Inzinerine Ekonomika-Engineering Economics, 2014, 25(3), 320–332

Two-Step Method Useful For Support of Technical Benchmarking Practice in the Automotive Market

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crossref http://dx.doi.org/10.5755/j01.ee.25.3.2659

The aim of this paper is to present a two-step method useful for support of product benchmarking practice in the automotive industry by measuring a technical value of car model. This method assumes that a car is a bundle of objectively and subjectively measurable attributes (i.e. functional features) provided to users. The car's technical value is thus a measure of the overall benefit it delivers to users, while the car's technical efficiency measures a relative benefit the users gain when they utilize a particular car model charged by certain ownership and usage costs. Technical efficiency is calculated by implementing Data Envelopment Analysis (DEA). As an example, the method is implemented to conduct a retrospective benchmarking study in the Italian domestic passenger car market in the years 1970s-1990s. Results show that cars differed remarkably due to their technical efficiency, but only 35 car models in the sample have been classified by DEA as 100 % efficient. Car models sold in the 1980s resulted not so competitive in terms of technical efficiency as models sold in the 1970s and 1990s. The results also revealed that the technical value increases with the purchasing cost, but it diminishes with the usage cost.

As additional value to literature and practice, the method suggests insights about how: a) to compare cars in a multi-dimension features space; b) to analyze technological trends in the car industry; c) to study the car market structure and identify the emergence of market niches still unexploited by automotive manufacturers.

Keywords*: data envelopment analysis, car, benchmarking, efficiency, product value, purchasing price, cost of usage.*

Introduction

Since the mid of the last century, in all developed countries, automotive industry has played a leading role and become a core industry for the creation of wealth and growth of the economical systems. Automotive industry went through an intense transformation to meet the challenge that is coming from the market in terms of customers' preferences, competition, need for manufacturing and development cost and time compression, environmental concerns, more pressing safety regulations, and opportunities offered by technology advancement (Calabrese, 2009). As a consequence, innovation in the automotive industry has acquired major significance, with an intensive effort of OEMs to develop new more performing car models, increase comfort and passengers safety, reduce manufacturing costs and fuel consumption, meet challenging environment needs, and a differentiated consumer demand (Goldberg, 1995; Klepper, 2002). In the last decades, due to this continuous pressure to innovate, increasing product complexity and rapid technology progress, the amount of R&D expenses that OEMs have to budget every year has achieved about 4.5% of total costs in their profit and loss statement, while about 5 % of the final market price of a car model accounts for R&D costs. Statistics also show that about 40% of total R&D expenses are absorbed by car models which are unable to achieve the targeted business revenue (Oliver Wyman Automotive, 2012). For these reasons, a sound technical or product benchmarking practice can be a valuable means that might assist car manufacturing companies to improve their innovative performance identifying trajectories for improving products and make them more competitive and appealing in the market (Griffin, 1997; Neely, 1999; Shetty, 1993). Product benchmarking is carried out in companies to compare the characteristics and performance of products they sell in the market with those of excellent competing companies with the aim to evaluate the state-of-the-art of the embodied technology, improve their design, manufacturing process, and marketing strategy and, finally, achieving competitive advantage (Lema & Price, 1995; Schumann, 1996). A major issue in the benchmarking analysis is identification of benchmark measurements, e.g. the standards of excellence against which to measure and compare product characteristics performance and carry on performance gap analysis (Bowman & Faulkner, 1994). Within the product development and manufacturing environment engineers and technical managers implement different approaches and adopt several tools that help collecting data and process information for product benchmarking purposes, i.e. Reverse Engineering, patent analysis and mapping, QFD, Taguchi DOEs, FMEA, DFMA, AHP (Bergquist & Abeysekera, 1996; Bradley & Guerrero, 2011; Hauser & Clausing, 1988; lo Storto, 2006; Nair, 1992; Tsui, 1992; Otto & Antonsson, 1993; Partovi, 1994; Samuelson & Scotchmer, 2002). However, many times collecting of data and implementing of benchmarking analysis may be a very costly and time consuming activity.

The aim of this paper is to present a two-step method that supports benchmarking practice in the automotive industry in the preliminary phase of the development process using data freely available and expert judgments.

This method measures technical value of a car model and investigates how this is associated to some economic variables, i.e. the purchasing price and cost of usage of the car. Measuring the value that a product delivers to users and investigating its determinants is of paramount importance to design and sell in the market the products that meet the consumers' expectation (Maleki *et al*., 2013).

In the first step, *the method implements Data Envelopment Analysis (DEA)* to calculate relative technical efficiency of a car model (CTE) as a weighted benefit to cost ratio where benefits are measured by a set of functional features performance measurements (i.e., engine performance, quality, etc.) and costs are the car purchasing and usage costs. A sample of car models is used to generate a benchmark for comparison. In the second step, *a regression analysis is run to investigate the existence of any relationships between the technical value measure of cars in the sample and the economic variables associated to them*, using CTE measure to split sample into meaningful groups. The technical value is measured as a function of the benefits provided by car. Henceforth, while in the first step benchmarking takes into account single car models, even though each one is compared to the others or a reduced number of them, in the second step benchmarking is aimed at investigating general trends.

In terms of additional value to literature and practice, the suggested method provides useful insights as to: a) how to compare cars in a multi-dimension features space; b) how to compare cars in terms of the objective technical value delivered to customers; c) how to analyze technological trends in the car industry; d) how to study the car market structure and identify the emergence of market niches still unexploited by automotive manufacturers. Moreover, this method is flexible and its implementation can be easily extended to other industries such as aircraft, computers and printers, household appliances, cellular phones, etc.

This paper is organized as follows. After the introductory issues in the first section, the second section presents the general framework of the benchmarking method and explains how variables are measured. In this section, steps 1 and 2 of the method are illustrated, too. The last two sections show the results relative to the implementation of the method in the Italian domestic car market in the years 1970s-1990s, and present some concluding remarks.

The Method

A General Framework

In the method, a car is conceptualised as a set of technological features that deliver measurable functionalities to the users. Technological features relate to what a product is, while functional features relate to what a product does (Saviotti & Metcalfe, 1984).

Technological features include all technological subsystems and components that are embodied in the tangible products. For instance, for a car these features are engine type, suspension type, transmission system, air conditioning equipment, etc. All subsystems and components are working according to certain scientific principles and design rules. These technological features are the outcome of the choices of engineers, technological advancement, and best engineering practices adopted in the automotive industry at the time a car model is developed. Functional features include the set of functions the product delivers to the users. For instance, for a car these functions are mobility, safety, comfort, quality, etc. Usually, one technological feature affects more than one functional feature. So, there is no one-to-one mapping between the two sets of technological and functional features.

