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Improving Efficiency in Fast Food Restaurants A Frontier Approach

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Abstract

Measurement of operating efficiency is indispensable for service businesses. Modern and rigorous methodologies for quantifying overall efficiency are required in competitive sectors such as the restaurant industry in Spain. For example, chain restaurant managers need tools for carrying out a benchmarking process among their own or franchised restaurants to identify which ones are inefficient and, as result, set targets for the improvement of their inputs and outputs in order to make them efficient. For this purpose, a methodology known as data envelopment analysis is used to measure the overall operating efficiency of a leading Spanish restaurant chain. The study found that, by correcting the inefficiencies identified through the model, profit improvements amounting over 1.5 million euros could be achieved.

Keywords

Operating efficiency, data envelopment analysis, restaurant industry, benchmarking, improvement targets

Resumo

A medição da eficiência de operações é indispensável para os negócios na área dos serviços. Sectores competitivos, como é o caso do sector da restauração em Espanha, requerem metodologias modernas e rigorosas para quantificarem a eficiência na sua globalidade. Por exemplo, os gestores de cadeias de restaurantes necessitam de ferramentas para poderem levar a cabo um processo de benchmarking nos seus próprios restaurantes franchisados de modo a identificar os que não são eficientes e, consequentemente, estabelecer metas para melhorar os seus inputs e outputs de modo a torná-los eficientes. Neste sentido, a metodologia conhecida como análise por envolvimento de dados é utilizada para medir a globalidade da eficiência de operações de uma cadeia de restaurantes líder em Espanha. O estudo mostra que, corrigindo as ineficiências identificadas pelo modelo, podem ser atingidos aumentos de lucro superiores a 1.5 milhões de euros.

Palavras-chave

Eficiência de operações, análise por envolvimento de dados, sector da restauração, benchmarking, metas de melhoria

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1 Introduction

Survival and the creation of value in both manufacturing and service businesses that operate in an environment of growing competitiveness undoubtedly requires the measurement and continued improvement of their operating efficiency. This concept is clearly defined in microeconomic theory, although it has rarely been applied to business management due to the lack of suitable techniques for these conditions. However, there has been significant interest in academic and business circles regarding its measurement, which is traditionally relegated to the calculation of partial productivity ratios.

The concept of efficiency is an especially useful tool in analysing the management of companies that do business through multiple business units, such as restaurant or hotel chains in the tourist industry. Follow-up of these units has usually taken place based on the monitoring of a number of absolute variables, such as turnover, costs grouped in various categories, consumption and results. These variables have frequently been complemented by others of a relative nature – ratios – associated with the concept of profitability or productivity. In the latter case, the numerator which appears in the ratios is an output, e.g. the units produced or sold of a given product or service, while the denominator is an input, e.g. the number of employees. What is known as partial productivity measure is thereby obtained. There are several examples of productivity ratios employed in the hospitality sector as meals produced/number of kitchen staff, total guest rooms/total kilowatt hours, restaurant revenue/total management salaries, food cost/food sales, etc. (Ball, Johnson and Slattery, 1986). These ratios can be designed to measure financial results or relationships between physical inputs and outputs, however financial measures are preferred by hospitality managers (Messenger and Mugomeza, 1995).

Unfortunately, several problems associated with the follow-up of business units based on ratios exist. Firstly, their conjunction is difficult in order to obtain an overall view of the business performance (Thanassoulis, Boussofiane and Dyson, 1996). However, it is essential to consider outputs and inputs simultaneously in the quest for productivity (Ball, Johnson and Slattery, 1986). For this purpose, tools such as the well-known "balanced scorecard" (Kaplan and Norton, 1996) have been devised. Nevertheless, these techniques generally fail in their attempt to obtain an overall view of the operation of the business. Kaplan (1990) argues that measures conducted in isolation do not give senior management the full picture for making effective decisions on strategy. Secondly, when comparing different size units, ratio analysis assumes constant returns to scale. In other words, it is supposed that performance does not depend on the size of facilities. Thirdly, environmental or non-discretionary factors influencing performance such as, location or area wealth, are not taken into account when performance measures are computed regardless of the technique applied (Banker and Morey, 1986; Lozano-Vivas, Pastor and Hasan, 2001). Finally, improvement targets set by managers based on traditional partial performance measures usually utilise as bottom line historical measures (Kaplan, 1990) while improvement targets are often set arbitrarily. However, targets for inefficient units should be set as result of a rigorous economic analysis based on a performance benchmarking of the whole units evaluated. In addition, targets should consider environmental factors (location, for instance) and the current service quality levels reached (Kaplan, 1990). For the relationship between quality and performance in the hospitality and restaurant industry see Schroeder (1985), Butterfield (1987), Witt and Moutinho (1994) and Jones (1988).

