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## Article

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## Measuring the technical efficiency of public service broadcasters: An application of DEA in Spain

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### ABSTRACT

The excessive debt of the Spanish economy in the last few year raises the issue of efficiency in the management of public resources. Within this context, this research measures the technical efficiency of regional public service broadcasters (PSBs) in Spain using data envelopment analysis (DEA). The results indicate that several corporations are not efficient and they need to make decisions regarding some of their inputs to guarantee their sustainability. In addition, those PSBs following a management model based on outsourcing are more efficient. This research also provides a theoretical framework and a methodological application for the measurement of efficiency in the public service media sector.

**Keywords:** data envelopment analysis; efficiency; public service broadcasters; outsourcing; input; output.

**JEL classification:** C14; L82.

**MSC2010:** 90B50.

# Midiendo la eficiencia técnica de los servicios públicos de televisión: una aplicación de DEA en España

## RESUMEN

La excesiva deuda pública que presenta la economía española obliga a analizar la eficiencia en la gestión de los recursos públicos. Dentro de este contexto, este artículo mide la eficiencia técnica de los servicios públicos autonómicos de televisión en España a través del Análisis Envoltente de Datos (DEA). Los resultados indican que varias televisiones autonómicas no son eficientes y que requieren variar algunos de sus inputs para garantizar su sostenibilidad. Además, los servicios públicos regionales de televisión que siguen un modelo de gestión basado en externalizar parte de su actividad son más eficientes. Esta investigación también aporta un modelo teórico y una aplicación metodológica a la medición de la eficiencia en el sector de los medios de comunicación públicos.

**Palabras claves:** análisis envoltente de datos; eficiencia; servicio público de televisión; externalización; input; output.

**Clasificación JEL:** C14; L82.

**MSC2010:** 90B50.



## **1. Introduction**

In the last three decades, the Spanish economy experienced significant growth, permitting an increase in public services provided by all different levels of government. However, in the last six years, economic growth has been frozen by a recession that has entailed heavy public debt and deficit. This makes it necessary to analyse the management of public resources to guarantee its sustainability.

Most regional governments in Spain own a public service broadcaster (PSB). From the 1980s to 2006, different regions created and developed public television services to supply content to citizens and promote the audiovisual industry within their territory (Casado, 2005). However, the management of resources and results differ considerably between the regions, justifying academic interest and proper analysis.

From a public management perspective, two models exist in opposition to each other. On the one hand, the classic model is based on imitating the structure of the national public service broadcaster, RTVE, at the regional level. RTVE runs many of its operations internally and owns sizeable fixed assets, as well as having many personnel. On the other hand, the alternative model is based on outsourcing most operational activities to private companies (Bustamante, 2009).

From a results perspective, the aggregated audience of all regional PSBs in Spain attained a share of 10.4% in 2011. Together, regional PSBs constitute the FORTA federation, ranked fourth in the television groups in Spain based on the viewing figures. However, these audience results are not homogeneous and dispersion among channels is large.

In addition, public opinion is becoming increasingly critical of several regional PSBs regarding their management of resources and outcomes. In fact, all regional PSBs ended 2011 with an aggregate debt of more than 1,500 million euros and an average cost of 30.6 euros per person per year (Accenture, 2012).

Given this situation, our research analyses the performance of regional PSBs in Spain from an efficiency perspective, taking into account that the vast majority of their income comes directly from public spending, that is, from the taxpayers. To do so, we apply data envelopment analysis (DEA), which makes it possible to measure the efficiency of each channel and propose the necessary measures for each factor so as to optimise resource management.

The article is structured as follows: Section 2 provides a literature review on the efficiency of production management of institutions; Section 3 sets out the methodology applied and data selection; Section 4 contains the results of the research; and finally, Section 5 presents conclusions and implications.