This conceptualisation of a car is consistent with what happens in the market. Indeed, Lancaster (1966, 1971) suggests that consumers choose and buy product characteristics rather than products themselves that are considered just as black boxes. Often, the users are fully ignorant of the technological components and systems embodied in a car and how these work integrated together. Thus, for passenger car users it is not relevant if a four or six cylinder engine is assembled in their car, but engine power or speed are surely more important when they choose a particular car model and decide to buy it. As in the model suggested by Saviotti & Metcalfe (1984), the method proposed in this paper takes into account technological features (TF) and functional features (FF) of a car, but uses the set of functional performance (FP) that is associated to the functional features of a car, which are more easily measurable than technological features. The functional performance items are finally clustered into a number of functional performance categories (FPC) that measure the performance of groups of homogeneous functionalities delivered by a car to the users (Figure 1,a). Measurements for these features give a quantitative indication of the benefits offered to car users and, at the same time indirectly, of the nature of the technology embodied in a car model. The technical value of a car model (CTV) is thus assumed to be a function of the functional performance category set (FPC_i) associated to functional features FF_1, FF_2, ..., FF_m:

$$CTV = f(FPC_1, FPC_2, ..., FPC_s) \quad (1)$$

CTV is thus a measure of the *overall benefit* a car delivers to users. When using a car, the consumers are also concerned with the price they have to pay for car availability, i.e. the ownership price of the product, and the cost they have to bear to use the car. The decision to buy a car is thus influenced by the product benefit/cost ratio. The *overall car technical cost* (CTC) that users have to bear to benefit by functional features FF_1, FF_2, …, FF_m is a function of the amount of these partial costs C_1, C_2, …, C_p

$$CTC = g(C_1, C_2, ..., C_p) \quad (2)$$

The technical efficiency of a car can be measured as the ratio of CTV to CTC measurements (Fig. 1,b):

$$CTE=\frac{CTV}{CTC} \quad (3)$$

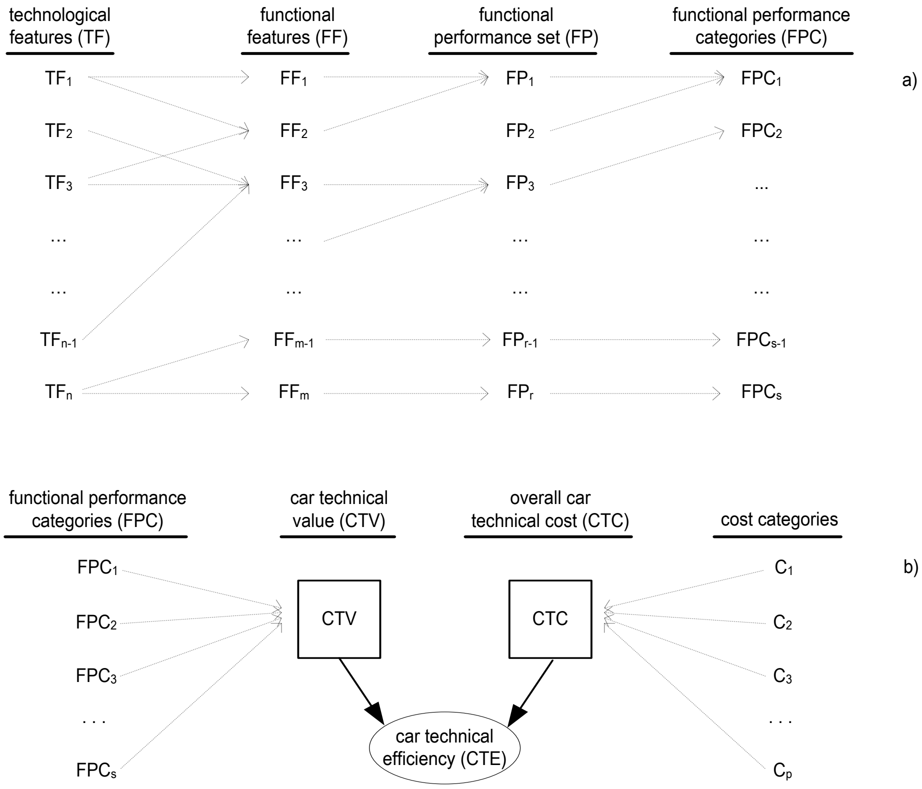

Figure 1. The framework

Thus, a car's technical efficiency measures the *relative benefit* the users gain when they are using a particular car model charged by certain costs.

Table 1

Variables used for measuring benefits and costs

	functional performance set
Benefits	
ENGINE	engine power, torque, capacity, car mass
MOBILITY	max speed, acceleration, pick up
SAFETY	braking space and quality, safety equipment
QUALITY	noise, comfort, internal fittings, space, ventilation, equipment, driving
Costs	
PPC	car price
PUC	(average) fuel consumption

The Measurement of Variables

For convenience, it is assumed that both CTV and CTC can be formulated respectively as the weighted summation of the normalized measurements of a set of four functional features performance, ENGINE, MOBILITY, SAFETY, and QUALITY, and the weighted sum of the normalized measurements of the car ownership price, PPC, and usage cost, PUC (Table 1). Particularly, as to the measurement of benefits, the ENGINE variable is used as a proxy for measuring the performance of the car engine; it depends on the engine power, engine torque, engine capacity, and car mass. The MOBILITY variable is a proxy which measures the car moving performance in terms of its maximum speed, acceleration and pick up functional features. In order to take into account several operational conditions of a car, this variable is measured by averaging several measurements relative to the acceleration and pick up car performance. The SAFETY measures the performance of the capability of a car to assure safety for the passengers and pedestrians. The measurement of this variable requests both subjective and objective evaluation of the braking performance, safety equipment, and driving quality of a car. The QUALITY functional performance variable relates to the extent a car provides the users (passengers and driver) with expected quality standards as to the internal fittings, comfort, driving easiness, etc. As to the measurement of costs, the car purchasing price, PPC, is used as a measure of the ownership cost, while fuel consumption, PUC, is used for measuring the cost of product usage. As to the cost of car usage, the operational costs of a car which are reported in trade literature are calculated assuming that the driver will travel a fixed distance every year (i.e., 5,000 km, 10,000 km, or 20,000 km), and include the product depreciation too; the consequence is a strong correlation between the purchasing price of a car and the operational cost on one side. Moreover, the cost of car usage might be exaggeratedly affected by the oil price. Consequently, to avoid any bias due to correlation between variables and market context variables, fuel consumption may be conveniently adopted as a proxy for measuring the cost of product usage. Major details are reported in Table A.1 in the Appendix.

Step 1: measuring the car model technical efficiency

Data Envelopment Analysis (DEA) is used to calculate technical efficiency rate (CTE) of a car model. DEA is a flexible non-parametric linear programming method developed as a reformulation of the Farrell (1957) efficiency measure to the multiple-output, multiple-input case that evaluates relative efficiency of a number of units, comparing the levels of inputs and outputs of one unit with its competitors, and generating a discrete piece-wise frontier determined by a set of efficient reference units (Charnes *et al.*, 1978). A unit (here, a car model) is considered technically 100 % efficient when any other unit uses a larger quantity of at least one of the input factors to achieve the same output amount. Efficient cars with “unusual” combinations cannot be directly compared to a reference car. A car model is found to be inefficient if it is possible to construct a “virtual” reference car as a linear combination of other cars, such as the virtual car produces at least the same amount of performance outputs while it uses a lower amount of inputs than the real car under examination. As an optimization method, DEA neither relies on the traditional assumptions required by many other types of analysis such as regression, nor requires any explicit specification of underlying functional relationship that links inputs to outputs or any weights to be assigned a priori.

The example in Figure 2 graphically illustrates how DEA works and measures technical efficiency of units. For simplicity, three units - Unit A, Unit B, and Unit C - are compared, and two outputs O_1 and O_2 and one input I_1 are respectively produced and consumed by each unit. For further simplification, let us assume that each unit uses the same amount of input I_1 and that the measure of such amount is 10. The measures of the output produced by the three units are as follows: Unit A (O_1=180, O_2=35), Unit B (O_1=90, O_2=45), Unit C (O_1=40, O_2=105).

