Examining the relationship between firm internationalization and firm performance: A nonparametric analysis

Halkos, George and Tzeremes, Nickolaos

University of Thessaly, Department of Economics

September 2007

Examining the relationship between firm internationalization and firm performance: A nonparametric analysis

George Emm. Halkos* and Nickolaos G. Tzeremes

Department of Economics, University of Thessaly
Korai 43, 38333, Volos, Greece

Abstract

Over the last 30 years researchers have examined the link between performance and the degree of internationalization having reported inconsistent and contradictory results. This paper by performing a bootstrapped Data Envelopment Analysis (DEA) tries to constitute to the existing literature by investigating if firms' internationalization levels have an impact on their performance. Using a sample of ten Transnational corporations from South-East Europe the paper provides information regarding their efficiency levels. Finally, using the "Transnationality Index" (TNI) provided by UNCTAD in order to capture the levels of internationalisation, our results reveal that there is a positive influence on firms' performance.

Keywords: Firm internationalization; Firm performance; Multinational corporations; Transnationality index; DEA.

JEL Classification: D21, C61, C67, M16

* **Address for correspondence:**
Associate Professor George Halkos
Director of Postgraduate Studies
Department of Economics,
University of Thessaly,
Korai 43, 38333, Volos, Greece.
Email: halkos@econ.uth.gr
http://www.halkos.gr/
Tel.: 0030 24210 74920
FAX: 0030 24210 74772

1. Introduction

Different theoretical perspectives have been used such as: portfolio investment theory (Markowitz, 1952), the resource-based view (Wernerfelt, 1984) or foreign direct investment (FDI) theories (Rugman, 1982) in order to establish the relationship of the degree of internationalisation (DOI) and firm's performance. In addition according to Hsu and Boggs (2003) equivocal findings have been emerged when examining such a relationship.

However, an extensive international business activity coincides with increased financial earnings. According to Annavarjula and Beldona (2000) international business researchers suggest that earlier studies can not provide clear conclusions for such a relationship. There are different uni-dimensional measures for firms' internationalisation such as: the ratio of foreign sales to total sales, the share of foreign employees and the number of countries in which a firm owns activities. Specifically, the ratio between foreign sales and total sales is the most commonly used measure of internationalization in the studies which focus on the impact of internationalization on firm performance. Several other aggregated multidimensional index have been used in order to capture the degree of DOI such as: the internationalization scale (Sullivan, 1994), the Transnationality Index (TNi) (published UNCTAD) and the Transationality Spread Index (TSi) (Ietto-Gilles, 1998)[1].

Several studies in international business research explore the relationship between internationalization and performance and show inconsistent results (Lu and Beamish, 2004). A number of studies have found empirical support for the hypotheses

[1] For analysis of internationalisation measures and issues see Sullivan (1994), Ramaswamy *et al.* (1996), Hassel *et al.* (2003), Depperu and Cerrato (2005).

of a linear positive relationship between internationalization and performance (Vernon, 1971; Errunza and Senbet, 1984; Grant, 1987) other studies have found no significant relationship (Morck and Yeung, 1991) or provided evidence of a negative relationship (Denis *et al.* 2002). Hit *et al.* (1997) suggest that the relationship between DOI and performance is curvilinear and has an inverted U shape relationship. Moreover, Lu and Beamish (2001) have found evidence that there is a U shaped relationship between DOI and firm performance. According to Buckley and Casson, (1976), traditionally, firms internationalize their activities in order to explore firm specific assets.

Furthermore, according to Barkema and Vermeulen (1998) firm's international competitiveness have been the focus of recent research. In addition countries' specific advantage can influence firm's competitiveness. According to Kogut (1985) operational flexibility and higher market power are the main advantages of internationalisation. However, other authors, (Caves, 1971, Hymer, 1976; Teece, 1980) suggest that the exploitation of economies of scale and scope is the main gain of firm's internationalisation.

According to McDougall and Oviatt (1996) the main motives of firms international expansion is higher growth and profitability.

Finally, Buhovac and Slapnicar (2007) found that focused performance measurements are aligned with business strategy which in turn improves firms' profitability. In fact studies showed that multinational business strategy and its international exposure has a direct impact on firm's efficiency. According to Bernard and Jensen (1999) exporting does not change firms' performance, however firms with higher performances are likely to export their products. Foreign ownership has also been found to have an important contributory influence on firms' performances.

Halkos and Tzeremes (2007) found that foreign ownership has a positive effect on medium size firms' productivity. In addition, Doms and Jensen (1998) found that firms establishing overseas activities have an advantage in efficiency compared to the domestic firms.