The aim of this work is to present a technique called Data Envelopment Analysis (DEA) that solve the problems described above. DEA models measure overall operative efficiency and are useful for establishing objectives for its improvement. This methodology is especially suitable for companies working through business units. Data Envelopment Analysis models take advantage of the know how of the business units being analysed, identifying those that are efficient and inefficient, and set improvement objectives for the latter based on the achievements of the former. In other words, they carry out a benchmarking of the units evaluated, using only the information available in the organisation itself regarding its business units, without needing to make any theoretical suppositions. DEA has the advantage of taking into account simultaneously all input and all output levels of a unit analysed (Thanassoulis, Boussofiane and Dyson, 1996). However, DEA models have some drawbacks that should be highlighted. Probably the most important is that the frontiers estimated by DEA models are very sensitive to the outliers. Thus, a previous analysis should always be carried out in order to assure that this units do no exist within the evaluated sample. Fortunately, in our case, this will not be necessary since data has been provided directly by the restaurant chain managers who assured us there was not errors in the data.

This technique is classified within the methodology of frontier models. It is upheld by the rigorous concept of technical efficiency offered in microeconomic theory. It is also supported by the abundant literature that has appeared in the most prestigious scientific publications specialising in business management (Andersen and Petersen, 1993; Athanassopoulos and Shale, 1997; Banker, Charnes and Cooper, 1984; Beasley, 1990; De Borger, Ferrier and Kerstens, 1998; Pedraja-Chaparro, Salinas-Jiménez and Smith, 1999; Seiford, 1995; Wagstaff, 1989; Thanassoulis and Dyson, 1992).

Frontier models have not been profusely applied to the tourism sector. Morey and Dittman (1995) evaluated the performance of a hotel general manager through the application of a DEA model. The model used by these authors was set up to identify the potential reduction in inputs while outputs were maintained (i.e. input minimisation). Two years later, Morey and Dittman (1997) applied DEA in selecting a hotel property. Their model combined DEA and regression analysis to deal with the interfaces between operations management and marketing. Anderson, Fish, Xia and Michello (1999) employed a stochastic frontier technique to estimate managerial efficiency levels in the hotel industry. This limited evidence makes it clear that efficiency analysis is generally lacking in the tourism sector. This paper aims to contribute to this type of study by evaluating the operative efficiency of the restaurant industry using a DEA model.

The remainder of the article is organised as follows: the section "The concept of efficiency" provides an analysis of the microeconomic and conceptual basis for DEA models; the analytical framework is formulated in the section entitled "Methodology". This is followed by the practical application of a DEA model to the modern restaurant industry for the real case of a group of 16 restaurants belonging to a well–known Spanish chain. Although, in this case, the empirical application is focused on the modern restaurant industry, it is equally applicable to other similar cases in the tourist industry, e.g. hotel chains. The article is completed with a synthesis and the main conclusions of the study.

2 The concept of efficiency

Efficiency of a DMU can be estimated by comparing the observed values with the optimum values corresponding to inputs and outputs. This comparison may be made using the maximum obtainable output, for a given level of inputs and the one really attained, or by comparing the minimum level of inputs necessary for a given level of outputs and that really used (Lovell, 1993). Efficiency normally refers to the level of inputs and outputs in physical units, and for this reason it is called operational or technical efficiency. However, the values observed can also be compared with the optimum values of variables such as costs, income and profit, in which case economic efficiency would be measured.

There are three basic problems with calculating efficiency (Lovell, 1993). Firstly, there is the dilemma of how many and which inputs and outputs should be included in the analysis. According to Stiegler (1976), the inefficiency of a production unit may be a result of the failure to include all the inputs and outputs. If the underlying technology is unknown, an essential input or output may easily be omitted. Secondly, how various inputs and outputs should be added when they are expressed in different measurement units. The solution frequently applied is to use prices as a homogenising element, but these are often unavailable or unreliable, especially when evaluating public sector units. Finally, there is the problem of how to determine the optimum level or performance for comparative purposes. This is a truly complex problem. At a theoretical level, it seems obvious that optimum behaviour should be located on the frontier of production, but this is a theoretical concept that cannot be observed in reality. It is for this reason that a considerable amount of literature has appeared regarding how to build empirical production frontiers and how to choose an empirical production unit as a comparative element when evaluating the performance of a specific production unit. The technique presented in this article provides answers to the last two questions.

In existing literature, the general nature of the concept has encouraged the appearance of various definitions. Fundamental contributions have been made by Koopmans (1951), Debreu (1951) and Farrell (1957). Koopmans defined the situation of technical efficiency as one in which an increase in any of the outputs demands a reduction in one of the others or an increase in at least one of the inputs (focusing on outputs), or where the reduction of any input requires at least an increase in another or the reduction of an output (focusing on inputs). On the other hand, Debreu and Farrell defined technical efficiency as either the difference between 1.00 and a coefficient representing the highest proportional reduction in all inputs that still enables all the outputs to be produced (focusing on inputs) or alternatively, as 1.00 plus the highest permitted proportional increase in all the outputs with the same consumption of inputs (focusing on outputs). A DMU with an efficiency coefficient of 1.00 therefore indicates that its performance is not improved by another. An efficiency of less than 1.00 or greater than 1.00, depending on whether an input- or output-based focus respectively has been chosen, will show the level of inefficiency. For example, in a focus on inputs, an inefficiency of 0.85 would indicate that this DMU must reduce consumption of all its inputs by 15% to be efficient. However, in an output-based study, an efficiency level of 1.20 would indicate that all its outputs must be increased proportionally by 20% in order to be efficient.