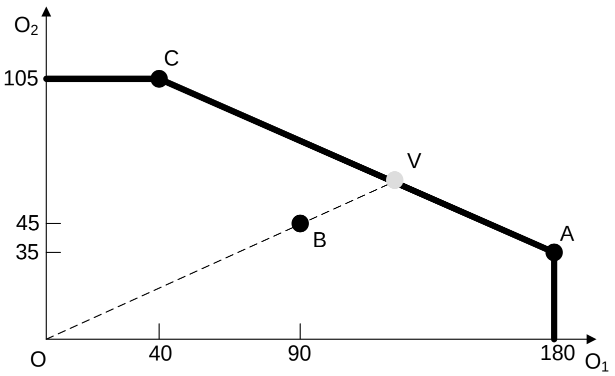

Figure 2. How DEA works

DEA determines if there exists a virtual unit that performs better than one or more of the real three units in the example. The line segment linking Unit A to Unit C is called the efficient frontier under the assumption of convexity. This frontier defines the maximum combinations of outputs that can be produced for the assigned input. Indeed, the segment AC lies beyond both the segment AB that can be drawn between Unit A and Unit B and segment BC drawn between Unit B and Unit C. As a consequence, a convex combination of Unit A and Unit C has the capability to generate the most output for a given set of inputs. Since Units A and C lie on the efficient frontier they are considered 100% efficient, but as Unit B lies under the efficient frontier, it is considered inefficient and its efficiency (or inefficiency) can be measured as the ratio OB/OV, where V is a virtual Unit formed through a combination of Unit A and Unit C. Units A and C are the reference set for Unit B. The efficiency rate of B is 70,7 %, while it is 100% for both A and C.

DEA has revealed to be a very useful method in the practice of benchmarking, as it provides insights as to the potential improvement capabilities of a unit, indicates sources of inefficiency, and also makes it possible to take into account the existence of preferences when efficiency rates are calculated (lo Storto, 2013; lo Storto & Ferruzzi, 2013).

DEA supplies several information that can be used in the benchmarking analysis: a) a relative rating of products classifying them as “efficient” or “inefficient”; b) the reference set for each inefficient product, that is the set of relatively efficient products to which it has been most directly compared in calculating its efficiency rating; c) the relative amount of specific inputs over-utilized or outputs under-produced by inefficient products.

Several DEA models are available for measuring unit efficiencies (Cooper *et al.*, 2006). The proposed method uses BCC DEA model introduced by Banker *et al.* (1984) which allows taking into account scale economies due to size difference. As car models compared in the benchmarking study can be very different, one might suspect that the relationship between inputs and outputs involves variable returns to scale, i.e., that there exists a varying relationship between increasing output and input.

The formulation of the input-oriented DEA BCC model in the envelopment form is as follows (Cooper *et al.*, 2006):

$$\begin{aligned} &\min_{\Theta_B,\lambda} \ \Theta_B \\ \text{subject to} \quad &\Theta_B x_0 - X\lambda \geq 0 \\ &Y\lambda \geq y_0 \\ &e\lambda = 1 \\ &\lambda \geq 0, \end{aligned} \tag{4}$$

where
$X = (\mathbf{x}_j) \in R^{m \times n}$ and $Y = (\mathbf{y}_j) \in R^{s \times n}$ are a given data set, $\boldsymbol{\lambda} \in R^n$ is a column vector with all elements non-negative, $\boldsymbol{e}$ is a row vector with all elements equal to 1, and Θ_B is a scalar.

Step 2: investigating the relationship between CTV, PUC, and PPC

Even though BCC DEA model does not allow to have a ranking of car models based on the calculated technical efficiency rate, this later can be used to cluster car models into homogeneous groups as to the efficiency score, i.e. a group including only 100% efficient car models, and a number of remaining groups that contain not efficient car models. At this step of the analysis, the measurements of the 4 functional features performance categories, ENGINE, MOBILITY, SAFETY, and QUALITY are aggregated to get an unweighted measure of the car technical value uCTV. The quadratic mean is calculated to aggregate measurements of the four functional performance variables, as the quadratic mean is particularly sensitive either to high or low values, thus making it possible to emphasize evident differences. At this stage of the benchmarking analysis, the relationships between the dependent variable uCTV, and the independent variables PUC and PPC can be investigated adopting the technical efficiency score class as a moderating variable of this relationship. This analysis is complementary to the analysis performed in step 1. As in step 1, the *Cost of Product Usage* (*PUC*) and the *Product Purchasing Cost* (*PPC*) can be imagined as resources that the users have to give up to use a car model and to enjoy its functionalities that provide them with a benefit measured by the *unweighted Car Technical Value* (*uCTV*). Thus, both *PUC* and *PPC* variables can be considered as factors of a production function that produces value (*uCTV*) to the car user. A convenient way to identify a formal relationship linking together these variables is to use the Cobb-Douglas formulation (Bridge, 1971; Cobb & Douglas, 1928; Richmond, 1974):

$$uCTV = \mathrm{a}PUC^{\mathrm{b}}PPC^{\mathrm{c}} \quad (5)$$

Here a is a constant, which depends on the units in which inputs and outputs are measured, while b and c are constants that take into account the relative importance of *PUC* and *PPC* in delivering technical value *uCTV* to car users. No particular assumptions or constraints relative to values assumed by these constants are imposed in the estimation of these parameters.

An Example: the Italian Domestic Car Market from the 1970s to 1990s

The Italian passenger car domestic market from the early 1970s to the 1990s was considered to implement the benchmarking method. All the car models selected for the analysis were ordinary passenger cars that have been equipped with conventional spark ignition petrol engines or turbocharged spark ignition engines. Data relative to cars have been collected from trade literature having as a reference three temporal market windows, the 1970-72s market (37 car models), the 1980-82s market (82 car models), and the 1990-93s market (97 car models). Each sub-sample was selected with the aim of having a good mix of all passenger cars sold in Italy in that period. The data were collected from trade literature (GenteMotori, 1980 to 1993; Quattroruote, 1970 to 1993). The use of published data found in the automotive press has the advantage of standardization, completeness, and impartiality of measurement. However, the need to assess and compare subjectively features required the researcher to consult an expert of the automotive field. In this case, a five points Likert-type scale was used to measure functional features' performance that could be measured only by means of subjective expert judgements (Table A.1 in Appendix). Moreover, to get comparable data, the purchasing prices for all cars were measured with reference to the year 1993 using the consumer price index CPI(1993). Next, the results relative to step 1 and step 2 are illustrated.

Table 2

The outcome of DEA: means of variables across groups[*]

variable	G1 CTE=100% # 35	G2 82,91%<CTE<100% # 90	G3 CTE<=82,91% # 91
engine capacity (cc)	2,070,31 [1,359]	1,514,91 [642,71]	1,774,59 [618,36]
car price (€, CPI 1993)	26,055 [34,161]	14,620 [15,390]	15,568 [12,738]
# cars in the 1970s	5 (14%)	19 (51%)	13 (35%)
# cars in the 1980s	3 (4%)	22 (27%)	57 (69%)
# cars in the 1990s	27 (28%)	49 (51%)	21 (22%)
efficiency score	100%	89,99% [4,67%]	73,17% [7,60%]
PUC	0,470 [0,156]	0,412 [0,077]	0,476 [0,085]
uCTV	0,626 [0,104]	0,533 [0,088]	0,535 [0,057]
ENGINE	0,463 [0,154]	0,382 [0,112]	0,383 [0,074]
MOBILITY	0,479 [0,142]	0,393 [0,088]	0,408 [0,064]
SAFETY	0,704 [0,129]	0,595 [0,115]	0,565 [0,085]
QUALITY	0,772 [0,123]	0,689 [0,114]	0,708 [0,075]

[*]*In square brackets standard deviations and in round brackets percentages are respectively indicated*

Step 1

Table 2 shows the outcome of DEA. The sample was split into three groups, depending on technical efficiency score. Particularly, group G1 contains 100 % efficient car models. The second group G2 contains car models whose technical efficiency rate is between 82,91 % and 100 %, while group G3 includes car models having technical efficiency lower than 82,91 %. The 82,91 % threshold is the median of the smaller sample made of 181 non efficient cars. The average sample technical efficiency is 81,53 %, while the minimum score is 45,21 %. Thus, there is a great variance as to efficiency of passenger cars in sample.

