating a competitive improvement of product efficiency in the distribution stage. On the other hand, if the *CI* index is lower than 1, then the dealer discount is not enough to maintain the competitive appeal of the model in the marketplace, giving rise to a competitive deterioration. We propose to further decompose the *CI* index into two components reflecting the commercial effort made by the dealer and the intensification of competition that results from the discounts offered by all the dealers. Note that:

$$\theta_o = \frac{P_o^F}{P_o} \text{ and } \theta_d = \frac{P_d^F}{P_d}$$

where P_o is the official price of the model, P_o^F is the price that the model should have in order to reach the *best-buy* frontier (i.e., the DEA target price), P_d is the discounted price of the model and P_d^F is the discounted price that the model should have in order to belong to the *best-buy* frontier after dealer discounts are taken into account (i.e., the DEA target discounted price). Therefore:

$$CI = \frac{\theta_d}{\theta_o} = \frac{P_d^F / P_d}{P_o^F / P_o} = \frac{P_o / P_d}{P_o^F / P_d^F} = \frac{CE}{IC}$$

As indicated, the *CI* index can be decomposed into two terms that reflect the commercial effort (*CE*) of the distributor and the intensification of competition (*IC*) that results from the joint commercial efforts made by all the dealers. The *CE* index compares the official price with the discounted price. The larger the discount, as compared to the official price, the larger the *CE* index. Therefore, it measures a movement of the model in the space of product attributes in the direction of the *best-buy* frontier (note that the discount cannot be negative). In turn, the *IC* index compares the target discounted price with the target official price. As such, it measures a movement of the DEA frontier after all discounts are taken into account. This movement must be also in the same direction, since discounts cannot be negative. However, this intensification of competition can, of course, be different for each model in the sample, since the shift in the DEA frontier can be different for different output configurations, depending on the discounts offered by the dealers with similar models. For instance, by using the simplifying assumption that size is the only relevant car feature, if a dealer offers a huge discount on a large car, manufacturers of similarly large cars will experience a high intensification of competition as measured by the *IC* index.

The joint effect of both indexes determines whether the model improves, or not, its market appeal in the marketplace. For instance, dealer X can make an important commercial effort with a 15% discount on the official price of a model. But if competitors are offering larger discounts for similar models (say 20%), then the shift in the DEA frontier (*IC*) will be larger than the commercial effort (*CE*) made by dealer X. The compound result will be a worsening of the product efficiency of that particular model (as measured by the *CI* index). We believe this decomposition can provide new insights into the analysis of the competitive dynamics of cars in the marketplace but can be also applied to other markets.

4. DATA

In order to measure the efficiency value of a product, we first have to compile a complete data set that covers its most relevant attributes. Given the extreme complexity in the segmentation of the automobile sector, we have limited our sample to passenger cars and multi-purpose vehicles (MPVs) commercialized at the end of 2010. Therefore, we explicitly excluded from the study the segments of sports cars, super-minis, off-road vehicles and pick-ups. We believe that the comparison of these kinds of vehicles with the rest is especially problematic, since they offer very specific appeals to customers. For the same reason, hybrid and electric vehicles were also excluded.

Once the scope of the sample was delimited, we relied on publicly available information about the most important models commercialized within those segments. Most of the data were collected from the printed car magazine AUTOFACIL and from the online car magazine KM77. These publications include updated information on all the relevant technical data of the different versions of each model and also on the standard and optional equipment. When some data were not available within these sources we explored manufacturer and dealer websites to complete the database. We also collected data from the AutoBild TÜV reliability report, which evaluates reliability on the basis of the results of the technical inspections made on used cars. In the measurement of automobile product efficiency, past literature has relied on variables such as size, boot space, horse power, fuel consumption, maximum speed, acceleration, safety, ecology and standard equipment. To this list we added information on reliability, which is also an important driver of automobile demand (Korenok et al., 2010). In sum, for each model's version, we compiled the following data:

Official price: manufacturer list price

Discounted price 1: best price offered by UNOAUTO[3], which is actually available in, at least, one car dealership

Discounted price 2: best price offered by AUTODESCUENTO, which is actually available in, at least, one car dealership

Discounted price: minimum of discounted price 1 and discounted price 2 (this will be the variable used in the DEA analysis)

Size: length/width/height. We use the product of these three variables as a volume measure of the size of the vehicle

Boot space: in liters

Real horse power: engine maximum horse power divided by car weight

Fuel consumption: kilometers per liter

Speed: maximum car speed

Acceleration: average acceleration in meters per second squared until the car reaches a speed of 100 kilometers per hour (this is obtained by dividing the constant 27.7 by the time in seconds that is required to reach that speed). We make this transformation in order to use the variable as an output in the DEA model, instead of an input.

[3] UNOAUTO and AUTODESCUENTO are two online platforms that provide information about new vehicles in Spain, including discounted price. Prospective buyers can contact each of these firms to be redirected to a car dealer that will make the indicated discounted price in Spain.