## **2. Efficiency in the production management of institutions**

Efficiency in the production management of an institution is determined by the costs and benefits of their activities. To analyse efficiency, one needs to find the optimal combination of costs and benefits that meets any of the following requirements: 1) generate the highest benefit from the combinations that have the same cost; 2) incur fewer costs for activities producing identical benefits; 3) present the best proportional relationship between the costs incurred and the benefits gained.

In the study of efficiency in the internal management of institutions, Farrell (1957) characterises three different dimensions: allocative efficiency, economic efficiency and technical efficiency. The latter is the concept of efficiency more commonly used in the public sector (Latorre, 2013) and hence is the one we employ in this article. Technical efficiency analyses the internal production processes of institutions by studying the quantities of inputs or production factors used and the quantities of outputs or final products obtained (Farrell, 1957). Institutions achieve technical efficiency through two different means: maximising the level of output with a combination of inputs (this approach is called output orientation), or minimising the combination of inputs (production factors) required to produce a given level of output (input orientation).

Focusing on the latter approach as it is more widely used (Campos and Velasco, 2013; Liu *et al.*, 2013; Rausell Köster *et al.*, 2013), an institution is efficient when it is situated on the frontier of possible production and maximises the performance of the inputs without wasting resources, i.e. there is no combination of the current level of inputs that could generate higher output, nor could the same level of output be achieved with a lower level of inputs (Latorre, 2013).

The different levels of efficiency that an institution might reach are determined by the heterogeneity of resources and capabilities on which organisations base their management (Taymaz, 2005). In relation to this, the resource-based theory (Barney, 1991; Rumelt, 1991; Wernerfelt, 1984) has been widely adopted as the theoretical

reference in the study of efficiency regarding the production management of institutions (Pestana and García del Barrio, 2008). This theory can help explain why some firms consistently outperform others.

### 3. Methodology

#### 3.1 Data envelopment analysis (DEA)

Efficiency measurement in the production management of institutions can be undertaken using different methodologies, one of which is data envelopment analysis (DEA). DEA can roughly be defined as a nonparametric method for the efficiency measurement of a decision-making unit (DMU) with multiple inputs and/or multiple outputs. DEA is used to measure the relative productivity of a DMU by comparing it to other homogeneous units, transforming the same group of measurable positive inputs into the same types of measurable positive outputs.

Charnes *et al.* (1978, 1981) introduced the DEA method to address the problem of efficiency measurement for DMUs with multiple inputs and multiple outputs in the absence of market prices. They coined the phrase “decision-making units” to include non-market agencies, such as schools, hospitals and courts, which produce identifiable and measurable outputs from measurable inputs but generally lack market prices of outputs (and often also of some inputs).

Let us suppose that there are  $N$  firms each producing  $m$  outputs from  $n$  inputs. Firm  $t$  uses the input bundle  $x^t = (x_{1t}, x_{2t}, \dots, x_{nt})$  to produce the output bundle  $y^t = (y_{1t}, y_{2t}, \dots, y_{mt})$ . As noted above, the measurement of average productivity requires the aggregation of inputs and outputs, but no prices are available. What is needed in this situation is to use vectors of *shadow* prices of inputs and outputs. Charnes *et al.* (1978) proposed a model – the Charnes–Cooper–Rhodes (CCR) model – in which  $x_{io}$  and  $y_{ro}$  are, respectively, the  $i$ th input and  $r$ th output for the DMU $_o$  (decision-making unit  $o$ ) under evaluation. This is estimated as follows:

$$\begin{aligned}
& \min \theta_0 - \varepsilon \left( \sum_{i=1}^m s_i^- + \sum_{i=1}^s s_i^+ \right) \\
\text{s. t. } & \sum_{j=1}^N \lambda_j x_{ij} + s_i^- = \theta_0 x_{io}, \quad i = 1, 2, \dots, m \\
& \sum_{j=1}^N \lambda_j y_{rj} - s_r^+ \geq y_{ro} \quad ; r = 1, 2, \dots, s \\
& \lambda_j \geq 0 \quad (j = 1, 2, \dots, n).
\end{aligned} \tag{1}$$