Table 3

The outcome of DEA: the 100 % efficient car models

car model	year	engine capacity	engine power	max speed	price	occurrence in reference sets	type of market
Fiat 127	1970s	903	47	143,85	5,153	61	
Mazda RX2 Coupè	1970s	1,146	130	183,54	12,756	0	niche
Innocenti Mini Cooper 1300	1970s	1,275	71	160,71	7,398	12	
Fiat 128 Rallye	1970s	1,290	67	152,93	6,939	5	
Simca 1000 Rallye 1	1970s	1,294	60	153,03	5,505	40	
Renault Alpine Turbo	1980s	1,397	110	184,5	11,386	7	
Talbot Sunbeam Lotus	1980s	2,172	155	197,1	15,357	0	niche
Jaguar XJ 5.3	1980s	5,345	287	227,8	47,249	0	niche
Fiat 500 new (700)	1990s	704	30	119,76	5,060	32	
Subaru M80 5P	1990s	758	42	142,75	6,027	94	
Fiat 500 new (900)	1990s	903	41	136,03	5,871	11	
Daihatsu Charade Gti Turbo	1990s	993	101.35	194,9	11,131	145	
Autobianchi Y10 Avenue	1990s	1,108	50.5	147,88	8,547	50	
Peugeot 306XT 1.4	1990s	1,360	75	165,6	11,349	7	
Fiat Uno 1.4 IE sx 5P	1990s	1,372	71	166,7	9,270	9	
Opel Corsa Swing 1.4 ie 3P	1990s	1,388	60	155,6	7,953	10	
Renault Clio automatic	1990s	1,390	76.5	163,83	11,104	17	
Opel Astra 1.6i GLS 5P	1990s	1,598	100.5	190	11,110	13	
Peugeot 306XT	1990s	1,761	102.8	184,7	11,938	4	
Audi 100 2.0 16V Avant	1990s	1,984	140	204,21	26,722	1	
Audi 100 2.0 Ecat	1990s	1,984	115.5	188,08	23,250	6	
Volvo 850 GLT L	1990s	1,984	143	202,3	20,710	2	
SAAB 900 Saero	1990s	1,985	112.9	208,2	21,095	0	niche
Ford Mondeo 2000 Ghia	1990s	1,988	134	206,99	15,205	16	
Ford Superescort RS luxury	1990s	1,993	223.35	224,3	28,121	0	niche
Rover 220 Turbo	1990s	1,994	200	237,8	19,548	17	
Honda Accord 2.0i 16V Coupè	1990s	1,997	133	202,15	20,090	3	
Nissan Sunny Gti - R	1990s	1,998	220	22,37	25,554	1	
Opel Astra Gsi 16V	1990s	1,998	150	218,79	15,748	11	
Maserati Ghibli	1990s	1,998	306	262,6	41,774	8	
Mercedes 280E-24V	1990s	2,799	197	230	38,815	0	niche
Alfa Romeo 164 V6 24V super	1990s	2,959	210	240	33,505	1	
Ferrari 512 TR	1990s	4,943	428	314	143,916	12	
Lamborghini Diablo VT	1990s	5,707	492	325	157,668	0	niche
Jaguar XJR-s	1990s	5,993	333,5	253,45	69,092	1	

Table 2 shows some relevant findings from DEA:

- car models that are 100% technical efficient are more expensive having a higher purchasing price (or, the normalized PPC), even though the standard deviation of this variable is great;
- unexpectedly, most cars (69 %) in group G3 that includes less efficient models were sold in the 1980s, while only 4 % of passenger cars in these years is 100 % efficient;
- the amount of car models sold in the market in the 1970s and belonging to group G2 is the same of cars sold

in the 1990s, while the amount of 1980s cars in this group remains smaller. These figures clearly make evident that passenger cars sold in the Italian market in the 1980s were not as competitive as cars in the 1970s and 1990s. That is not surprising, as between the end of the 1970s and the mid of the 1980s there was a profound restructuring of the manufacturing and product development processes in search of a higher production efficiency to decrease costs and achieve better product quality. Indeed, there was a great effort to survive competition coming from the Far East car manufacturers, primarily from Japan. This effort was successful as the automotive industry was able to improve performance of both manufacturing and product development processes;

- on the average, car models in group G1 have higher functional feature performance measures and an overall uCTV, but – in the same time – are more expensive, even though with a great price variance.

Table 3 illustrates some details relative to 35 car models identified by DEA as 100 % efficient. As the previous table showed, this group of cars is rather variegated as it contains models that belong to several market segments classified, for instance, as A (i.e., Fiat 127), B (Simca 1000 Rallye), or even sport cars (Lamborghini Diablo VT). That should not be surprising, as DEA identifies efficient units on the base of the ratio of weighted outputs to weighted inputs. The last column but one presents information that is useful to assess the competitiveness of cars, i.e. the number of times each model compares in the reference set of an inefficient car. Seven passenger cars – Mazda RX2 Coupè, Talbot Sunbeam Lotus, Jaguar XJ5.3, Saab 900 Saero, Ford SuperEscort RS luxury, Mercedes 280E-24V, and Lamborghini Diablo VT – have only themselves as a reference car, not being in any reference set. This information can be used to identify market niches of the product offering. "A niche market is a relatively small segment of a market that the major competitors or producers may overlook, ignore, or have difficulty serving. The niche may be a narrowly defined geographical area, it may relate to the unique needs of a small and specific group of customers, or it may be some narrow, highly specialized aspect of a very broad group of customers" (Gross *et al*., 1993, p. 360). Effective niche strategies may be sometimes very profitable, because a niche market may actually be very large. Emphasis on niche marketing provides a very clear focus for the development of business strategies and action plans. As a final comment about figures in the "occurrence in reference sets" column, two car models merit particular attention, Daihatsu Charade Gti Turbo and Subaru M80 5P, the first one in the reference sets of 145 cars and the second in those of 94 cars. So, even though both cars are efficient, they occupy a market position that clearly is not defendable. Unexpectedly, the Ferrari 512 TR that was sold in the market in the 1990s appears in the reference sets of 12 cars, including some cars that do not belong to the same market segments (e.g., BMW 318i and BMW 730i). Of course, customers who buy a Ferrari car do not expect to have higher technical value as the only benefit for their expensive purchase!

The analysis of the reference sets of inefficient car models provides insights about the nature of competition in the market. Table 4 reports the reference sets for some inefficient car models extracted from sample. As to the first car in table, Volkswagen Golf 2,8 vr6, three cars of its reference set are clearly in the same market segment (Ford Mondeo 2000 Ghia, Rover 220 Turbo, and Alfa Romeo 164). Even, this car has as its reference a Ferrari. The second car, Citroen Gs Club, has in its reference set two car models sold in the market twenty years later (both Fiat 500) and one car that in the 1970s was in a higher market segment (Fiat 128 Rallye). Two cars, Fiat Ritmo 75s and Fiat Argenta 2000, have the same reference set made of cars positioned in a lower market segment (A). But, the comparison of Fiat Argenta with cars of the reference set is much more unfavorable (as emphasized by the efficiency score). Indeed, in the automotive market positioning Fiat Argenta is much more distant from segment A than Fiat Ritmo. Finally, Jaguar XJS 4.2, which is the lower performing car in sample in terms of technical efficiency, is compared with cars that position between the A and B market segments, even though the reference cars appeared in the market ten years later.