Safety: passenger protection score in the EuroNcap crash tests (the models that did not perform the EuroNcap test were normalized to a value 0.6, which is the minimum value obtained by the cars that did perform the test)

Ecology: the result of dividing 100 by CO_2 emissions. The Spanish car taxing system uses 100 as the cutoff point that distinguishes the most ecological cars (i.e., those with emissions below 100). We make the transformation in order to use the variable as an output in the DEA model

Reliability: we use the fault rate (FR) from the AutoBild TÜV report which is based on the problems found in the tests made to at least 500 units of each model. When the fault rate of the model was not available because it had been recently introduced in the market, we used the fault rate of the model that had been replaced. To use the variable as an output we used the equivalent 100-FR, which can be interpreted as the percentage of vehicles without significant problems in the TÜV inspections.

We also used dummy variables to register whether the version includes, or not, the following items as standard equipment:

Active safety equipment: ABS, ESP, EBD, BAS, TCS

Passive safety equipment: front airbags, rear airbags, curtain airbags, knee airbag, pre-safe, isofix

Comfort seats: adjustable, leather, heated, electric, sportive, etc.

Electronics: radio, DVD, bluetooth, GPS, parking sensors, parking camera, special sound system, tire pressure monitoring system, cruise control, USB and i-Pod connections, TV, on board computer, etc.

Lights: fog lights, xenon lamps, bi-xenon lamps, adaptive lamps, automatic lights

Aesthetics: alloy wheels, tinted windows, metallic or pearl paint, metallic or wood details, spoilers, sport pedals, etc.

Comfort: panoramic roof, sunroof, electrically operated wing mirrors, electro-chromic rear-view mirror, keyless entry, central locking, power windows, steering wheel-mounted controls, leather-wrapped steering wheel, air conditioning, automatic air conditioning, power steering, number of doors, etc.

Mechanical aids: front/rear/4x4 drive, manual/automatic transmission

The most complex part in the elaboration of the data set was to aggregate the standard equipment represented by these dummies into a single variable that appropriately reflects the money value of such attributes. The number of equipment elements is so large that introducing them directly as categorical variables into the DEA program would not be appropriate. Instead, it is preferable to aggregate these data into a synthetic composite indicator. The aggregation will allow comparing vehicles with different configurations of standard equipment. Our approach was to check, for each of these elements, what was the average price at which they were offered as an optional extra in the models that did not include them within the standard equipment. For instance, a car model that includes ESP within the standard equipment would receive an estimated value of about 600€ (the average price of ESP when the customer has to add it as an extra). For computing the average prices, we considered all the models in which each of the elements was listed as an optional extra. Therefore, for each model we have a vector of dummies indicating which of the equipment elements are included in the price. Multiplying this vector by the vector of estimated equipment prices, we obtain an estimate of the value of the standard equipment (*Equipment*), which is entered as an additional output to the DEA model[4].

An important issue in DEA analyses is to compare items which are comparable. In a highly segmented market, such as the automobile market, we have to take into account the basis of segmentation in order to make meaningful comparisons. Regarding size segmentation, the DEA program can take this dimension into account, since car volume is one of the outputs. Therefore, the weighting scheme in the DEA program can take into account size segmentation. However, the DEA model cannot take into account the brand image component of segmentation. For this reason, we conducted three different DEA analyses, one for "generalists", a second for "semi-premium" and the third for "premium" brands. Generalists will be compared with all types of models. In contrast, premium cars will only be compared with other premium cars. Finally, semi-premium will be compared with other semi-premium cars and also with premium cars. The assumption behind this specification is that an average customer who is thinking of buying a generalist car would also be attracted by a semi-premium or a premium model if the price was low enough. However, a premium customer would not be attracted by a generalist even if the price is convenient. In other words, the generalist frontier will contain the semi-premium frontier, which in turn will contain the premium frontier[5].

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[4] Since not all the equipment elements are listed as an option by the same number of car models, the precision of these estimates may vary considerably. Appendix A contains basic descriptive statistics about each element of standard equipment considered, including the number of cars in which the element is an option. For some elements, we observe that only a few cars list the element as an option. The reason is that the element has become a standard in the industry and only very few models do not include it as standard equipment (e.g., ABS, front airbag).

[5] Theoretically, the value of the extra equipment should not be equal across segments. For instance, premium car buyers could attach more value to these elements than generalists buyers. In order to capture these differences we should estimate the value of the Equipment variable independently for each cluster. Unfortunately, this approach will reduce the list of optional equipment with enough data availability within each cluster. However, it must be noted that using a single common estimate is not problematic, since comparisons are still referred to within cluster benchmarks. Therefore, if Equipment is underestimated for premium cars, it will be also underestimated for premium benchmarks.

5. RESULTS

Table 1 shows the average results of product efficiency estimation for the brands included in the sample. The first column contains the efficiency scores using the official listed price as the input. These scores indicate the average distance of the brand's models to the "official frontier" that manufacturers are implicitly establishing with the technical specifications of the models and the official price lists. In turn, the second column contains the product efficiency averages that obtain when the discounted price is used as the input. These indexes are indicative of the final average distance of the brand's models to the real "commercial frontier" that the dealers are finally establishing in the marketplace with their commercial policies. The third column shows the average discount for each brand.