Performance measurement is the normal way to handle internal and external pressures, by monitoring and benchmarking a company's production. Productivity and efficiency are the two important concepts in this regard and are frequently utilised to measure performance. Unfortunately, over the last ten years or so, these two similar but different concepts have been used interchangeably by various commentators (Coelli *et al.,* 2005). Data Envelopment Analysis (DEA) is one of the most important approaches to measuring efficiency. Since its advent in 1978 (Charnes *et al.,* 1978), this method has been widely utilised to analyse relative efficiency and has covered a wide area of applications and theoretical extensions (Allen *et al.,* 1997).

In addition, the obvious payoff from efficiency measurement of multinational enterprises is that it provides an objective basis for evaluating the performance of a decision-making agent. In our case this decision is based in the level of internationalization of the company. The outcome at the highest level of efficiency (e.g., the maximum profit/ sales achievable) provides an absolute standard for management by objectives.

In this paper, using Data Envelopment Analysis, we explore the effect of internationalization on firm performance by investigating the top 10 non-financial transnational corporations from South-East Europe ranked by their foreign assets. The structure of the paper is as follows. Section 2 the methodology adopted both in its theoretical and mathematical formulation and the various variables used in the formulation of the proposed model are presented and discussed. In section 3 the empirical findings of our study are obtained. The final section concludes the paper discussing the derived results and the implied policy implications.

2. Methodology and data description

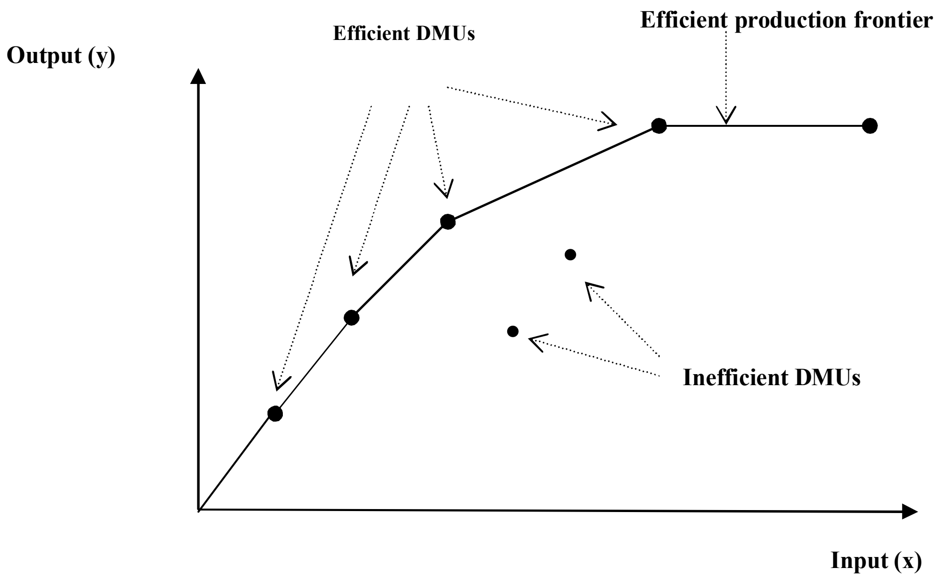
2.1 Data Envelopment Analysis

Following Farrell (1957) and Charnes *et al.* (1978) first introduced the term DEA (Data Envelopment Analysis) in order to describe a mathematical programming approach of the production frontier construction and the efficiency measurement of these frontiers. These last authors set up the CCR model that adopted an input orientation and assumed constant returns to scale (CRS). Later studies have considered some alternative assumptions. For instance, Banker *et al.* (1984) introduced the assumption of variable returns to scale (VRS) establishing in this way the BCC model. DEA is applied to assess homogeneous units, called Decision-Making Units (DMUs). A DMU actually converts inputs into outputs. The orientation choice, input orientation or output orientation, depends on the DMU market conditions.

In our case we use output orientation because we assume that multinationals try with a given input to maximise their output through their internationalisation strategies. With regard to the returns to scale, they may be either constant or variable. Both forms (CCR and BCC models) are often presented for comparative purposes. In relation to the weights associated with the inputs and the outputs within the objective function, these are subject to the inequality constraints. They are endogenous and defined by the algorithm. They actually measure the distance between the DMU and the frontier.

The production frontier that is constructed through the optimization process (Figure 1) consists of a discrete curve formed by the efficient DMUs, those that maximize the outputs. The inefficient DMUs are below the production frontier because they do not maximize the outputs at the production level. However, as Dyson *et al.* (2001) indicate there are some problems associated with application of DEA.