Table 4

The reference sets of some inefficient car models

car model	reference set
VOLKSWAGEN Golf 2,8 vr6	Ford Mondeo 2000 Ghia, Rover 220 Turbo, Alfa Romeo 164 V6 24V super, Ferrari 512 TR
CITROEN Gs Club	Fiat 127, Fiat 128 Rallye, Fiat 500 new (700), Fiat 5oo new (900)
FIAT Ritmo 75S	Subaru M80 5P, Daihatsu Charade Gti Turbo, Autobianchi Y10 Avenue
FIAT Argenta 2000	Subaru M80 5P, Daihatsu Charade Gti Turbo, Autobianchi Y10 Avenue
JAGUAR XJS 4.2	Daihatsu Charade Gti Turbo, Renault Clio automatic

Table 5 shows some information that further makes evident the strength of DEA in the practice of product benchmarking. In particular, this table illustrates how DEA can be used to identify some improvement trajectories for inefficient car models. The efficiency rating provided by DEA suggests the degree of inefficiency of a car model compared with a virtual car on the frontier defined by its reference set. However, it does not provide any ranking of cars. Thus, for instance, the car model Fiat Argenta 2000 is about 63,66 % efficient compared with its reference set cars, while Citroen Gs Club is about 82,91 % efficient if compared with cars on its reference frontier segment (Fiat 127, Fiat 128 Rallye, and both Fiat 500 new models). Generally, this means that Fiat Argenta should reduce the cost of usage and purchasing price by approximately 36,34 % = 100 % - 63,66 % without decreasing the performance of any functional features delivered to users in order to increase its overall efficiency score. In theory, technical efficiency of inefficient cars might be improved either by increasing the functional performance outputs or by decreasing inputs used (e.g., cost of usage and purchasing price).

Table 5 summarizes the DEA outcome regarding specific inputs that inefficient cars over-utilize or outputs that they under-produce. The extent to which inputs can be reduced is indicated as a negative percentage by figures in columns "PPC" and "PUC", while extra output generated by the inefficient car moving toward the efficient frontier as positive percentage in the remaining columns (Engine, Mobility, Safety, and Quality) that indicate the extent to which output benefits should be increased to move the car to the efficient frontier. For instance, the car model Fiat Ritmo 75s can become efficient by decreasing its purchasing price by about 29 %. As a general rule for decision-making, if on the average the excess of a certain input is extremely high, that input is not critical because there might be large room for improvement. Vice versa, if the input excess is very low, that input variable might be seriously critical when redesigning that car model because of a limited space of action.

Table 5

Potential improvement of functional features/potential reduction of costs for some car models

car model	years	CTE (%)	PPC	PUC	ENGINE	MOBILITY	SAFETY	QUALITY
VOLKSWAGEN Golf 2.8 vr6	1990s	89,60	-10,4 %	-10,4 %	17,0 %	0 %	0 %	3,8 %
CITROEN Gs Club	1970s	82,91	-17,1 %	-17,1 %	1,0 %	0 %	0 %	9,1 %
FIAT Ritmo 75S	1980s	74,29	-29,4 %	-25,7 %	1,4 %	0 %	21,91 %	0 %
FIAT Argenta 2000	1980s	63,66	-42,4 %	-36,4 %	0 %	0 %	31,23 %	0,77 %
JAGUAR XJS 4.2	1980s	45,21	-67,3 %	-54,8 %	2,2 %	0 %	10,6 %	0 %

Table 6

The outcome of the nonlinear regression analysis

	G1 (CTE = 100%)			G2 (82,91% < CTE < 100%)			G3 (CTE≤ 82,91%)		
parameter	estimate	t-value	p-level	estimate	t-value	p-level	estimate	t-value	p-level
a	0,831	32,759	0,000	0,810	27,611	0,000	0,756	32,994	0,000
b	-0,370	-4,299	0,000	-0,268	-4,466	0,000	-0,224	-4,296	0,000
c	0,269	9,343	0,000	0,252	15,855	0,000	0,211	12,628	0,000
	loss function final value=0,0642			loss function final value=0,1409			loss function final value=0,0914		
	% variance explained=83,7 %			% variance explained=79,6 %			% variance explained=68,5 %		
	R=0,915			R=0,892			R=0,828		

Step 2

In step 2, benchmarking study is conducted at a more aggregate level, in order to identify some general trends which can guide marketing professionals, engineers and designers in their search for a better and more successful product.

Table 6 shows the outcome of the regression analysis between the unweighted car technical value (uCTV) as a dependent variable and the car cost of usage (PUC) and purchasing price (PPC) as independent variables. Particularly, using the equation presented in (5) and the Livenberg-Marquardt least square estimation method, a nonlinear regression was performed for each group. Table 6 provides information relative to parameter estimates, statistical significance, and predictive reliability. All parameters are significant at least 1 %, and variance absorbed is between 68,5 % and 83,5 %. In all cases, estimate of parameter *b* is negative, while estimate of *c* is positive. Thus, uCTV increases when the purchasing price (PPC) increases, and diminishes when the cost of usage (PUC) of a car increases. The uCTV sensitiveness to PUC increase is higher in group G1. A graphical visualization of these relationships may better support the analysis.

Figures 2a, 2b, 2c illustrate how uCTV changes as a function of PUC, for fixed PPC values. These plots disclose how the investigated relationship may be affected by the technical efficiency score. In particular, for a low purchasing price (Figure 2,a), when PUC is greater than 0,6, inefficient cars of group G3 seem to behave better in terms of technical value delivered to users. But, when PUC is far below this threshold, efficient cars in group G1 provide higher benefit. Worth to note that cars in group G3 behave better than cars in group G2, even being less efficient.

With a small purchasing price increase (Figure 2,b), the PUC threshold that determines a change in the way cars belonging to different groups behave moves ahead, about PUC=0,8. For this purchasing price, cars in group G2 are better than cars in group G3.

Moving to the last graph, the better behavior of cars in group G2 compared to cars in group G3 becomes more evident.