In fact, Koopmans' concept of efficiency is stricter than that of Debreu-Farrell, and as will be seen, all efficient units in Koopmans' terms are also efficient in those of Debreu-Farrell, while the opposite is not necessarily true. In order to define the Debreu-Farrell (DF) measurement more exactly and to make it comparable with that of Koopmans, some concepts and a notation that will also be useful to us throughout this study will be introduced.

Let there be some DMUs that use the inputs $x=(x_1,...,x_n)\in R^n_+$ to obtain the outputs $y=(y_1,...,y_m)\in R^m_+$.

A production possibility set is defined as:

$$L(y)=\{x:(y,x)\ is\ feasible\} \quad [1]$$

i.e. those levels of use of inputs "x" that produce at least the possible different combinations of the outputs vector "y".

The isoquant is defined as:

$$IsoqL(y)=\{x: x\in L(y),\ \lambda x\notin L(y),\ \lambda\in[0,1)\}$$
[2]

which represents those minimum combinations of inputs "x" necessary to obtain the same output vector "y". As is well known, isoquants are the set of all the possible combinations of production factors sufficient to obtain a given production quantity.

Efficient set is another important concept when describing a technology which can be formally defined as:

$$EffL(y)=\{x: x\in L(y),\ x'\notin L(y),\ x'\le x\}$$
[3]

with the property that all points belonging to the efficient set also belong to the isoquant, thus making the statement $EffL(y)\subseteq IsoqL(y)$ true.

DF efficiency measurement in the case of input-oriented DF can be mathematically expressed as:

$$DF_I(x,y)=min\{\lambda: \lambda x\in L(y)\} \quad [4]$$

with $DF_I(x,y)\le 1$.

Note that:

$$IsoqL(y)=\{x: DF_I(x,y)=1\} \quad [5]$$

means that the unit would denote total efficiency and lower values than 1.00 the importance of inefficiency.

Focusing on the outputs approach the production possibility set would be made up of all the combinations of factors and technologically feasible products that can be formalised in the following way:

$$P(x)=\{y:(x,y)\ are\ feasible\} \quad [6]$$

In this case, the isoquant would be:

$$IsoqP(x)=\{y: y\in P(x),\ \theta y\notin P(x),\ \theta\in(1,+\infty)\}$$
[7]

The efficient set would be defined as:

$$EffP(x)=\{y: y\in P(x),\ y'\notin P(x),\ y'\ge y\}$$
[8]

and the DF efficiency measurement as:

$$DF_o(x,y)=max\{\theta: \theta y\in P(x)\} \quad [9]$$

Thus,

$$DF_o\ (x,\ y) \geq 1 \qquad [10]$$

and:

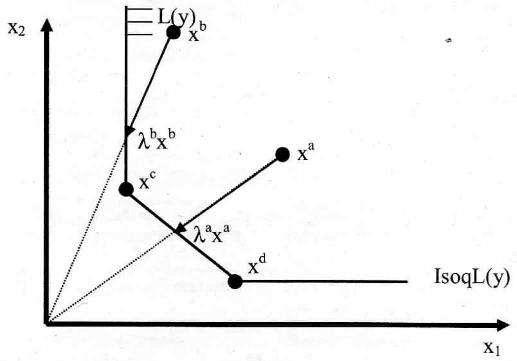
$$IsoqP(x) = \{\ y:\ DF_o\ (x,\ y) = 1\} \qquad [11]$$

denoting the unitary value of total efficiency, while values greater than this denote the level of inefficiency.

Note that Koopmans' definition of efficiency supposes that an efficient DMU will always belong to the efficient set, while Debreu-Farrell's definition of efficiency only supposes that it belongs to the isoquant.

Figure 1 depicts the meaning of the efficiency measurements of Koopmans and Debreu-Farrell, in order to demonstrate the differences between them more clearly.

Figure 1 - Debreu-Farrell's and Koopmans' measurement of technical efficiency (inputs-oriented).