The fourth column compares the product efficiency scores measured under official and discounted prices, respectively, to obtain the *CI* index of relative improvement of competitive appeal. When this index is larger than 1 it indicates a competitive improvement in the relative product efficiency of the brand's models (on average), as a result of the commercial effort made by the dealers with their discounts. In contrast, indexes lower than 1 indicate a competitive deterioration of the market appeal of the models.

<<<<<<<<<<<<TABLE 1 ABOUT HERE>>>>>>>>>>>>>>>>>>

The *CI* index can, in turn, be decomposed into the two terms shown in the last two columns of Table 1. First, the commercial effort index measures the magnitude of the discounts applied by the dealers of the brand. Second, the intensification of competition index measures the movement of the *best-buy* frontier after taking into account the discounts. In other words, it measures the distance between the official frontier and the commercial frontier, which is due to discount competition at the dealership level. When this index is greater than the commercial effort, then the products of the brand are losing appeal, indicating that the commercial effort made was insufficient to maintain the competitive position.

The product efficiency frontier, with the official price, is dominated by most of the Japanese brands (Mitsubishi, Toyota, Suzuki, Mazda, and Honda), the brands of the Fiat group (Fiat, Lancia, and Alfa Romeo), some low price competitors (Dacia, Citroën, Hyundai) and finally some German and Swedish brands (VW, BMW, Mercedes and Saab). The rest of the brands show scores below the sample average. This picture does not change significantly after dealers' discounts are taken into account. Japanese brands consolidate their leadership in the commercial frontier (with the exception of Suzuki, which falls dramatically from 0.97 to 0.89). There are notable improvements in Seat and Kia (jumping from 0.89 to 0.93). Conversely, Citroën, Peugeot and Škoda drop 4, 6, and 7 points, respectively, as a consequence of the low discounts offered at the dealership level.

The largest competitive improvements are registered by Opel (1.058) and Seat (1.039), followed by Kia (1.036) and Hyundai (1.014). In contrast, significant competitive worsening after discounts is detected for Suzuki (0.921), Škoda (0.921), Peugeot (0.933), Citroën (0.957), VW (0.957) and Fiat (0.959). The rest of the brands maintain their competitive appeal at a relatively stable level after dealer discounts. In other words, their relative position to the *best-buy* frontier remains almost unchanged. This means that their commercial efforts are just enough to counteract the efforts of competing brands. Not surprisingly, the biggest commercial efforts are made by the brands that show the largest competitive improvement (Opel, Kia, Seat, and Hyundai). The case of Saab is markedly different. Saab made a big commercial effort, similar to these brands (1.210), but did not improve the competitive appeal of its models because the intensification of competition was 1.237 and virtually neutralized the commercial effects. This means that commercial activity was particularly intense in the part of the *best-buy* frontier that acts as referent for Saab's models. In contrast, the commercial efforts of Suzuki, Peugeot, Citroën and Fiat were so small that these models lose competitive appeal, even though the intensification of competition was less than average for them.

In order to visualize the changes in the competitive appeal of the models of each brand after taking into account the commercial discounts more clearly, we have represented in Figure 1 their positions regarding the two relevant dimensions: product efficiency and discount percentage. Each brand is represented twice, before and after taking the discounts into account. The number 1 represents the position of the brand relative to the official price *best-buy* frontier. The number 2 represents the position of the brand in the map after taking into account dealer discounts (i.e., relative to the commercial frontier). We have divided the figure into quadrants taking as cutoff points a discount of 12% and a product efficiency level of 0.92, which roughly correspond to the sample averages.

Quadrant I contains the most competitive brands in both the technical and commercial arena. Despite counting on efficient products, they also make important commercial efforts. In the core of this quadrant, we find all Japanese brands (except Suzuki and Nissan) and some other European brands such as Alfa, Lancia, Saab and BMW. The Korean Hyundai is also around the boundary of this quadrant. Quadrant II also counts on efficient products but, unlike brands in Quadrant I, the dealers of these brands do not make great commercial efforts. Here we find competitive European brands such as Citroën, Fiat or Volkswagen, Japanese Suzuki and premium brands such as Mercedes and Audi (in the boundary). If dealership level competition intensifies in the marketplace for these brands, they will be at a risk of losing competitive appeal, due to the low relative level of commercial effort. The other two quadrants include brands whose cars are not competitive in terms of product efficiency. The difference is that while dealers in Quadrant III are making a significant commercial effort in order to gain competitive appeal, dealers in Quadrant IV offer uncompetitive discounts.