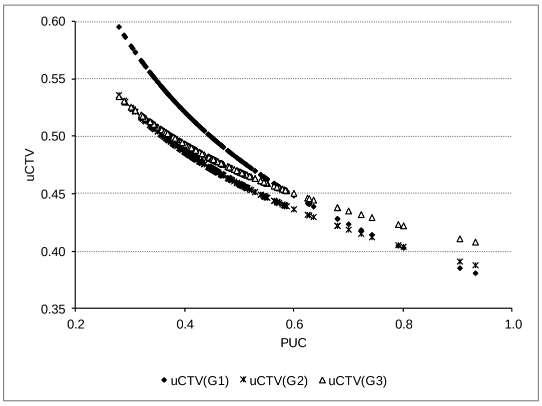

Figure 2, a. Plot of uCTV vs PUC, PPC=0,05

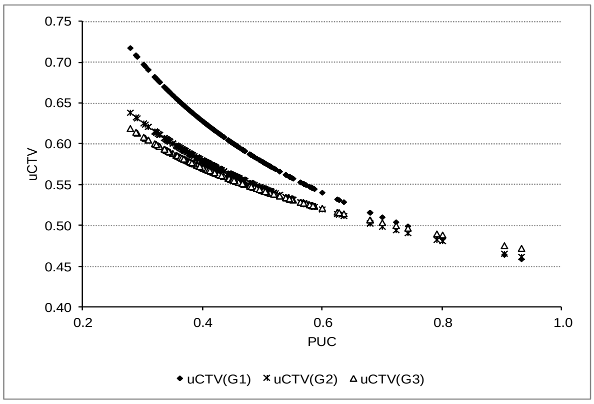

Figure 2, b. Plot of uCTV vs PUC, PPC=0,10

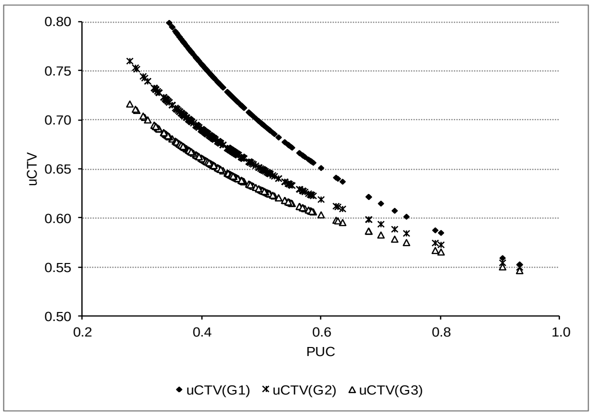

Figure 2, c. Plot of uCTV vs PUC, PPC=0.20

Conclusion

This paper has proposed a two-step method useful for implementation of the benchmarking practice to compare products in the automotive market. It is assumed that a car is a bundle of objectively and subjectively measurable attributes or functional features delivered to the users.

In the first step, the method adopts Data Envelopment Analysis to calculate the relative technical efficiency of a car model (CTE) as a weighted benefits to costs ratio where benefits are associated to a set of functional features performance measures (Engine, Mobility, Safety, and Quality) and costs are measured by the car purchasing and usage costs. A sample of car models is used to generate a benchmark for comparison. In the second step, a nonlinear regression analysis is run to investigate the existence of relationships between the measure of technical value of car models and the associated economic variables, using the CTE measure to split the sample into meaningful groups. The technical value is measured as a function of the benefits provided by a car. Henceforth, while in the first step product benchmarking has a micro-analytic perspective, focusing on single car models and taking into account the specific measurements of their features, even though each car is compared to the others or to a reduced number of them, in the second step benchmarking has a macro-analytic perspective, aimed at investigating general trends in the market.

As an illustrative case, the method has been implemented to benchmark a sample of 216 cars that were sold in the Italian domestic market between the 1970s and the early 1990s. The results show that passenger cars in the sample differ remarkably as to their technical efficiency, but only 35 car models have been classified by DEA as 100 % efficient. This group of efficient cars includes models that belong to several market segments, i.e. city cars or sport cars. Generally, 100 % efficient car models tend to be more expensive than not efficient cars having a higher purchasing price. In the second step of the method the findings revealed that car's technical value CTV increases when the car's purchasing price (PPC) increases, but it diminishes when the cost of usage of a car (PUC) goes up. Passenger car models sold in the market in the 1980s resulted not so competitive in terms of technical efficiency as models sold in the 1970s and 1990s. The method has also provided useful insights as to the nature of competition in the Italian car market from 1970s to 1990s. In particular, seven market niches have been identified. Car models that are in these niches such as the Mazda RX2 Coupè, Talbot Sunbeam Lotus, Jaguar XJ 5.3, Saab 900 Saero, Ford SuperEscort RS luxury, Mercedes 280E-24V, and Lamborghini Diablo VT had some specific combinations of functional features that made them unique car models in the market. Unexpectedly, the Ferrari 512 TR sold in the market in the 1990s was not a market niche car, as it was a benchmark for 12 different car models, even not belonging to the same market segment, such as the BMW 318i and BMW 730i models. Furthermore, some car models sold in the 1970s remained still competitive in the 1980s and 1990s, as the Citroen Gs Club, while some others were competitive in different market segments, e.g. the Fiat Ritmo 75s. The method also suggested how to improve specific performance categories for each inefficient car model to make them more competitive in the market.

Even though the method has been applied to conduct a retrospective analysis of the Italian car market, the utilization of a set of objective and subjective metrics for measuring performance of functional features delivered to the users and cost parameters rather than technology features embodied in a car makes it simple, flexible and easily implementable to study the present country-specific car markets worldwide. The method may easily incorporate further functional features measurements. That is the case of parameters that measure the extent to which a car is environment respectful. Until the 1990s environmental concerns were not challenging in the Italian car market, and for this reason - given the specificity of the sample that collects cars sold between 1970s and 1990s – the implementation of the method has not taken into account any environmental concerns, i.e. tailpipe emissions, carbon dioxide production, and recycling. When a more refined analysis is needed, all or some functional measurements may be fragmented into their components using these later as the outputs in DEA implementation. Finally, the method's flexibility allows introducing a weighting system that accounts for the preferences that consumers have either for certain functional categories or some functional features by adding further constraints in DEA model formulation.

Furthermore, application of the method can be extended to other industries such as aircraft, computers and printers, cellular phones, household appliances, etc.

The adoption of such a method as a technical benchmarking and product analysis tool could help managers to make sound decisions and plans. Indeed, the positioning of a product based on a sound benchmarking of functional features is useful to explore the market competitive inter-relationships among different products in the same segment or belonging to different segments, and to identify temporal changes in a manner that is similar in appearance to a perceptual map. Generating measurements for the technical value and the technical efficiency of a product linked to its capability to provide the users with benefits associated to a set of functional features suffering some ownership and usage costs helps to get information and alleviate ambiguity related to a number of issues, i.e. an in-depth comprehension of the nature of competition relative to certain types of product features, the relative assessment of the whole set of product performance, how to increase product performance by improving specific functional and technological features, the correct product pricing and advertising strategy, the identification of gaps or niches within some segments of the market, etc. In general, the comparative assessment of products provides managers with important insights as to how products can be improved or new product can be developed to fit more closely with the opportunities offered by technology and market needs, giving the company a competitive edge. Indeed, measuring the technical efficiencies of products and mapping their functional features may contribute to gain insights related to current and prospective product offering, helping to find business opportunities for improving the existing products or launch new product in the market. As the state of technology does not remain static either in the short or the long run, and new technology devices can be mounted in a product to have better or new functionalities at disposal of the users, the method can also be usefully adopted to implement dynamic benchmarking studies, as it was illustrated by the analysis of the Italian car market presented in this paper. For instance, in the short run one way that products compete in the market is by leapfrogging each other in terms of performance - whether measured in speed, safety, quality, comfort, reliability, etc. When the measurements of the technical efficiencies of a sample of products either in the same or in different segments are averaged and used as a single efficiency score, the product's technical efficiency can be utilized to have a picture of the technology state in that product market, or to trace the evolution of the technical value of the product in its market segment over time, and analyze the relationships between performance, technology, and costs.

Of course, the benchmarking studies which adopt the proposed method that is fundamentally based on the analysis of product features support rather than substitute for the perceptual data that can be provided by customers when market demand should be analyzed (see, for instance, Djokic *et al*., 2013). Methods that take into account perceptual data remain critical to understand the determinants of the consumers purchasing behavior and the relation between this and their perception of product value (Kazakeviciute & Banyte, 2012).

Appendix

Table A.