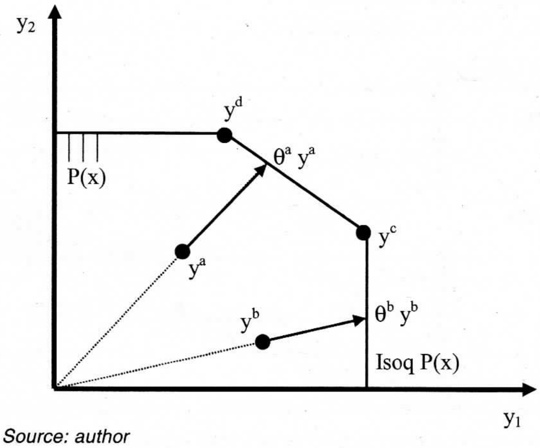


Source: author

The DMUs "x^c" and "x^d" that appear in Figure 1 are efficient, as they lie below the isoquant ($DF_I (x, y) = 1$). Hence, a reduction in any of the inputs would lead to an observation that does not belong to L(y), being obtained, and the outputs vector would thus be different. The DMUs "x^a" and "x^b" are inefficient as they obtain a production of "y", with a worse consumption of inputs than that represented by any of the points belonging to the isoquant. The value $DF_I (x,y)$ represents the maximum proportional reduction of inputs that inefficient DMUs must achieve in order to place themselves above the isoquant. These values are l^a and l^b for x^a and x^b respectively.

According to Koopmans' definition of efficiency, DMUs "x^c" and "x^d" are still considered as efficient, since the increase in output "y" would demand the consumption of an inputs vector not belonging to L(y). In the case of "x^a", a l^a proportional reduction of its inputs would give an observation belonging to the isoquant and the efficient set as a result. So, this virtual unit taken as a reference point to measure inefficiency would be efficient in Koopmans' terms. However, in the case of "x^b" the l^b reduction of its inputs would lead to a value that belongs to the isoquant, but that is not efficient in Koopmans' sense since some input could be reduced with no need to increase any other or to reduce any output. Indeed, the $l^b x^b$ "virtual" DMU is not efficient according to Koopmans, as the consumption of input x_2 may be reduced to the level of x^c, while a production of "y" units is still obtained. Koopmans' definition is therefore stricter than that of Debreu-Farrell, from the point of view that the efficiency in DF terms is necessary but not sufficient for that of Koopmans. Figure 2 depicts the case of outputs. The analysis that can be made of Figure 2 is totally parallel to that considered for the case of inputs.

Figure 2 - Debreu-Farrell's and Koopmans' technical efficiency measurement (outputs-oriented).



Source: author

3 Methodology

DEA models based on the quantities used for inputs and those produced in outputs (Charnes, Cooper and Rhodes, 1978) determine the best practices, by comparing the DMU selected with all possible lineal combinations of the rest of the units in the sample, in order to use them subsequently to define an empirical production frontier. The efficiency of each unit analysed is measured in terms of the distance to the frontier. It is important to highlight that both inputs and outputs may be expressed in either monetary terms or in physical units. This characteristic is a significant advantage of this technique over others.

Unlike traditional methods based on ratios, in which the search for overall performance evaluation measurements generally forces the *a priori* establishment of weighting of outputs and inputs, DEA models provide this measurement of overall efficiency without the need for establishing *a priori* weights. In fact, it is the methodology itself that assigns them, with the weighting employed for one DMU generally being different to that used for another.

As a consequence of the considerable amount of literature that has appeared on the subject (Seiford, 1995), various DEA models have been formulated, the most basic of which are described below.

The first model, initially proposed by Charnes, Cooper and Rhodes (1978), is based on the ratios model, but with the particular characteristic that the weights assigned to the various outputs and inputs are not established *a priori*, but are determined by a lineal programme. Its mathematical formulation for the case of *n* inputs, *m* outputs and I DMUs analysed is as follows:

$$\begin{aligned} & Max \quad \frac{\sum_{r=1}^{m} u_r \, y_{rO}}{\sum_{i=1}^{n} v_i \, x_{iO}} \\ & s.t \\ & \frac{\sum_{r=1}^{m} u_r \, y_{rj}}{\sum_{i=1}^{n} v_i \, x_{ij}} \le 1 \quad j = 1,\ldots,O,\ldots,I \\ & u_r, v_i \ge 0 \quad r = 1 \ldots m \; ; \; i = 1 \ldots n \end{aligned} \qquad [12]$$

where y_{rj} is the output r of the DMU j, x_{ij} the input i of the DMU j, u_r the weight assigned to the output r and v_i the weight of input i.

This lineal programme is solved for each of the units analysed. The efficiency of the DMU analysed is defined as the ratio between the weighted sum of its outputs and the weighted sum of its inputs. However, these weightings are left free in order to maximise the efficiency of the unit analysed and, under this supposition, compare its performance with the rest of the units. The aim of these restrictions is forcing the efficiency ratios of the DMUs included in the analysis to be less than or equal in order to normalise the efficiency coefficient. This will therefore be less than or equal to 1, with the unit denoting the overall technical efficiency and values lower than this the amount of inefficiency.