As the efficient frontier determined by (1) exhibits constant returns to scale (CRS), we call model (1) the CRS (DEA) model. A DMUo is said to be CRS efficient if and only if (a)  $\theta_0^* = 1$  and (b) all optimum slack values ( $s_i^{-*}$ ,  $s_r^{+*}$ ) are zero. If the DMU under evaluation satisfies these two conditions, it represents the best practice or is on the efficiency frontier. In DEA,  $\theta_0^*$  is called the efficiency score and is adopted in our study. The dual linear program for (1) is:

$$\begin{aligned}
& \max \sum_{r=1}^s u_r y_{ro} \\
\text{s. t. } & \sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} \leq 0 \quad j = 1, 2, \dots, n \\
& \sum_{i=1}^m v_i y_{io} = 1, \\
& u_r, v_i \geq \varepsilon.
\end{aligned} \tag{2}$$

If an additional convexity constraint of  $\sum_{j=1}^n \lambda_j = 1$  is imposed on the CRS model (1), the resulting frontier exhibits variable returns to scale (VRS). This we term the VRS (DEA) or Banker–Charnes–Cooper (BCC) model (Banker *et al.*, 1984):

$$\begin{aligned}
& \min b_0 - \varepsilon \left( \sum_{i=1}^m S_i^- + \sum_{r=1}^s S_r^+ \right) \\
\text{s. t. } & \sum_{j=1}^N \lambda_j x_{ij} + s_i^- = b_0 x_{io}, \quad i = 1, 2, \dots, m \\
& \sum_{j=1}^N \lambda_j y_{ij} - s_i^+ = y_{io}, \quad r = 1, 2, \dots, s \\
& \sum_{j=1}^n \lambda_j = 1, \\
& \lambda_j \geq 0, \quad j = 1, \dots, n.
\end{aligned} \tag{3}$$

The BCC model assumes the convex combination of the observed DMUs as the production possibility set, wherein the BCC score is called local pure technical efficiency (PTE). The CRS assumption implies that when the radial expansion and reduction of all observed DMUs and their nonnegative combinations is possible, the CCR score will give what is called global technical efficiency (TE). Comparison of the CCS and BCC scores thus provides a deeper insight into those sources of inefficiency that a DMU might display. If  $\theta_{\text{CRS}}^0$  and  $\theta_{\text{BRS}}^0$  denote, respectively, the CCS and BCC scores of a DMU, the scale efficiency is defined by:

$$\text{SE} = \frac{\text{CRS}}{\text{VRS}} = \frac{\text{TE}}{\text{PTE}} \tag{4}$$

Thus, the global or overall inefficiency of a DMU is explained by inefficient operation (PTE), by the scale effect (SE), or by both. Characterisation of the CCR model as having *constant returns to scale* is technically correct, but somewhat misleading, as the model can also be used to determine whether returns to scale are increasing (IRS) or decreasing (DRS). This is achieved using the following theorem proved by Banker and Thrall (1992):

**Theorem 1.** Let  $(\underline{x}_0, \underline{y}_0)$  be a point on the efficiency frontier. Employing a CCR model in envelopment form to obtain an optimal solution  $(\lambda_1^0, \dots, \lambda_n^0)$ , returns to scale at this point can be determined from the following conditions:



(i) If  $\sum_{i=1}^n \lambda_j \nu_j = 1$  in any alternate optimum, then CRS prevails;

(ii) If  $\sum_{i=1}^n \lambda_j \nu_j > 1$  for all alternate optima, then DRS prevails;

(iii) If  $\sum_{i=1}^n \lambda_j \nu_j < 1$  for all alternate optima, then IRS prevails.

The relationship between the BCC and CCR models is described by the following theorem, taken from Ahn *et al.* (1989):

**Theorem 2.** A DMU0 found to be efficient with a CCR model will also be found to be efficient with the corresponding BCC model and CRS prevails for DMU0.