Measurements of variables

$$ENGINE^i = \left(\frac{POW^i_{ENG}}{CAP^i_{ENG}} \cdot \frac{TOR^i_{ENG}}{MASS^i} \right)^{\frac{1}{2}}$$

$POW^i_{ENG} =$ max engine power of car i, $TOR^i_{ENG} =$ max engine torque of car i, $CAP^i_{ENG} =$ engine capacity of car i,

$MASS^i =$ mass of car i

All measurements are objective and available in trade technical literature. $ENGINE^i$ was further normalized in the range [0, 1] by dividing its measurement by the maximum ENGINE value in sample.

$$MOBILITY^i = \left[\left(AC^i_1 \cdot AC^i_2 \cdot AC^i_3 \cdot AC^i_4 \cdot AC^i_5 \cdot AC^i_6 \right)^{\frac{1}{6}} \cdot \left(U^i_1 \cdot U^i_2 \cdot U^i_3 \cdot U^i_4 \right)^{\frac{1}{4}} \cdot V^i_{MAX} \right]^{\frac{1}{3}}$$

$AC^i_1 =$ acceleration of car i in the space [0 - 1 km], $AC^i_2 =$ acceleration of car i after 400 m,

$AC^i_3 =$ acceleration of car i to increase speed from 0 to 60 kmh, $AC^i_4 =$ acceleration of car i to increase speed from 0 to 80 kmh,

$AC^i_5 =$ acceleration of car i to increase speed from 0 to 100 kmh, $AC^i_6 =$ acceleration of car i to increase speed from 0 to 120 kmh,

$U^i_1 =$ pick up of car i to increase speed from 40 kmh, $U^i_2 =$ pick up of car i to increase speed from 70 to 80 kmh,

$U^i_3 =$ pick up of car i to increase speed from 70 to 100 kmh, $U^i_4 =$ pick up of car i to increase speed from 70 to 120 kmh,

$U^i_4 =$ pick up of car i to increase speed from 70 to 120 kmh, $V_{MAX} =$ max speed of car i

All measurements are objective and available in trade technical literature. $MOBILITY^i$ was further normalized in the range [0, 1] by dividing its measurement by the maximum MOBILITY value in sample.

$$SAFETY^i = \left[\left(BRAS^i \cdot BQ^i \right)^{\frac{1}{2}} \cdot \left(S^i_1 \cdot S^i_2 \cdot S^i_3 \cdot S^i_4 \right)^{\frac{1}{4}} \right]^{\frac{1}{2}}$$

$$BRAS^i = \frac{\frac{MASS^i}{MASS^{MAX}}}{\frac{\left(BS^i_1 \cdot BS^i_2 \cdot BS^i_3 \right)^{\frac{1}{3}}}{BS^{MIN}}}$$

$BQ^i =$ subjective measure of the braking quality of car i, $BRAS^i =$ braking space of car i, $MASS^i =$ mass of car i,

$MASS^{MAX} =$ maximum car mass in sample, $BS^i_1 =$ braking space of car i at speed of 60 kmh,

$BS_2^i =$ braking space of car i at speed of 80 kmh, $BS_3^i =$ braking space of car i at speed of 100 kmh,

$BS_3^i =$ braking space of car i at speed of 100 kmh, $BS^{MIN} =$ minimum $\left(BS_1^i \cdot BS_2^i \cdot BS_3^i\right)^{\frac{1}{3}}$ in sample,

$S_1^i =$ subjective measure of the steering quality of car i, $S_2^i =$ subjective measure of the visibility quality of car i,

$S_3^i =$ subjective measure of the road holding quality of car i, $S_4^i =$ subjective measure of the safety equipment quality of car i

All subjective measurements were provided by expert judgment by means of a 5 level Likert type scale in the range [0, 1]. Objective measurements were available in trade technical literature. SAFETY^i was further normalized in the range [0, 1] by dividing its measurement by the maximum SAFETY value in sample.

$$QUALITY^i = \left[\left(NO_1^i \cdot NO_2^i \cdot NO_3^i \cdot NO_4^i\right)^{\frac{1}{4}} \cdot \left(IQ_1^i \cdot IQ_2^i \cdot IQ_3^i \cdot IQ_4^i \cdot IQ_5^i\right)^{\frac{1}{5}} \cdot CO^i\right]^{\frac{1}{3}}$$

$NO_1^i =$ internal noise level of car i at speed of 60 kmh, $NO_2^i =$ internal noise level of car i at speed of 80 kmh,

$NO_3^i =$ internal noise level of car i at speed of 100 kmh, $NO_4^i =$ internal noise level of car i at speed of 120 kmh,

$IQ_1^i =$ subjective measure of the car i internal fittings quality,

$IQ_2^i =$ subjective measure of the car i internal ventilation and climate quality,

$IQ_3^i =$ subjective measure of the car i internal equipment quality, $IQ_4^i =$ subjective measure of the car i internal space quality,

$IQ_5^i =$ subjective measure of the car i driving seat quality, $CO^i =$ subjective measure of the car i travel comfort quality

All subjective measurements were provided by expert judgment by means of a 5 level Likert type scale in the range [0, 1]. Objective measurements were available in trade technical literature. QUALITY^i was further normalized in the range [0, 1] by dividing its measurement by the maximum QUALITY value in sample.

$$uCTV^i = \left(\frac{ENGINE^{i2} + MOBILITY^{i2} + SAFETY^{i2} + QUALITY^{i2}}{4}\right)^{\frac{1}{2}}$$

$$PUC^i = \left(FU_1^i \cdot FU_2^i \cdot FU_3^i\right)^{\frac{1}{3}}$$

$FU_1^i =$ fuel consumption of car i in city driving, $FU_2^i =$ fuel consumption of car i at speed of 90 kmh,

$FU_3^i =$ fuel consumption of car i at speed of 120 kmh

$$PPC_{1993}^i = \frac{CPI(1993)}{100} \cdot PPC_t^i$$

$CPI(1993) =$ the 1993 consumer price index, $PPC_{1993}^i =$ purchasing price of car i at year 1993,

$PPC_t^i =$ purchasing price of car i sold at year t

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Corrado lo Storto

Dviejų etapų metodo taikymas automobilių rinkos lyginamajai analizei

Santrauka

Technikos pramonės gaminių palyginimas gali būti vertinga priemone, padedančia automobilių pramonės gamintojams sustiprinti savo inovacinę veiklą, numatyti perspektyvą kaip pagerinti savo gamybą ir padaryti ją konkurencinga ir patrauklia rinkoje. Gaminių palyginimas leidžia kompanijoms ne tik palyginti ar įvertinti savo gaminių savybes ir veiklą su konkuruojančių kompanijų gaminių savybėmis ir veikla, tačiau ir įvertinti įdiegtos technologijos šiuolaikiškumą, taip pat gerinti jų projektavimą, gamybos procesą, rinkodaros strategiją ir taip įgyti tvirtą konkurencinį pranašumą.

Šiame darbe pasiūlytas dviejų etapų metodas: a) leidžiantis palyginti gaminius automobilių pramonėje, prieš tai įvertinus jų techninę vertę, kurią automobilis suteikia vartotojams ir b) išsiaiškinti, kaip tai siejasi su automobilio pirkimo kaina ir naudojimo kaštais.