<<<<<<<<<<<<FIGURE 1 ABOUT HERE>>>>>>>>>>>>>

Not surprisingly, brands in Quadrant III are the ones that gain more competitive appeal as a consequence of aggressive pricing at the dealership level. Some of those brands actually moved from Quadrant III to Quadrant I as a result of such aggressive discounting (Seat and Kia). The opposite movement happens between Quadrants II and IV. Well positioned brands such as Suzuki and Volkswagen (Quadrant II) move to Quadrant IV as a consequence of poor discounts, which are insufficient to counteract the increase in competitive intensity at the dealership level. Other brands that were not well positioned in the figure (Škoda and Peugeot) only worsen their position further after accounting for the discounts. Within Quadrant I, the commercial effort of brands is just enough to maintain or minimally improve the high competitive appeal of their products. We can observe also that the magnitude of the movements is not always proportional to the magnitude of the discounts. For instance, Saab is making a commercial effort similar to Hyundai but moves in opposite direction. This is due to differences in the intensification of competition in their respective reference points on the *best-buy* frontier. The same happens with Ford and Nissan.

After estimating product efficiency and decomposing the competitive improvement of brands after dealer discounts, a final objective of this paper was to test a number of hypotheses about the variables that drive the magnitude of dealership discounts. For this purpose, we estimated a regression model in which the dependent variable is the discount percentage applied to each model, obtained by comparing the official price with the discounted price. As stated in the hypotheses developed in Section 2, the magnitude of dealership discounts may depend on many variables, such as product efficiency, market segmentation, newness of vehicles, type of fuel and brand specific factors.

We included the size dimension of the vehicle (approximated by its volume) as a control variable in the regression model. The image dimension of market segmentation is accounted for by a premium dummy variable for the premium brands (Audi, BMW, Mercedes) and a generalist dummy variable for generalist brands (Citroën, Dacia, Fiat, Ford, Hyundai, Kia, Nissan, Opel, Peugeot, Renault, Seat and Škoda). Since these dummy variables will be perfectly collinear with the brand dummies for these brands, we carried out two estimations, one with the premium-generalist dummies and a second with the brand dummies. Regarding newness, we use two variables: age and new. Age measures the number of years that the model has remained unchanged (without a restyling) in the market. New is a dummy variable that takes the value 1 for new models launched in 2010. Type of engine is accounted for by a dummy variable that takes the value 1 for gasoline models.

<<<<<<<<<<<<TABLE 2 ABOUT HERE>>>>>>>>>>>>>>>>>>

We followed a conventional OLS specification, correcting for clustered errors. Given the structure of the data, there is a strong case for clustered standard errors, as discounts may be correlated within the same brand. Therefore there may be problems of autocorrelation and heteroskedasticity within brands. In order to account for this possibility, we estimated the OLS model with clustered errors at the brand level. To avoid perfect collinearity between the brand dummies and the intercept, we excluded the brand dummy for Alfa Romeo in the second specification which includes the rest of brand dummies. Table 2 shows the results.

The estimated coefficients are similar under both specifications and they have the expected sign according to the hypotheses formulated. As expected, the magnitude of discounts is inversely related to *product efficiency*. When the relative merits of a model do not justify the official price in comparison with other (similar) models available in the market, dealers need to make bigger adjustments to the final price. This result is statistically significant under both specifications, therefore supporting Hypothesis 1.

The control variable volume has a positive but insignificant coefficient under both specifications. Crawford (2008) has also reported a positive effect of size on discounts for the European auto market, which is attributed to the preference of European consumers for small and energy efficient cars, which reduces the elasticity of demand in the entry level segments. Price sensitivity is also expected to differ greatly between premium and generalist segments. The *premium* and *generalist dummies* have the expected sign and are statistically significant at conventional levels. Therefore, we can confirm that premium brands make significantly lower discounts than semi-premium brands (the omitted category), while generalist brands make larger discounts. This confirms Hypothesis 2.

The newness of the model is also expected to be a fundamental driver of demand. Our results show that new models offer significantly lower discounts. In the same way, as the model ages in the marketplace the magnitude of the discount increases significantly. Therefore, the sign and significance of the coefficients of *age* and *new* support Hypotheses 3 and 4, respectively. Finally, we indicated that the type of fuel used by the engine could also have an effect on the magnitude of discounts. The *gasoline dummy* is positive and significant in both specifications, which supports Hypothesis 5. Gasoline models require larger discounts in a dieselized market such as the Spanish auto market.

Model 2 incorporates the *brand dummies* in the regression. As we noted above, the sign of the other coefficients remains unchanged. Brand dummies reflect important facts that are also implicitly represented in Figure 1. If we focus on premium brands, we observe that while Audi and Mercedes offer significantly lower discounts than the omitted brand (Alfa Romeo), BMW offers similar discounts. In this sense, the competitive intensity of BMW dealers in the marketplace seems to be significantly more aggressive. There are also notable differences between generalist brands. The most aggressive dealers correspond to Kia, Seat, Opel and Hyundai, with discounts significantly higher than the omitted brand. In contrast, Fiat, Dacia, Citroën, Peugeot, and Škoda price less aggressively than the omitted brand, which reduces their competitive relative position, as reflected in Figure 1.