As can be seen, [12] is not lineal, which makes its numerical resolution difficult. To solve this problem, it can be linealised by means of a simple transformation:

$$\begin{aligned} & Max \quad \sum_{r=1}^{m} u_r \, y_{rO} \\ & s.t \\ & \sum_{i=1}^{n} v_i \, x_{iO} = 1 \\ & \sum_{r=1}^{m} u_r \, y_{rj} \le \sum_{i=1}^{n} v_i \, x_{ij} \quad j = 1,\ldots,O,\ldots,I \\ & u_r, v_i \ge 0 \quad r = 1 \ldots m \; ; \; i = 1 \ldots n \end{aligned} \qquad [13]$$

The formulation [13] of the CCR model is usually called the CCR ratio form, although it is much more common to use its dual program:

$$\begin{aligned} & Min \ \theta \\ & s.t \\ & \left(\sum_{j=1}^{I} \lambda_j \, y_{rj} \right) - s_r^+ = y_{rO} \quad r = 1 \ldots m \\ & \left(\sum_{j=1}^{I} \lambda_j \, x_{ij} \right) + s_i^- = \theta \, x_{iO} \quad i = 1 \ldots n \\ & \lambda_j, s_r^+, s_i^- \ge 0 \; ; \; \theta \in \Re \end{aligned} \qquad [14]$$

Note that as a consequence of the generally accepted characteristics of production technologies, è cannot take a negative value as positive outputs cannot be obtained from a negative input vector or free production. On the other hand, because the objective function is of minimisation, the smallest value for è that fulfils the restriction will be obtained. In fact, what is intended is the search for a lineal combination of DMUs (or reference unit) that attains a greater or equal output level to that of the DMU analysed, with an equal or lower consumption of inputs. This implies that, if such a lineal combination cannot be found, the DMU analysed will itself be obtained as a reference unit, meaning that è will take the value of 1 at most, and therefore $\theta \in (0,1]$.

The overall efficiency rate of the DMU analysed is thus provided by è. Its interpretation is the maximum by which consumption of all its inputs can be reduced without changes in its mix. It is for this reason that this formulation of the problem is oriented towards inputs and it is a radial model.

However, additional decreases can be achieved in some inputs, by admitting changes in the input mix. The objectives established for inputs in this case would be given by the following expression, where the asterisks denote the optimum value of the variables:

$$\theta^* x_{iO} - S_i^{-*} \quad [15]$$

The objective for output *r* must be established as:

$$y_{rO} + S_r^{+*} \quad [16]$$

At the same time, the CCR model oriented towards outputs can be expressed in the following terms:

$$\begin{aligned} & Max \ \phi \\ & s.t \\ & \left(\sum_{j=1}^{I} \lambda_j y_{rj}\right) - s_r^+ = \phi y_{rO} \qquad r = 1 \ldots m \\ & \left(\sum_{j=1}^{I} \lambda_j x_{ij}\right) + s_i^- = x_{iO} \qquad i = 1 \ldots n \\ & \lambda_j, s_r^+, s_i^- \geq 0 \ ; \phi \in \Re \end{aligned} \quad [17]$$

In this case, too, owing to the characteristics of the production technology, the value of Ö will not be negative, as positive outputs cannot be obtained from a negative inputs vector or free production. On the other hand, because the objective function is of maximisation, the greatest value for *f* that fulfils the restriction will be obtained. In fact, what is intended is the search for a lineal combination of DMUs that achieves an output level greater than or equal to that of the DMU analysed, with an equal or lower consumption of inputs. This means that if such a lineal combination cannot be found, the DMU analysed itself will be obtained as a reference unit, so that *f* will take have a value of 1 at most, therefore $\phi \in [1, +\infty)$.

In this case, *f* must be interpreted as the increase that may be attained in all the outputs without changes in its mix. Hence if a DMU can expand all its outputs radially, *f*>1 will be obtained, and in the opposite case, *f*=1. In this case we are also faced with a radial model.

As occurs in the case of orienting the model towards outputs, additional increases can be obtained in some outputs, with changes admitted in the output mix as compensation. The objective that should be established for output *r* in this case would be given by the following expression:

$$\phi^* y_{rO} + S_r^{+*} \quad [18]$$

while the objective for input *i* should be established as:

$$x_{iO} - S_i^{-*} \quad [19]$$

4 Application of DEA Models to the modern restaurant industry

In this section, model [17] is applied to the case of 16 restaurants belonging to an important Spanish chain in the modern restaurant industry. Only one of the models defined theoretically in the previous section is chosen, as a consequence of the similarities of the results that they all provide. Moreover, by only applying one of them, the reader will appreciate the kind of results that can be obtained from this type of model and its interpretation more easily. The output-oriented model [17] has been chosen because it is considered to be the most appropriate for the prevailing business conditions as it priorises the maximisation of outputs based on the available inputs.