### 3.2 DEA applications in public services

DEA applications can be found in several services and industries (Hollingsworth, 2008; Liu *et al.*, 2013; Segovia *et al.*, 2009). In the public sector, this technique has been widely used to measure efficiency in health care services (Sherman, 1981), judicial courts (Lewin *et al.*, 1982), public schools (Bessent and Bessent, 1980), universities (Tomkins and Green, 1988) and airports (Gillen and Lall, 1997), among others. Comparisons between different efficiency levels of production units can be used to propose changes and improvements in the management of publicly funded services.

In public service television, empirical studies analysing the efficiency of broadcasters from a DEA perspective are scarce (Asai, 2011). They use different measurement variables of inputs and outputs (Asai, 2005, 2011; Campos and Velasco, 2013), as shown in Table 1. Asai (2005) measures the efficiency and productivity of 30 public and private television stations in Japan within the period 1997–2002. This study considers as inputs the number of employees, capital employed and production costs. Output is understood as income divided by price index. The results show that, on average, smaller, publicly owned broadcasters do not operate efficiently.

Later, Asai (2011) analysed the efficiency of seven local television channels in Japan (2002–2006) by differentiating two activities: production itself and broadcast programming. In this study, the inputs and outputs are different for each activity. For production, the inputs are labour, materials and the capital of that division and the

outputs are programmes for sale and programmes produced for transmission. Regarding transmission, the inputs are also labour, materials and capital employed in the division, but the output is revenues. The results show greater variation in the efficiency scores for the labour-intensive programme production division than for technically standardised transmission work.

Table 1. Research on efficiency in the television sector using the DEA method

<b>Author(s) &amp; Date</b>	<b>Number of Networks</b>	<b>Inputs</b>	<b>Outputs</b>	<b>Results</b>
Asai (2005)	30 public and private television networks (Japan)	Number of employees	Revenue/price ranges	Smaller public television networks are not managed efficiently
		Capital		
		Production Costs		
Asai (2011)	7 local television networks (Japan)	Labour	Programmes produced for sale	Differences in the efficiency of production management among networks
		Materials	Programmes produced for local broadcast	
		Capital	Revenue	
Campos and Velasco (2013)	12 regional TV networks (Spain)	Fixed asset investments	Public funds received	Only networks from the Cataluña, Basque and Castilla-La Mancha regions demonstrated efficiency in production management
		External financing		
		Personnel expenses		

Source: Authors' own elaboration.

Finally, the study undertaken by Campos and Velasco (2013) analyses the efficiency of 12 regional PSBs in Spain using DEA. It considers as inputs, fixed assets investment, long-term external liabilities and personnel spending. The basic output is the total revenue received from public funds. It adopts a strict economic efficiency perspective, taking into account four types: global, technical, scale and super-efficiency. The conclusions indicate that only three regional PSBs (those in Cataluña, País Vasco and Castilla-La Mancha) are globally efficient.

Therefore, DEA has proven useful in analysing the efficiency of public service television. However, the literature review indicates that there is no clear consensus on which inputs and outputs should be considered in measuring efficiency.

### 3.3 Data selection

Here, we use the data of 13 regional PSBs in Spain in an illustrative example to demonstrate how DEA can be employed to measure efficiency in a multidimensional construct and to provide additional information regarding efficiency.

Regional PSBs appeared in Spain after the Third Channel Act was passed (46/1983, 26 December 1983) as a response to the political, cultural and economic aspirations of Spanish regions concerning public television. The creation of regional PSBs took place in two different periods (1982–1989 and 1999–2006), determining the production management system adopted by each public corporation. In relation to this, there are two opposing models, classic and outsourced (Bustamante, 2009). Regional PSBs in País Vasco (1982), Cataluña (1983), Galicia (1985), Andalucía (1987), Madrid (1989) and Comunidad Valenciana (1989) adopted the classic model to manage their production. This management system is based on imitating the organisational structure of the national public service broadcaster, RTVE, on a regional scale. This management model implies high production costs and usually generates too much debt. On the other hand, the outsourced model was adopted by PSBs in Canarias (1999), Castilla-La Mancha (2001), Asturias (2005), Baleares (2005), Murcia (2006), Extremadura (2006) and Aragón (2006). This model is based on assigning some activities (such as suppliers of content, technology, advertising management or other aspects) to external private companies. This management system aims to reduce costs and minimise a channel's operational structure.