Regarding the group of semi-premium brands, only Saab and Honda are more aggressive than the omitted brand. In the case of Saab, this impressive commercial effort can be explained by the threat of discontinuation of the brand, which has significantly reduced the market appeal of its products. However, as reflected in Figure 1, none of these brands improves their competitive position significantly. On the other hand, Suzuki, Volkswagen and Volvo offer lower discounts than the omitted brand, as a result experiencing a negative impact on product efficiency.

6. Concluding Remarks

This paper extended the DEA framework for the measurement and analysis of product efficiency in two empirically relevant dimensions. First, both official listed prices and real market discounted prices were employed in product assessment. This allowed the construction of two frontiers, the official frontier and the commercial frontier, with respect to which each vehicle in the sample can be evaluated. Second, we computed an index that measures the competitive improvement attained for each model as a consequence of dealer discounts. This index provides unique information about the relative strength of the commercial networks of each brand. Furthermore, we proposed a decomposition of the index of competitive improvement into two terms: the commercial effort and the intensification of competition. We believe that this decomposition can bring new insights to the analysis of product efficiency.

For instance, the analysis can identify brands that, despite making significant commercial efforts, suffer a competitive deterioration because the commercial efforts of competitors are larger. In those cases, the effect of the intensification of competition is greater than the effect of the commercial effort. In other cases, we observe the opposite situation. Finally, some brands experience neither competitive improvement nor competitive worsening, because the commercial effort is just enough to counteract the effect of the intensification of competition at the dealership level.

Our contribution is also innovative in terms of the database employed. We have analyzed data on 2,092 different versions of 103 different models of 25 different brands. More than 75 variables have been taken into account in the process of estimating the DEA scores of product efficiency. This data set provided a unique opportunity to test some hypotheses about dealership discounts.

In general, the product efficiency of the models is moderately high, since the average is around 0.937. This means that the average car could be on the competitive edge just by adjusting the price by 6.3%, while the typical dealer discount is about 10% for most models. However, the complexity of the competitive dynamics at the dealership level makes commercial efforts ineffective for some brands. If a model is 10% unfit, offering a 10% dealer discount, will not be enough to reach the frontier in most cases. The reason is that competition intensifies as all the dealers offer discounts. Our results show that Nissan, Kia, Škoda, Peugeot, Renault, Ford, Opel, Volvo and Seat show the lowest scores of product efficiency when the official price is considered. Once dealer discounts are accounted for, this situation remains unchanged for Nissan, Škoda, Peugeot, Renault, Volvo and Ford. However, Seat and Kia significantly move towards the *best-buy* frontier. The explanation is that the commercial efforts of these brands at the dealership level more than compensate for the intensification of competition. Both firms improve their competitiveness by more than 4%, while other firms like Suzuki or Škoda deteriorate by 9% and 5%, respectively.

The group of semi-premium brands, which includes the Japanese Honda, Toyota, Mazda, Mitsubishi, and the European Alfa Romeo, Lancia, and Saab occupies the best positions in the competitive quadrants represented in Figure 1. BMW and Hyundai also occupy relevant positions within this quadrant. These brands have competitive products with the official price and also with the discounted price, since they make significant commercial efforts. Other brands with good products in terms of product efficiency (Fiat, Citroën, Volkswagen, or Suzuki) significantly reduce their competitiveness because their commercial efforts are found to be insufficient to compensate for the intensification of competition.

Our data set contains information to test several hypotheses about the drivers of dealer discounts, including characteristics of the vehicles and brands names. First of all, our results show that product efficiency is a fundamental driver of dealer discounts. When product efficiency is low, dealers tend to offer larger discounts in order to *catch up* with the product frontier and be able to meet sales targets. We also find evidence that premium brands offer lower discounts than generalist brands, the type of fuel being another important factor. The Spanish auto market has been described as a "dieselized market" in which more than 70% of sales correspond to diesel vehicles. Our results indicate that dealers tend to offer larger discounts on gasoline models. We think this is due to notable differences in the elasticity of demand of gasoline and diesel models. Consistent with previous research, we detect a significant effect of product aging on the magnitude of discounts. New models need significantly lower discounts. Finally, we find no significant effect of car size on discounts.

This paper was innovative in certain aspects regarding the completeness of the data set and the comparison between official and discounted prices. However, the data set also imposes also important limitations on our study, since we only observe data from one period.

Future research may compare the time evolution of brands with regard to technical and commercial advancements. Comparison between two periods could be done by computing and decomposing Malmquist indexes, traditionally used to measure productivity improvements (Caves et al., 1982; Färe et al., 1994). The estimation of Malmquist indexes in the context of automobile evaluation has already been proposed by Fernandez-Castro and Doldán (2002) and Chumpitaz et al. (2010), although both papers limited to price variations, while maintaining the characteristics constant. Allowing for changes in prices and characteristics may bring new insights into innovation policies in the automobile industry.

References

Álvarez A, Arias C. Some important issues in applied stochastic frontier analysis. Economics and Business Letters 2014; 3(1): forthcoming.

Arruñada B, Vázquez L, Zanarone G. Institutional constraints on organizations. The case of Spanish car dealerships. Managerial and Decision Economics 2009; 30:15-26.