The application of any DEA model requires a prior definition of the inputs and outputs to be used in the analysis. Its selection must, in practice, be agreed upon by the evaluator and preferably also with the units evaluated. In our example, annual sales (SALES), expressed in millions of euros and a quality rating of between 1 and 100 (QUALITY), based on the results of internal audits, the mystery shopper and client surveys, have been included as outputs. All the restaurants analysed apply the same prices, since they belong to a local chain. So, efficiency can not be improved by making each restaurant its own decisions on product prices. Regarding the quality variable, one could wonder if perceived quality measures based on customers surveys should be used. In fact, two restaurants with the same "objective" quality (technical quality) could obtain different scores depending on its customers point of view. However, our opinion is that perceived quality has a greater effect in total sales than objective quality. Consequently, all restaurants should effort to achieve the greater levels of perceived quality to increase their sales. Four components as inputs have been selected for each restaurant: the square metres of the business premises (M^2); its location (LOC) valued in a range from 1 to 100 (the reason for including this variable is to consider environmental factors that may increase efficiency); staff costs (STAFF); and total food costs (FCOST). Due to purchasing process is centralised, raw materials are also bought at the same prices for all restaurants. All data were provided directly by the chain managers and refers to 1999. Owing to the fact that headquarters do not allocate advertising expenditures to each store, it made no sense to consider this variable. Detailed data is found in Table 1.

It must be pointed out that all the results exposed below refer to the long-run, since changes in the fixed inputs are allowed in the evaluation (location and restaurant size). Now, we look at the results obtained. The overall efficiency coefficients (*f*) obtained by applying model [17] to the restaurants in the sample are shown in Table 2.

If coefficient *f* is equal to 1.00, it means that the unit is efficient. When it is greater than 1.00, the unit should be interpreted as being inefficient, and the higher this value, the greater the inefficiency of the unit. The additional interpretation that can be made of a value greater than 1.00 for this coefficient is the minimum increase that can be achieved in all the outputs simultaneously, i.e. without changes in the output mix. Hence the greater it is, the less efficient is the unit analysed. For example, in the case of restaurant 11, its efficiency coefficient is 1.109. This means that all its outputs may be

Table 1 - Inputs and outputs utilised

	OUTPUTS		INTPUTS			
RESTAURANT	**SALES**	**QUALITY**	**M²**	**LOC**	**STAFF**	**FCOST**
#	**€**	**(0-100)**		**(0-100)**	**€**	**€**
1	552,931	72	180	60	171,409	163,115
2	877,478	68	220	75	280,793	263,243
3	522,881	59	175	45	146,407	159,479
4	901,518	69	280	62	315,531	279,471
5	1,622,733	59	360	95	535,502	490,065
6	721,215	71	178	92	238,001	214,922
7	691,164	82	186	82	221,172	206,658
8	607,022	71	160	89	182,107	188,177
9	588,992	68	189	65	200,257	194,367
10	1,346,267	81	195	76	457,731	399,841
11	1,177,984	52	236	84	353,395	380,489
12	943,589	68	290	79	273,641	283,077
13	588,992	79	199	87	182,588	172,575
14	619,042	51	173	82	198,093	182,617
15	667,123	78	213	70	220,151	205,474
16	1,009,700	81	247	55	333,201	314,017

Source: author

Table 2 - Efficiency scores

Restaurant	Efficiency coefficient	% Outputs increase
1	1.000	0.00
2	1.158	15.77
3	1.039	3.93
4	1.186	18.63
5	1.000	0.00
6	1.093	9.32
7	1.000	0.00
8	1.000	0.00
9	1.121	12.12
10	1.000	0.00
11	1.109	10.89
12	1.041	4.05
13	1.006	0.55
14	1.460	45.96
15	1.049	4.91
16	1.000	0.00

Source: author

Table 3 - Maximum increases attainable in each output

Restaurant	Sales (€)	Increase %	Quality	Increase %
1	552931	0.00	72.00	0.00
2	1015831	15.77	78.72	15.77
3	659971	26.22	61.32	3.93
4	1123232	24.59	81.85	18.63
5	1622733	0.00	59.00	0.00
6	788468	9.32	77.62	9.32
7	691164	0.00	82.00	0.00
8	607022	0.00	71.00	0.00
9	660392	12.12	76.24	12.12
10	1346267	0.00	81.00	0.00
11	1306240	10.89	64.12	23.31
12	981813	4.05	70.75	4.05
13	669588	13.68	79.44	0.55
14	903501	45.96	74.44	45.96
15	873210	30.89	81.83	4.91
16	1009700	0.00	81.00	0.00

Source: author

multiplied by this value, i.e. increased by 10.9%. An output model was selected due to chain managers interest in establishing improvement goals for sales.

Table 2 shows that only restaurants 1, 5, 7, 10, and 16 are totally efficient – all have a coefficient equal to 1.00. The rest are inefficient, with restaurant 14 being the most inefficient, for it is the one that could at least increase all its outputs by the largest amount (almost 46%, to be precise), as can be seen in the column of the table entitled "% outputs increase". It can also be seen that of the inefficient restaurants, the best is number 13, owing to the fact that it could only increase its outputs radially by 0.55%. The average inefficiency overall is 11.5%.

Identifying business units that are efficient in overall terms and those that are not has many applications. Firstly, it enables the best restaurant managers to be identified, which facilitates the implementation of a policy whereby they can transfer between the various establishments. Secondly, internal audits of the efficient units may be carried out, aimed at identifying the reasons for their operational superiority and subsequently emulate them in the inefficient units. Finally, it is very useful information for the implementation of an incentives system for business unit managers.