To measure the management efficiency of regional television in Spain using the DEA method, we need to take into consideration some variables of analysis in order to quantify the performance of each public institution. To calculate the number of variables in analysing efficiency, Drake and Howcroft (1994) suggest that the technique works best when the number of DMU units (in this case, television networks) is at least twice the sum of inputs and outputs. In this study, there are 13 DMUs and we consider three inputs and one output.

Section 3 notes that there is no clear consensus in the literature on the inputs and outputs which should be employed to analyse technical efficiency in the television sector. Therefore, in this research we use the following variables to analyse the PSBs in Spain: market experience, external purchases, public subsidies and audience share. The variable *market experience* (input 1) is measured as the numbers of years that the PSB

has been on air. Organisations learn about their efficiency as they operate in a market and thus, the more years they have been on air, the greater their experience. The variable *external purchases* (input 2) is measured as suppliers and external services sourced by PSBs from other companies within the sector. The variable *public subsidies* (input 3) is measured from direct public subsidies provided by the respective regional governments. The output is measured using the variable *audience share* (percentage of viewers watching the main channel of the PSB on a 24-hour basis).

Finally, this research does not consider other variables, such as number of employees, gross rating points or advertising revenues. This is justified on the basis of the significant differences in the numbers of employees hired by classic model PSBs and outsourced PSBs. For advertising, the aggregate advertising revenues of all regional PSBs were less than five times the taxpayers' money they received (Infoadex, 2012). Table 2 provides input and output data for all 13 companies taking part in this study for the year 2011.

Table 2. Input and output data

DMU n°	DMU name	Input 1	Input 2	Input 3	Output
1	Andalucía	25	123,002,000	166,887,000	10.70
2	Cataluña	31	197,709,000	241,390,000	14.10
3	Madrid	25	76,619,000	105,364,000	6.40
4	Valencia	26	106,099,000	124,110,000	5.20
5	Galicia	30	57,826,000	101,147,000	12.30
6	País Vasco	32	98,963,000	140,762,000	8.20
7	Canarias	15	32,133,000	37,720,000	7.90
8	Castilla-La Mancha	14	36,950,000	50,000,000	6.40
9	Murcia	10	27,572,000	30,109,000	4.00
10	Aragón	9	50,586,000	54,344,000	10.70
11	Baleares	10	40,452,000	42,952,000	5.20
12	Extremadura	8	19,190,000	31,056,000	1.70
13	Asturias	11	30,884,000	29,450,931	7.70

Source: Authors' own elaboration, with data from annual reports of regional PSBs. External purchases and public subsidy figures in euros.

#### 4. Results

Table 3 presents the results obtained. The columns labelled 'CCR' and 'BCC' indicate the efficiency scores for PSBs with constant and variable returns to scale, respectively. PSBs on the efficiency frontier have an efficiency score of 1. Lower scores indicate inefficiency.

Table 3. Results of CCR and BCC models

DMU n°	DMU Name	CCR Model (CRS)	BCC Model (VRS)	Scale Efficiency	RTS
1	Andalucía	0.40108	0.40976	0.97881687	Decreasing
2	Cataluña	0.38257	1.00000	0.38257000	Decreasing
3	Madrid	0.34377	0.39481	0.87072263	Increasing
4	Valencia	0.21709	0.32287	0.67237588	Increasing
5	Galicia	0.85315	1.00000	0.85315000	Decreasing
6	País Vasco	0.34188	0.34471	0.99179020	Decreasing
7	Canarias	0.98609	0.99758	0.98848213	Decreasing
8	Castilla la Mancha	0.69472	0.76726	0.90545578	Increasing
9	Murcia	0.58188	0.99653	0.58390615	Increasing
10	Aragón	1.00000	1.00000	1	Constant
11	Baleares	0.56826	0.87395	0.65022026	Increasing
12	Extremadura	0.35532	1.00000	0.35532000	Increasing
13	Asturias	1.00000	1.00000	1	Constant