Banker RD, Charnes A, Cooper WW. Some models for estimating technical and scale inefficiencies. Management Science 1984;39:1261-1264.

Bauer HH, Hammerschmidt M, Staat M. Analyzing product efficiency. A customer oriented approach. Working paper 57/2002, Institute for Market- Oriented Management.

Bolton RN, Drew JH. A multistage model of customers' assessment of service quality and value. Journal of Consumer Research 1991;17:375-384.

Brayman JMD. Building a better business tool-Customer Value Analysis. Paper presented at the AMA Conference, Conference on Customer Satisfaction, 1996.

Brenkers R, Verboven F. Liberalizing a distribution system: the European car market. Journal of the European Economic Association 2006;4(1): 216-251.

Caves D, Christensen L, Diewert E. The economic theory of index numbers and the measurement of input, output, and productivity. Econometrica 1982;50(6):1393-1414.

Charnes A, Cooper WW, Rhodes E. Measuring the efficiency of decision making units. European Journal of Operational Research 1978;2:429-44.

Chen C, Zhu J, Yu JY, Noori H. A new methodology for evaluating sustainable product design performance with two stage network data envelopment analysis. European Journal of Operational Research 2012; 221: 348-359

Cherchye L, Kuosmanen T, Post T. What is the economic meaning of FDH? A reply to Thrall. Journal of Productivity Analysis 2001; 13: 263-267.

Choi H, Oh I. Analysis of product efficiency of hybrid vehicles and promotion policies. Energy Policy 2010; 38:2262-2271.

Chumpitaz R, Kerstens K, Paparoidamis N, Staat M. Hedonic price function estimation in economics and marketing: Revising Lancaster's issue of "noncombinable" goods. Annals of Operations Research 2010; 173: 145-161.

Cook WD, Tone K, Zhu J. Data envelopment analysis: prior to choosing a model. OMEGA 2014; 44: 1-4.

Crawford AJD. Product differentiation, collusion, and empirical analyses of market power. PhD. Dissertation, Virginia State University; 2008

Deprins D, Simar L, Tulkens H. Measuring labor efficiency in post offices. In Marc-hand M, Pestieau P, Tulkens H (Eds.), The Performance of Public Enterprises: Concepts and Measurements. Amsterdam, North Holland, 1984, pp. 243-267.

Dodds WB, Monroe KB, Grewal D. Effects of price, brand, and store information on buyers' product evaluations. Journal of Marketing Research 1991;28:07-391.

Doyle JR, Green RH. Comparing products using data envelopment analysis. OMEGA 1991;19:631-638.

EEC. Regulation (EEC) No 4064/89, Merger Procedure: Case No COMP/M.1406 – Hyundai/Kia; 1999.

Ekeland I, Heckman J, Nesheim L. Identification and estimation of hedonic models. Journal of Political Economy 2004; 112, 60-109.

Färe R, Grosskopf S, Norris M, Zhang Z. Productivity growth, technical progress, and efficiency change in industrialized countries. American Economic Review 1994;84(1):66-83.

Fernández-Castro AS, Doldán FR. Aplicación del índice de productividad de Malmquist a la evaluación de productos. Revista Europea de Dirección y Economía de la Empresa 2002;11(3):173-180.

Fernández-Castro AS, Smith P. A mathematical programming approach to product characteristics. Discussion Papers in Economics, The University of York, 96/3; 1996

Fernández-Castro AS, Smith P. Lancaster's characteristics approach revisited: product selection using non-parametric methods, Managerial and Decision Economics 2002;23(2):83-91.

Førsund F. Weight restrictions in DEA: misplaced emphasis? Journal of Productivity Analysis 2013; 40(3): 271-283.

Gale BT. Managing Customer Value. New York: Free Press; 1994.

González E, Ventura J, Cárcaba A. Product efficiency in the Spanish automobile market, Investigaciones Europeas de Dirección y Economía de la Empresa 2013; 19(1): 1-7.

Hampf, B. Nonparametric efficiency analysis in the presence of undesirable outputs. Doctoral Dissertation: Technische Universität Darmstadt; 2013.

Holbrook MB. The nature of customer value: an axiology of services in the consumption experience. In Rust RT, Oliver RL (Eds.), Service Quality: New Directions in Theory and Practice. Thousand Oaks, Sage Publications, 1994, pp. 21-71.

Hollingsworth B, Smith P. Use of ratios in Data Envelopment Analysis. Applied Economics Letters 2003;10:733-735.

Hwang SN, Chen C, Chen Y, Lee HS, Shen PD. Sustainable design performance evaluation with applications in the automobile industry: Focusing on inefficiency by undesirable factors. OMEGA 2013; 41:553-558.

Kamakura W, Ratchford BT, Agrawal J. Measuring market efficiency and welfare loss. Journal of Consumer Research 1988; 15(3):289-302.

Korenok O, Hoffer GE, Millner EL. Non-price determinants of automotive demand: Restyling matters most. Journal of Business Research 2010; 63, 1282-1289.