Although *f* shows the level to which increase all the outputs may be increased without varying the input mix, additional increases could be reached in some outputs. The maximum increases attainable in each, calculated according to expression [18], are depicted in Table 3.

The second and fourth columns of Table 3 show sales and quality objectives respectively. Both are expressed in absolute terms, as well as their variation percentage compared to the values currently seen in the third and fifth columns. There are restaurants in which the variation percentage is the same for both outputs, as is the case for restaurant 2, which is the same, as one would expect, as the maximum radial increase shown in Table 2. For instance, in the case of restaurant 3 where the coefficients differ, sales could be increased by 26.22% and quality by 3.93%. The maximum radial increase for this restaurant is exactly 3.93% (Table 2), i.e. it is the same as the lesser of the increases individually achievable in the outputs shown in Table 3.

It should be pointed out that the information provided in Table 3 is very useful since enables specific sales and quality objectives to be established, calculated on the basis of benchmarking of its own business units. He/she can also decide whether to establish these objectives on a radial or individual basis. It would surely be more suitable to use the radial increase coefficient for those outputs related to product sales or real services, given that the difficulty of changing the sales mix is usually a feature of the modern restaurant industry. However, personalised coefficients would be more appropriate when there are no difficulties in changing the mix of sales, or when dealing with special outputs, such as quality or any positive external feature.

Finally, as is shown in formula [19], additional reductions that can be achieved and inputs may be calculated once all the outputs are increased (Table 4), thus identifying possible idle or underused resources. This information could be used to support and reduce costs, especially in the case of human resources, associated with an expansion policy involving the opening of new restaurants.

From Table 4, it can be deduced that there are four restaurants that have excessively large facilities, i.e. numbers 2, 12, 13 and 14. Of these, number 12 is the most over-sized, as it could operate with premises up to 42.40% smaller. In the other three cases, the excess space does not surpass 17%. Staff costs are demonstrated to have the narrowest margin, with five restaurants - numbers 3, 4, 6, 9 and 14 – having an excess of costs, which is not very high, at around 4% of sales on average (apart from restaurant 3, at around 9%). With regard to consumption, there are six restaurants where this could be reduced - numbers 2, 3, 9, 11, 12 and 13. The restaurants that present the greatest imbalance in this aspect are numbers 3 (20.97%), 11 (17.27%) and 12 (13.68%).

The environmental input location results must be interpreted in a different way. Obviously, a "reduction" in the location of a restaurant by a certain percentage could make no sense if chain managers do not consider the reorganisation of their facilities in the short run, and consequently this information should not be interpreted in a similar way to the previous cases. Its usefulness lies only in that it alerts us to the fact that restaurants presenting a given percentage of decrease in this variable may improve their performance even with

Table 4 - Maximum decreases attainable in each input

Restaurant	M²	Decrease %	LOC	Decrease %	STAFF	Decrease %	FCOST	Decrease %
1	180.00	0.00	60.00	0.00	171,409	0.00	163,115	0.00
2	187.17	14.92	75.00	0.00	280,793	0.00	253,240	3.80
3	175.00	0.00	45.00	0.00	133,259	8.98	126,036	20.97
4	233.71	16.53	62.00	0.00	303,383	3.85	279,471	0.00
5	360.00	0.00	95.00	0.00	535,502	0.00	490,065	0.00
6	178.00	0.00	81.78	11.10	226,625	4.78	214,922	0.00
7	186.00	0.00	82.00	0.00	221,172	0.00	206,658	0.00
8	160.00	0.00	89.00	0.00	182,107	0.00	188,177	0.00
9	189.00	0.00	65.00	0.00	191,947	4.15	180,956	6.90
10	195.00	0.00	76.00	0.00	457,731	0.00	399,841	0.00
11	236.00	0.00	75.01	10.70	353,395	0.00	314,778	17.27
12	167.04	42.40	67.85	14.11	273,641	0.00	244,352	13.68
13	180.19	9.45	79.44	8.69	182,588	0.00	170,607	1.14
14	173.00	0.00	80.45	1.89	192,250	2.95	182,617	0.00
15	213.00	0.00	70.00	0.00	220,151	0.00	205,474	0.00
16	247.00	0.00	55.00	0.00	333,201	0.00	314,017	0.00

