STUDY REGARDING THE EFFICIENCY MEASURE OF CONSTRUCTION FIRMS FROM WESTERN EUROPE

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1. Introduction

In this article we have proposed to use the data envelopment technique in order to study the efficiency of the companies that are classified according to the object of activity in the construction sector, during 2008-2010. In this way, we intend to highlight the manner in which the economic crisis from this period has affected this sector. The premise of choosing companies with activities in construction is related to the fact that their efficiency is closely correlated with the evolution of economic activity in general, the construction sector being one of the most important sectors of the economy. In this study we have introduced a sample of the top 15 companies from Western Europe, depending on the turnover. The information necessary for the study was drawn from the annual financial statements of the companies for the years under review. The period subject to the analysis gives us a clear picture regarding the influence of the financial crisis on the effectiveness of the activity in constructions.

Data envelopment technique (Data Envelopment Analysis-DEA) is a relatively new approach for evaluating the performance of a set of entities called decision units, converting a series of inputs to outputs. Defining a decision unit is generic and flexible. In the last few years there has been observed a wide variety of the usage of DEA to assess performance of different types of entities engaged in different activities, in different contexts and different countries. Many forms of data envelopment technique were used to assess the performance of various entities such as hospitals, universities and companies. The data envelopment technique opened the possibility of its utilization in situations where other techniques could not be used because of the complex (often unknown) nature of the relationship between the inputs and outputs of a company.

To analyze the efficiency of the companies from the construction sector we used both the option BCC (Banker, Charnes and Cooper) and the option CCR (Charnes, Cooper and Rhodes). Under the option BCC the efficiency scores are higher because under this option the companies are grouped and analyzed by size, while under the CCR option, they are analyzed in a comprehensive manner not taking account of their size. The use of the data envelopment technique also allows the calculation of the scale efficiency scores, which are calculated as the ratio between the scores obtained by using the BCC option and those obtained using the CCR option. These scale efficiency scores show if and the extent to which the companies benefit or not from the economies of scale .

This paper is structured as follows: the following section presents some references from the economic literature, in the third section the methodology and the data used are presented, in the fourth the obtained results are highlighted and in the last section the conclusion are summarized.

2. Literature review

The efficiency analysis using the data envelopment technique has been used in several studies for decision

making units from various branches of industry.

Pareto and Koopmans were concerned to examine all the economic systems. In such a context it is reasonable to allow input prices and quantities to be determined according to their ability to meet the final demand. However, Farrell extended the property of inputs developed by Pareto and Koopmans, also to the outputs and explicitly avoided any use of price in terms of "exchange mechanism". More important is the fact that he used the performance of other decision units to assess the behavior for each unit of decision regarding the inputs and outputs they use. This resulted in determining the indicator of relative efficiency.

As said by Cooper, Seiford and Tone (2000), the data envelopment technique was used to provide new information concerning the activities and entities that were previously assessed with the help of other methods. For example, the identification of a standard through the data envelopment technique allowed to determine the causes for the inefficiency in some of the most profitable companies - companies that have served as a standard to the criterion of profitability. So, DEA is a method of finding more effective standards in the empirical studies. Because of these possibilities, DEA efficiency studies revealed that previous valuations have failed to properly assess performance and thus, the efficiency of the companies.

Zhu (2002) proposed a series of models using DEA that can be used for the evaluation of performance and for the selection of a standard. The empirical orientation of the data envelopment technique as well as the absence of the several aprioristic hypotheses that are necessary to other approaches have led to use this method in several studies involving the estimation of efficiency frontiers for both the governmental sector and nonprofit companies and the private sector.

In the context of Pakistan's economy, Burki and Khan (2005) have analyzed the implications of the efficiency of the energy resources allocation.The study covered two periods between 1969 - 1970 and 1990 - 1991, using chronologically centralized in series data of the productive sector from Pakistan to estimate an overall cost function.The results highlighted the allocative inefficiency that leads to over / under-use of resources resulting in a higher cost of production.

In 2006, Wang used the data envelopment technique to measure the effectiveness of the ACER company with the registered office in Taiwan for the 2001-2003 period. The obtained results provided a clear picture of the company's strategy in the year 2003. The ACER company has been able to create added value without cost increase.

In 2008, Basti and Akin compared the national companies with the foreign ones operating in Turkey. There were selected non-financial companies, listed at the Stock Exchange in Istanbul for the period 2003-2007. The Data Envelopment Analysis (DEA), was used to calculate the Malmquist index in order to measure productivity. Subsequently, the Malmquist productivity was decomposed into two indicators that measure the changes in efficiency and technical changes. Study results showed no differences between the productivity of national companies and that of the foreign ones. On average, the productivity of both types of companies included in the study decreased in the analyzed period of time, except the year 2006.