DMUs 10 (Aragón) and 13 (Asturias) are considered to have been technically efficient in 2011 under the assumption of CRS. Six companies obtain an efficiency score of less than 50 per cent. Only 46 per cent of the companies studied achieve a score of more than 0.5000. Besides, Aragón and Asturias are the only efficient channels in the CCR model. They are also efficient in the BCC model (as predicted by Theorem 2) and have the most productive scale size (MPSS).

The VRS efficiency scores measure pure technical efficiency (PTE) excluding the effects of scale operations and are more encouraging. They are higher than the corresponding CRS efficiency scores. Three more companies achieve pure technical

efficiency. In the BCC model, DMUs 2 (Cataluña), 5 (Galicia) and 12 (Extremadura) are locally technically efficient, but not globally efficient. According to (4), the global (CCR) inefficiency of Cataluña, Galicia and Extremadura is caused by scale inefficiency (see Table 3, column *Scale Efficiency*). By contrast, Andalucía's global inefficiency (and that of other companies, for instance, Canarias) is caused primarily by its inefficient operations and only to a small extent by the scale effect (its *Scale Efficiency* figure being very close to 1.0).

Apart from the inefficiencies that could arise in the conversion process, another reason for the inefficiencies of the low scoring units could be the scale of operations. DMUs that do not operate at the most efficient (or productive) scale size cannot be fully efficient. The inefficiency may arise because they are operating under DRS or IRS. A DMU is said to be operating under DRS if changing all inputs by the same proportion results in a smaller proportional change in outputs. IRS may also be defined similarly.

The extreme right-hand column indicates whether a PSB has increasing (IRS), decreasing (DRS), or constant (CRS) returns to scale (on the basis of the  $lj$ -value for the CCR model, as asserted by Theorem 1). All corporations, except Aragón and Asturias, display increasing/decreasing returns to scale, thereby implying the existence of multiple most productive scale sizes. In other words, they have the potential to improve their efficiency by scaling up their activities.

## 5. Conclusion

This piece of research adopts an output-orientated super-efficiency DEA methodology to assess the performance of 13 regional public service broadcasters (PSBs) in Spain, based on multidimensional performance indicators under the assumptions of CRS and VRS. Four variables are used for the assessment: three inputs (market experience, external purchases and public subsidies) and an output (audience share). The results suggest that only two PSBs (Aragón and Asturias) can be considered technically efficient and only 46 per cent of the PSBs studied achieve a score of more than 0.5000.

Following the empirical analysis, it is now necessary to translate and transfer the results obtained in a practical manner, that is, list the factors that make a PSB efficient. Therefore, it can be observed that those PSBs following a management model based on outsourcing are more efficient. These results do not come from greater

experience in the market, but from the appropriate allocation and management of public resources. In contrast, most PSBs following a classic management model are significantly inefficient. Consequently, the recommendation would be for PSBs in Comunidad Valenciana, País Vasco, Madrid and Andalucía to reduce their substantial external purchases and their public subsidy so as to guarantee sustainability. In fact, in Comunidad Valenciana, the regional government has recently closed down the corporation. The one in Madrid is also under budgetary reductions and public scrutiny.

Finally, some problems regarding the data need to be considered. Like any other efficiency evaluation technique, DEA has several limitations. Sample size and input–output selection could affect DEA efficiency and might explain the differences in the results given by Campos and Velasco (2013).

Strategies which are not resource-based are unlikely to be successful in such environments (Wernerfelt, 1995). For this reason, it is necessary to continue to explore tools with which to analyse firm-level sources of sustained competitive advantage. With this in mind, future research could include other input/output factors not considered here, as well as analysing the variation needed in each input so as to attain efficiency.

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