Source: author

Table 5 - Estimation of improvement in potential results

Restaurant	SALES1 €	SALES2 €	Var. €	STAFF1€	STAFF2 €	Var. €	FCOST1 €	FCOST2 €	Var. €	Var. Result. €
1	552,931	552,931	0	171,409	171,409	0	163,115	163,115	0	0
2	877,478	1,015,831	138,353	280,793	280,793	0	263,243	253,240	10,003	148,356
3	522,881	659,971	137,090	146,407	133,259	13,148	159,479	126,036	33,443	183,681
4	901,518	1,123,232	221,714	315,531	303,383	12,148	279,471	279,471	0	233,862
5	1622,733	1,622,733	0	535,502	535,502	0	490,065	490,065	0	0
6	721,215	788,468	67,253	238,001	226,625	11,376	214,922	214,922	0	78,629
7	691,164	691,164	0	221,172	221,172	0	206,658	206,658	0	0
8	607,022	607,022	0	182,107	182,107	0	188,177	188,177	0	0
9	588,992	660,392	71,400	200,257	191,947	8,310	194,367	180,956	13,411	93,121
10	1346,267	1,346,267	0	457,731	457,731	0	399,841	399,841	0	0
11	1,177,984	1,306,240	128,256	353,395	353,395	0	380,489	314,778	65,711	193,967
12	943,589	981,813	38,224	273,641	273,641	0	283,077	244,352	38,725	76,949
13	588,992	669,588	80,596	182,588	182,588	0	172,575	170,607	1,968	82,564
14	619,042	903,501	284,459	198,093	192,250	5,843	182,617	182,617	0	290,302
15	667,123	873,210	206,087	220,151	220,151	0	205,474	205,474	0	206,087
16	1,009,700	1,009,700	0	333,201	333,201	0	314,017	314,017	0	0
TOTALS			1,373,432			50,825			163,261	1,587,518

Source: author

a location worse than the one they currently have, meaning that it may be deduced that they are underusing it.

Finally, it is interesting to reflect on the suggestions provided by applying the DEA model, related to the variations in inputs and outputs in an estimation of the variation of the result that could be achieved in the optimistic scenario of attaining them exactly in reality. The projection of the potential improvement in results, supposing that efficiency is improved, is shown in Table 5.

This table shows the variations in the three variables that directly affect the calculation of economic results, i.e. sales, staff costs and consumption. The model application shows that a potential increase in sales of €1,373,432 could be achieved for the total of the 16 restaurants, while the savings derived from staff costs are €50,825 and those associated with consumption are €163,261. This would add up to an estimated improvement in the overall result of €1,587,518 if the restaurants were able to remove all their inefficiencies. However, it should not be forgotten that this value must be corrected by incorporating other costs not included in this study that would probably be associated with the increase in sales.

5 Conclusions

The aim of this article has been to present a rigorous methodology called Data Envelopment Analysis (DEA) or analysing the operational efficiency of a set of business units. This methodology is applicable to a wide range of organisations that operate through business units, such as hotel and restaurant chains or bank offices.

The technique is characterised by offering a single coefficient that provides an overall evaluation of the efficiency of each of the units analysed. This index allows a distinction to be made between those units that have been efficient and those that have not, as well as quantifying their inefficiency. DEA models also determine the levels that inputs and outputs should reach to become efficient. This makes them a highly suitable and useful tool not only for the follow-up and evaluation of business units, but also for establishing objectives that lead to greater operational efficiency, which is essential in any highly competitive environment. DEA models undertake a comparative analysis of the inputs and outputs of the production process carried out by the business units evaluated, using a benchmarking process to identify the best management practices.

Their empirical application was carried out on a sample of 16 restaurants belonging to a leading Spanish restaurant chain. The outputs used were the sales expressed in monetary terms and an index indicating the quality attained by each restaurant. In the inputs section, the surface area of the business premises, its location, staff costs and consumption were used. The results of the application made clear that only five restaurants were efficient in overall terms. Average inefficiency was calculated as 11.5%. In addition, the model provided the output increase and input reduction objectives that the inefficient restaurants should achieve in order to remedy their situation. On the basis of these figures, it was possible to estimate that an improvement of approximately €1,200,000 in the results could be achieved by correcting the inefficiencies. From Table 5 it can easily be deduced that inefficiencies are more a result of low sales than high costs. Restaurant 14 is the least efficient, demonstrating an attainable result increase of around €300,000. Information provided by frontier models are very useful for managers since they can easily take into account environmental factors influencing restaurants performance or service quality achieved. Setting improvement targets based on a chain's own know-how is also easy with this technique as a result of an internal benchmarking process. There is no doubt that this study clearly demonstrates the advantages of frontier models over other techniques, such as ratios, generally used in business practice. There are five drawbacks to the ratios technique that should be highlighted: 1) they provide only partial productivity measures instead of evaluating the overall performance of organizations; 2) it is difficult to set objective improvement targets; 3) they do not consider relationships between variables; 4) they do not take into account environmental factors such as location or social-demographic characteristics that affect performance; and 5) they assume constant returns to scale technologies when comparing different decision-making units. In contrast, frontier models overcome all these defects, as has been demonstrated in the case study.

Finally, it should be highlighted that DEA models could also be very useful for the case of sales targeting in the opening of new restaurants. Sales targets could easily be estimated by introducing the new establishment to be opened in the sample with the known inputs data and a unitary value for each output. In this way, DEA models would provide the output levels (sales and quality in this case) that should be reached in order to make the restaurant efficient, taking into account its available inputs.

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