3. Methodology and data used

Although there are sundry ways in which to study the efficiency of decision making units, the envelopment data technique (Data Envelopment Analysis DEA) is the most popular in the specialized literature. DEA is a linear programming model that measures the

relative efficiency of decision units. The purpose of this technique is to generate indicators that reflect in a more complete and adequate way the performance in any sector of activity. Thus, initially, the method involves specifying a model to define the inputs and outputs that are most important to a decision unit. Then, there is collected data regarding the inputs and outputs and through the linear programming is estimated the efficiency frontier. Depending on how each decision unit is placed against this frontier, the efficiency score is determined.

According to the envelopment data method, for each combination of resources it is achieved a maximum result, but the data of the results may actually coincide with this maximum level or can be lower. The enterprise that obtains a maximum result in relation to a unit of resources is taken as a standard with which to compare all the enterprises studied according to the level of the resources use. So, the estimation of the efficiency is determined by calculating the distance between the studied enterprises and the efficiency frontier. Changing the efficiency frontier is usually carried out by two methods.

Charnes, Cooper and Rhodes (1978) have proposed a model based on the allocation of the inputs and outputs for each decision making units. The efficiency can be obtained from the following problem:

$$\max w_0 = \frac{\sum_r u_r y_{rj_0}}{v_r x_{ij_0}}, \text{ subject to:}$$

$$\frac{\sum_r u_r y_{rj_0}}{v_r x_{ij_0}} \le 1, \text{ for each } j = 1,2,...,n; \quad (1)$$

$$u_r, v_i \ge 0, r = 1,...,k; i = 1,...,m,$$

where: w_0 - relative efficiency; u_r, v_i - weights of output r and inputs i; x and y – the input and output vectors; n, m and k number of DMUs, inputs and outputs, respectively.

The objective of this consists in maximizing the first relation. The model is partially linear in which the numerator must be maximized and the denominator minimized simultaneously. One problem with this particular ratio formulation is that it has an infinite number of solutions. To avoid this one can impose the constraint:

$$\sum_{i=1}^{m} v_i x_{i_0} = 1 \quad (2)$$

By introducing this restriction, the problem becomes:

$$\max w_0 = \sum_r u_r y_{rj_0}, \text{ subject to:}$$

$$\sum_r u_r y_{ij_0} = 1$$

$$\sum_r u_r y_{rj} - \sum_r v_r y_{ij} \le 0 \mid pentru\_ j = 1,...,n \quad (3)$$

$$u_r \ge 0 \, pentru\_ r = 1,...,k$$

$$v_i \ge 0 \, pentru\_ i = 1,...,m$$

In the case of linear programming problems the more restrictions we have the more difficult it is to solve the problem. Using the duality in linear programming, one can derive an equivalent envelopment form of this problem:

$$\begin{aligned} &\min \theta, \text{subject to:} \\ &\theta x_{ij_i} - s_i^- - \sum_j x_{ij}\lambda_j = 0, \text{for } i = 1,...,m \\ &-s_r + \sum_j x_{ij}\lambda_j = y_{rj_0}, \text{for } r = 1,...,k \\ &s_i^-, s_r, \lambda_j \geq 0, j = 1,...,n \end{aligned} \tag{4}$$

θ_j - efficiency of DMU; y_{rj} - the amount of rth output produced by DMU j using x_{ij} amount of ith input; s_i^-, s_r - input and output slack.

The result of problem (3) represents technical efficiency. The optimum solution θ_j represents the level of technical efficiency of the decisional unit j. The efficiency level for all decision making units is obtained by solving the problem (4) for all n decision units. The CCR model is only appropriate when all DMU`s are operating at an optimal scale. Imperfect competition, constraints on finance may cause a DMU to be not operating at optimal scale. Banker, Charnes and Cooper (1984) suggested an extension of the CCR model to account for variable returns to scale situations. The BCC model introduces another restriction for the CCR model: $-\sum \lambda = 1$. Thus, the BCC model can be written:

$$\begin{aligned} &\min z_0 = \theta - \varepsilon \sum_i s_1^- - \varepsilon \sum_i s_r, \text{ subject to:} \\ &\theta x_{ij_i} - s_i^- - \sum_j x_{ij}\lambda_j = 0, \text{for } i = 1,...,m \\ &-s_r + \sum_j x_{ij}\lambda_j = y_{rj_0}, \text{for } r = 1,...,k \\ &\sum \lambda_j = 1, s_i^-, s_r, \lambda_j \geq 0 \end{aligned} \tag{5}$$

The units with the level of efficiency $\theta_j < 1$ are inefficient, and the ones with $\theta_j = 1$ are efficient units.

In order to estimate the efficiency of the construction sector we have used data from the financial statements for a sample of 15 units for the 2008-2010 period. The data were extracted from Orbis database. In the analysis we will use the following inputs: total assets, number of employees and operational expenses, and the following outputs: turnover, added value.