Šioje analizėje, automobilis yra suvokiamas kaip techninių charakteristikų rinkinys, kuris suteikia tam tikras funkcijas ir kurios yra vertinamos vartotojų. Techninės charakteristikos asocijuojasi su pačiu gaminiu, o funkcionalumo savybės asocijuojasi su gaminio veiksmu. Techninės charakteristikos apima visas technologines posistemes ir sudėtines dalis, kurios yra automobilyje, t. y. variklio tipas, pakabos tipas, transmisijos sistema, oro kondicionavimo įranga ir t. t. Visos posistemės ir sudėtinės dalys veikia pagal tam tikrus techninius principus ir projektavimo taisykles. Šios techninės charakteristikos yra inžinierių pasirinkimo, technologinės pažangos, automobilio kūrimo laiko ir automobilių pramonėje pritaikytų geriausių inžinerinių praktikų rezultatas. Funkcionalumo savybės atlieka daug funkcijų, kurias automobilis suteikia vartotojams, t. y. mobilumas, saugumas, komfortas, kokybė ir t. t. Dažniausiai viena techninė charakteristika daro įtaką kartais vienai, kartais daugiau nei vienai funkcinei savybei. Iš tiesų, vartotojai renkasi ir perka greičiau jau gaminio charakteristikas, negu patį gaminį, kuris tiesiog yra laikomas tarsi „juoda dėže“. Dažnai vartotojai visiškai ignoruoja automobilio technologinius komponentus ir sistemas bei tai, kaip jie veikia visi kartu. Keleivinių automobilių vartotojams ne taip svarbu ar automobilyje įmontuotas keturių ar šešių cilindrų variklis, tačiau variklio galia arba greičio matai tikrai yra labai svarbūs jiems renkantis konkretų automobilio modelį ir nusprendus jį pirkti. Metodas panaudoja seriją funkcinės veiklos (FV), siejamos su automobilio funkcinėmis savybėmis (FS), kurią įvertinti yra daug lengviau negu technines charakteristikas. Funkcinės veiklos punktai yra sugrupuojami į keletą funkcinės veiklos kategorijų (FVK), kurios įvertina homogeniškų funkcijų, kurias automobilis suteikia vartotojams, veiklą. Šių savybių įvertinimai parodo automobilio naudotojams siūlomos naudos kiekybinę indikaciją ir tuo pat metu netiesiogiai, automobilio modelyje apjungtų technologijų pradinę kiekybinę indikaciją. Pirmame etape metodas pritaiko *Duomenų apsupties analizę* (DAA), kad apskaičiuotų santykinį techninį automobilio modelio efektyvumą (ATE), nes svertinis naudos ir kaštų santykis yra siejamas su serija funkcinių savybių, kategorijos veiklos įvertinimų, galinčių apibūdinti konkretų automobilio modelį (variklis, mobilumas, saugumas, ir kokybė), o kaštai yra įvertinami pagal automobilio pirkimo ir naudojimo kaštus. Norint sukurti palyginimui rodiklį, yra naudojamas automobilių modelių pavyzdys. Antrame etape, norint išsiaiškinti ryšį tarp automobilių modelių techninės vertės įvertinimo ir susijusių ekonominių kintamųjų egzistavimo, atliekama nelinijinė analizė, tam panaudojant ATE įvertinimą Techninė vertė įvertinama kaip automobilio teikiamos naudos funkcija. Nors pirmame etape gaminių palyginimas turi mikroanalitinę perspektyvą, tačiau šiuo atveju sutelkiamas dėmesys į atskirus automobilių modelius ir atsižvelgiama į jų charakteristikų specifinius įvertinimus. Antrame etape palyginimas turi makroanalitinę perspektyvą, nukreiptą į bendrų rinkos krypčių nagrinėjimą.

Metodas buvo įdiegtas norint ištirti rodiklius Italijos vietinių keleivinių automobilių rinkoje 1970-1990 metais. Pirmame etape rezultatai parodė, kad keleiviniai automobiliai, parduoti Italijos rinkoje nuo aštuntojo iki dešimtojo dešimtmečio, labai skyrėsi vertinant jų techninį efektyvumą. Tik 35 automobilių modeliai paimti pavyzdžiais, DAA buvo klasifikuoti kaip 100% efektyvūs. Šioje efektyvių automobilių grupėje yra modelių, kurie priklauso keliems rinkos segmentams, t. y. miesto arba sportiniai automobiliai. Iš tikrųjų, 100% efektyvūs automobilių modeliai yra brangesni už neefektyvius automobilius. Didelis automobilių modelių skaičius (90) pasiekia aukštą techninio efektyvumo laipsnį, nuo 100% iki 82.91%, kur paskutinis efektyvumo įvertinimas yra „vidutinis efektyvumo matmuo“ kitame, mažesniame pavyzdyje, kuris apima tik 181, o ne 100% efektyvių automobilių modelių. Keleivinių automobilių modeliai, parduoti rinkoje devintajame dešimtmetyje, buvo ne tokie konkurencingi techninio efektyvumo prasme kaip modeliai, parduoti aštuntajame ir dešimtajame dešimtmečiuose. Iš tiesų, tik 4% keleivinių automobilių yra 100% efektyvūs. Nuo aštuntojo dešimtmečio pabaigos iki devintojo dešimtmečio vidurio Europos ir JAV automobilių gamintojai investavo daug pinigų, kad padidintų gaminių efektyvumą ir kokybę savo gamyklose ir pateiktų rinkai geresnių gaminių. Metodas taip pat pateikė naudingas įžvalgas apie konkurencijos esmę Italijos automobilių rinkoje nuo aštuntojo iki dešimtojo dešimtmečio. Buvo nustatytos septynios rinkos nišos, įskaitant automobilių modelius, turinčius tam tikras funkcinių savybių kombinacijas, kurios daro juos unikaliais Italijos automobilių rinkoje.

Antrame etape buvo atliktas lyginamasis tyrimas bendresniu lygiu, turint tikslą nustatyti bendras kryptis, kurios galėtų būti naudingos rinkodaros profesionalams, inžinieriams ir projektuotojams, kuriant geresnį ir sėkmingesnį gaminį automobilių pramonėje. Rezultatai parodė, kad automobilio techninė vertė didėja, kai didėja automobilio pirkimo kaina, bet mažėja, kai kyla automobilio naudojimo kaštai.

Pasiūlytas metodas buvo pritaikytas norint atlikti retrospektyvinę Italijos keleivinių automobilių rinkos analizę, tačiau ir objektyvių ir subjektyvių rodiklių panaudojimas, norint geriau įvertinti efektyvumą, kurį automobilis suteikia vartotojui, ir kaštų parametrus, o ne technines charakteristikas, apjungtas automobilio modelyje, daro šį metodą tinkamu taikyti, net jei būtų analizuojamos dabartinės pasaulio automobilių rinkos, turinčios savos šalies specifiką. Siūlomas metodas kaip papildomą vertę siūlo naudingas įžvalgas: a) kaip palyginti automobilius, vertinant kelių matmenų savybes erdvėje, vartotojams prieš tai pateikiant objektyvias technines vertes; b) kaip analizuoti technologines kryptis automobilių pramonėje; c) kaip nagrinėti automobilių pramonės struktūrą ir nustatyti rinkos nišas, kurių dar neeksploatuoja automobilių gamintojai, atsiradimą. Tokio metodo taikymas gali būti labai naudingas rinkodaros ir techniniams vadovams priimant teisingus sprendimus ir planus. Metodo privalumą sudaro didelis taikymo paprastumas, nes jis panaudoja nemažai objektyviai ir subjektyviai vertinamų funkcinių savybių bei kaštų parametrų, kurių dauguma yra pateikiami techninėje literatūroje. Dar daugiau, metodas yra labai lankstus ir gali lengvai įtraukti tolesnius funkcinius instrumentus. Tai toks rodiklis, kuriuo įvertinama ar automobilis yra tausojantis aplinką (tai nebuvo įtraukta į analizuojamą Italijos automobilių rinkos atvejį, nes tai nebuvo aktualu pavyzdyje įtrauktiems to meto automobilių modeliams, parduotiems rinkoje). Taip pat, šį metodą galima pritaikyti ir kitose srityse, pvz.: lėktuvų, kompiuterių ir spausdintuvų, namų ūkio prekių, mobiliųjų telefonų ir t.t.

Raktažodžiai: *duomenų apsupties analizė, automobilis, palyginimas, efektyvumas, gaminio vertė, pirkimo kaina, naudojimo kaštai*.

The article has been reviewed.

Received in October, 2012; accepted in June, 2014.