Kortelainen M, Kuosmanen T. Eco-efficiency analysis of consumer durables using absolute shadow prices. Journal of Productivity Analysis 2007; 28, 57-69.

Kwoka JE. The sales and competitive effects of styling and advertising practices in the U.S. auto industry. Review of Economics and Statistics 1993; 75(4), 649-656.

Lancaster KJ. A new approach to consumer theory. Journal of Political Economy 1966; 74, 132-157.

Lee JD, Hwang S, Kim TY. The measurement of consumption efficiency considering the discrete choice of consumers. Journal of Productivity Analysis 2005; 23: 65-83.

Liu JS, Lu LYY, Lu WM, Lin BJY. Data envelopment analysis 1978-2010: a citation based literature survey. OMEGA 2013a; 41: 3-15.

Liu JS, Lu LYY, Lu WM, Lin BJY. A survey of DEA applications. OMEGA 2013b; 41: 893-902.

Oh I, Lee JD, Hwang S, Heshmati A. Analysis of product efficiency in the Korean automobile market from a consumer's perspective, Empirical Economics 2010; 38(1): 119-137.

Papagapiou A, Mingers J, Thanassoulis E. Would you buy a used car with DEA? OR Insight 1997; 10: 13-19.

Papachristodoulou C. A DEA model to evaluate car efficiency. Applied Economics 1997; 29: 1493-1508.

Podinovski VV, Bouzdine-Chameeva T. Weight restrictions and free production in Data Envelopment Analysis. Operations Research 2013; 61(2):426-437.

Rust RT, Oliver RL. Service quality: insights and managerial implications from the frontier. In Rust RT, Oliver RL (Eds.), Service Quality: New Directions in Theory and Practice. Thousand Oaks, Sage Publications, 1994, pp. 1-20.

Seiford LM, Zhu J. Context-dependent data envelopment analysis: measuring attractiveness and progress. OMEGA 2003; 31: 397-408.

Shudir K. Competitive pricing behavior in the Auto market: A structural analysis, Marketing Science 2001; 20(1): 42-60.

Smirlis Y, Despotis DK, Jablonsky J, Fiala P. Identifying “best-buys” in the market of prepaid mobile telephony: An application of imprecise DEA. International Journal of Information Technology and Decision Making 2004; 3(1): 167-177.

Staat M, Hammerschmidt M. Product performance evaluation: a super efficiency model. International Journal of Business Performance Management 2005; 7(3): 304-319.

Sun S. Assessing computer numerical control machines using data envelopment analysis, International Journal of Production Research 2002; 40(9): 2011-2039.

Thrall RM. What is the economic meaning of FDH? Journal of Productivity Analysis 1999; 11, 243-250.

Train KE, Winston C. Vehicle choice behavior and the declining market share of U.S. automakers. International Economic Review 2007; 48(4): 1469-1496.

Vázquez L. La racionalidad económica de la concesión en la venta y reparación de automóviles. Cuadernos de Economía y Dirección de Empresas 2000; 5: 51-66.

Voltes-Dorta A, Perdiguero J, Jiménez JL. Are car manufacturers on the way to reduce CO2 emissions? a DEA approach. Energy Economics 2013, 38: 77-86.

Zeithaml VA. Consumer perceptions of price, quality, and value: a means-end model and synthesis of evidence. Journal of Marketing 1988; 52: 2-22.