Table no.1 The inputs and outputs used in the analysis

Outputs	Inputs
Turnover	Total assets
Added value	Number of employees
	Operational expenses

In order to obtain more robust results we have chosen to study the efficiency of construction firms from Western Europe because this area is far more developed than others, these firms operating on developed markets and the level of activity is complex.

The firms included in this study are the following:

Table no. 2 Firms included in the study

1.	Vinci (FR)	6.	Eiffage (FR)	11.	Saipem SPA (IT)
2.	Bouygues SA (FR)	7.	Strabag SE (AU)	12.	Balfour Beatty PLC (UK)
3.	Hochtief AG (D)	8.	Fomento de Construcciones y Contratas SA (SP)	13.	Bilfinger Berger SE (D)
4.	ACS SA(SP)	9.	Ferrovial SA (SP)	14.	Koninklijke Bam Groep NV (N)
5.	Skanska AB (SU)	10.	Colas SA (FR)	15.	Acciona SA (SP)

4. Empirical results and discussion

Analyzing the results, we observe that three firms from 15 have obtained maximum efficiency scores. We can conclude that in 2009 there was a recovery in the efficiency level of the firms from the construction sector, all the units obtaining higher scores than in 2008. Also, in this period it may be observed an increasing trend for the efficiency, even if in 2010 a slight decrease is underlined.

Table no. 3 The obtained results

	CRS(CCR)			**VRS (BCC)**			**Scale Efficiency**		
	2008	2009	2010	2008	2009	2010	2008	2009	2010
Vinci	0.525	0.751	0.684	1.000	1.000	1.000	0.525	0.751	0.684
Bouygues SA	0.540	1.000	0.872	1.000	1.000	1.000	0.525	1.000	0.872
Hochtief AG	0.443	0.778	0.803	0.533	0.778	0.820	0.831	1.000	0.979
ACS	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
Skanska AB	0.415	1.000	0.843	0.567	1.000	0.853	0.732	1.000	0.988
Eiffage	0.662	0.951	0.569	0.700	1.000	0.752	0.945	0.951	0.756
Strabag SE	0.422	0.708	0.780	0.561	0.747	0.789	0.751	0.947	0.989
Fomento de Construcciones y Contratas SA	0.510	0.818	0.755	0.569	0.842	0.785	0.898	0.972	0.962
Ferrovial SA	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
Colas SA	0.315	0.590	0.659	0.442	0.659	0.664	0.713	0.895	0.992
Saipem SPA	0.446	1.000	0.877	0.541	1.000	0.887	0.825	1.000	0.989
Balfour Beatty PLC	0.400	0.915	0.826	0.671	1.000	0.885	0.596	0.915	0.932
Bilfinger Berger SE	0.343	0.779	0.704	0.509	0.856	0.833	0.674	0.910	0.845
Koninklijke Bam Groep NV	0.493	0.867	1.000	0.759	1.000	1.000	0.650	0.867	1,000
Acciona SA	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**
MEDIA	***0.568***	***0.877***	***0.825***	***0.724***	***0.926***	***0.885***	***0.779***	***0.947***	***0.933***

Source: own computations

Regarding the approach CRS, it is observed that in 2008 only three companies were able to obtain maximum efficiency scores, while the rest have obtained very low scores that highlight the high degree of inefficiency for the year 2008, the average value standing just a little over the half of the optimal level. In 2009, the situation has improved significantly, doubling the number of the companies with maximum scores and the other companies managing to get very close to the maximum level. Though it is observed a slight decrease, the results obtained in 2010 are very close to those in 2009, their average reaching at the level of 0.825 from 0.877 in 2009.

The VRS approach brings forward much higher values of efficiency scores, this being due to the fact that in this approach the companies are analyzed according to size, while in case of the CRS approach they are analyzed as a whole. As in the case of the CRS approach, the situation is similar, on average being registered significant increases in 2009 and a slight decrease in 2010, except that the number of the companies that have achieved maximum efficiency scores is higher.

In what regards the economies of scale, if in 2008 only three companies benefited from this, in 2009 their number increased, the companies from France, Germany, Sweden and Italy benefiting also from the economies of scale. For the three years the same trend is kept, namely that of significant increase in 2009 compared to 2008, and a slight decrease in 2010, keeping scores at high enough levels.

5. Conclusions

In the undertaken study we tried to capture the efficiency of the activity of constructions for the Western European countries, as well as the the extent to which they were affected by the financial crisis. The analysis revealed that these companies were strongly hit by the economic and financial problems in 2008, receiving the lowest scores of efficiency from the period studied. Also, it seems that their efforts to overcome a difficult period for any economic activity - namely those of making their activity more efficient, of increasing productivity, and restructuring costs - have resulted in the revival of the activity in constructions in 2009's economy.

We can conclude that the construction companies, like most of the companies from different fields have been affected by the economic and financial crisis. But unlike those who have failed to survive this period, those included in the survey were able to recover significantly during the year 2009.

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