Table 1. Product efficiency and competitive improvement after dealer discounts

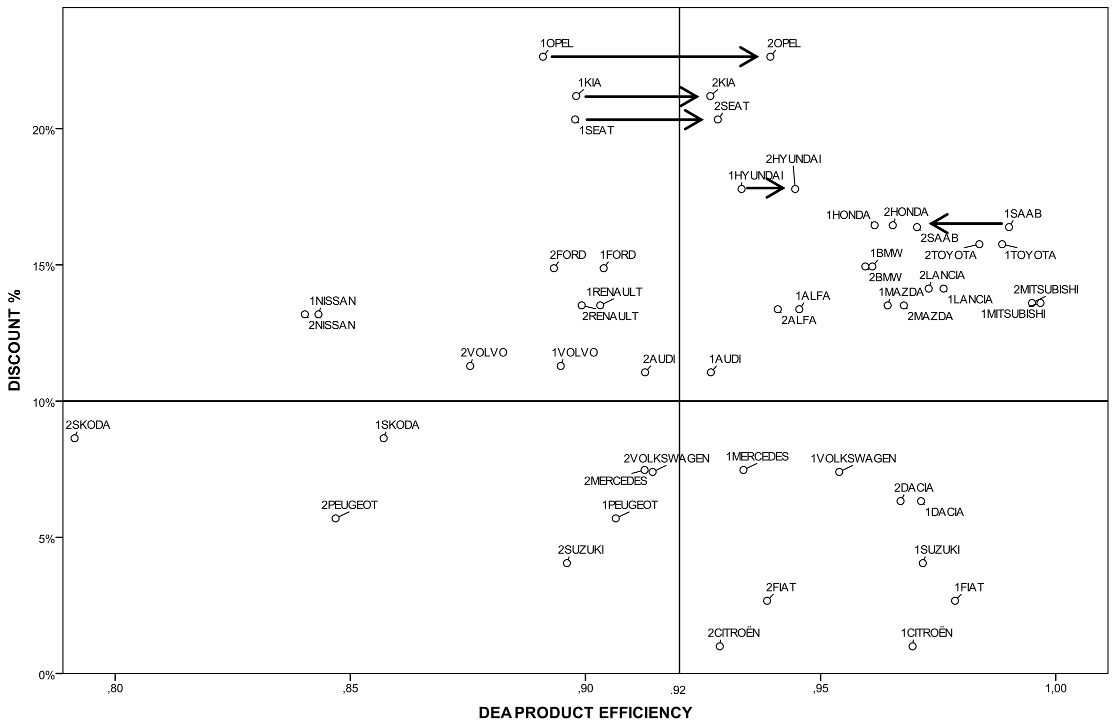
BRAND	Product Efficiency Official Price θ_o	Product Efficiency Discounted price θ_d	Dealer Discount	Competitive Improvement *CI*	Commercial Effort *CE*	Intensification of Competition *IC*
ALFA ROMEO	0.945	0.941	13.4%	0.995	1.156	1.161
AUDI	0.927	0.913	11.1%	0.985	1.125	1.144
BMW	0.961	0.960	14.9%	0.999	1.178	1.181
CITROËN	0.970	0.929	1.0%	0.957	1.011	1.059
DACIA	0.971	0.967	6.3%	0.995	1.068	1.073
FIAT	0.979	0.939	2.7%	0.959	1.028	1.073
FORD	0.904	0.893	14.9%	0.990	1.181	1.194
HONDA	0.961	0.965	16.5%	1.004	1.198	1.193
HYUNDAI	0.933	0.945	17.8%	1.014	1.219	1.203
KIA	0.898	0.927	21.2%	1.036	1.275	1.236
LANCIA	0.976	0.973	14.1%	0.997	1.166	1.171
MAZDA	0.964	0.968	13.5%	1.004	1.157	1.153
MERCEDES	0.934	0.913	7.5%	0.978	1.084	1.114
MITSUBISHI	0.997	0.995	13.6%	0.998	1.160	1.162
NISSAN	0.843	0.840	13.2%	0.997	1.154	1.157
OPEL	0.891	0.939	22.6%	1.058	1.297	1.227
PEUGEOT	0.906	0.847	5.7%	0.933	1.061	1.139
RENAULT	0.903	0.899	13.5%	0.998	1.159	1.163
SAAB	0.990	0.971	16.4%	0.980	1.210	1.237
SEAT	0.898	0.928	20.3%	1.039	1.258	1.213
ŠKODA	0.857	0.791	8.6%	0.921	1.095	1.191
SUZUKI	0.972	0.896	4.1%	0.921	1.043	1.137
TOYOTA	0.989	0.984	15.8%	0.995	1.189	1.195
VOLKSWAGEN	0.954	0.914	7.4%	0.957	1.081	1.131
VOLVO	0.895	0.875	11.3%	0.977	1.130	1.158
Average	0.937	0.924	0.123	0.987	1.147	1.163

Table 2. Drivers of dealership discounts

	Specification 1 Premium/Generalist dummies		Specification 2 Brand dummies	
Variable	**Coefficient**	**t-test**	**Coefficient**	**t-test**
Intercept	0.148	2.5*	0.145	3.1***
Product efficiency	-0.076	-2.1**	-0.041	-2.4**
Volume	0.001	0.71	0.001	1.0
Premium dummy	-0.010	-1.9*		
Generalist dummy	0.006	1.8*		
Age	0.009	2.9***	0.003	2.2**
New dummy	-0.030	-2.2**	-0.030	-4.2***
Gasoline dummy	0.007	2.0*	0.004	2.4**
Brand Dummies				
Audi			-0.033	-5.3***
BMW			0.010	1.3
Citroën			-0.115	-13.1***
Dacia			-0.086	-11.4***
Fiat			-0.114	-11.5***
Ford			0.011	3.3***
Honda			0.019	2.2**
Hyundai			0.030	4.9***
Kia			0.065	8.4***
Lancia			-0.006	-0.8
Mazda			0.010	1.2
Mercedes			-0.071	-7.8***
Mitsubishi			-0.006	-0.6
Nissan			0.001	0.1
Opel			0.076	10.6***
Peugeot			-0.090	-10.9***
Renault			-0.005	-0.7
Saab			0.020	1.8*
Seat			0.057	7.2***
Škoda			-0.062	-6.5***
Suzuki			-0.082	-8.2***
Toyota			0.015	1.8*
Volkswagen			-0.055	-9.2***
Volvo			-0.035	-3.5***

* significance level 0.1 **significance level 0.05 *** significance level 0.01

Figure 1. Competitive positioning of brands before (1) and after (2) discount



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