Figure 1: Data Envelopment Analysis Production Frontier



The two main problems are the heterogeneity of the DMUs assessed either environmentally or within the entities and the sensitivity of efficiency measurement to outliers. Other pitfalls of DEA can be related to sample size and its influence on efficiency measurement. Several authors (Dyson *et al.*, 2001; Zhang and Barlets, 1998; Staat, 2001; Banker and Morey, 1986) suggest that efficiency scores are significantly influenced by the variation in sample size. In addition Bauer *et al.* (1998) suggest that when there are too few observations of the number of inputs and outputs used then DEA may be sensitive to 'self identifiers'. Moreover, Fried *et al.* (2002) concentrate in two drawbacks when applying DEA techniques: its deterministic view and its omission of relevant variables. Finally, Dyson *et al.* (2001) examining the 'pitfalls and protocols' of DEA application concentrates on the homogeneity of the units under assessment, the choice of inputs/outputs, the measurement of variables and the weights attributed to variables.

Despite, those pitfalls which in most of the cases affect equally also the parametric techniques, DEA is still one of the most popular tools of analysing efficiency measurements due to its analytical nature. Furthermore, in this paper taking into consideration the main pitfalls of the technique we apply probabilistic methodologies introduced by Simar and Wilson (1998, 2000, 2002) and Daraio and Simar (2007) in order to produce unbiased efficiency results.

2.2 Efficiency measurement

The model is designed to evaluate the relative performance of some decision making unit (DMU) denoted as DMU$_o$, based on observed performance of $f=1,2,..,n$ DMUs. A DMU is to be regarded as an entity responsible for converting inputs into outputs. The $t_{\varphi f}$, $w_{lf} > 0$ in the model are constants which represent observed amounts of the φ th output and the l th input of the f th DMU which we shall refer to as DMU$_f$ in a collection of $f = 1,..,n$ entities which utilize these $l= 1,..,m$ inputs and produce these $\varphi = 1,\ldots, s$ outputs. One of the $f = 1,\ldots,n$ DMUs is singled out for evaluation, accorded the designation DMU$_o$, and placed in the functional to be maximized in (1) while also leaving it in the constraints.

It then follows that DMU$_o$'s maximum efficiency score will be $e_o^* \leq 1$ by virtue of the constraints.

$$
\begin{aligned}
&\max \quad e_o = \frac{\sum_{\phi=1}^{s} u_\phi y_{\phi o}}{\sum_{l=1}^{m} \upsilon_l x_{lo}} \\
&s.t. \frac{\sum_{\phi=1}^{s} u_\phi t_{\phi f}}{\sum_{l=1}^{m} r_l w_{lf}} \leq 1;\ f = 1,2,\ldots n \\
&\frac{u_\phi}{\sum_{l=1}^{m} r_l w_{lo}} > \varepsilon;\ \phi = 1,\ldots, s \qquad\qquad (1) \\
&\frac{r_l}{\sum_{l=1}^{m} r_l w_{lo}} > \varepsilon;\ l = 1,\ldots, m \\
&\varepsilon > 0
\end{aligned}
$$

The ε>0 in (1) represents a non-archimedean constant which is smaller than any positive valued real number. The numerator in the objective of (1) represents a set of desired outputs and the denominator represents a collection of resources used to obtain these outputs. This ratio results in a scalar value similar to ratio forms often used in accounting and other types of analyses. The e_o^* value obtained from this ratio satisfies $0 \le e_o^* \le 1$ and can be interpreted as an efficiency rating in which $e_o^* = 1$ represents full efficiency and $e_o^* \le 1$ represents inefficiency. The star (*) used in our calculations indicates an optimal value obtained from solving the model.

Also, note that no weights need to be specified a priori in order to obtain the scalar measure of performance. The optimal values u_ϕ^*, r_l^* may be interpreted as weights when solutions are available from (1). Furthermore, the u_ϕ^*, r_l^* values secured by solving the above problem are called *virtual multipliers* and interpreted in DEA so that they yield a *virtual output* $t_o = \sum u_\phi^* t_{\phi o}$ (summed over φ = *1,…,s*) and a *virtual input* $w_o = \sum r_l^* w_{lo}$ (summed over *l* = *1,…,m*) which can allow us to compute the efficiency ratio $e_o \frac{t_o}{w_o}$. As can be observed from (1), e_o^* is the highest rating that the data allow for a DMU. No other choice of u_ϕ^*, r_l^* can yield a higher e_o^* and satisfy the constraints. We are transforming problem to (1) into a linear programming form as has been illustrated by Charnes *et al.* (1978) as:

$$\begin{aligned}
&\max \sum_{\phi=1}^{s} u_\phi t_{\phi o} \\
&st \sum_{\phi=1}^{s} u_\phi t_{\phi f} - \sum_{l=1}^{m} r_l w_{lf} \le 0 \\
&\sum_{l=1}^{m} r_l w_{lo} = 1 \\
&-u_\phi \le -\varepsilon \\
&-r_l \le -\varepsilon
\end{aligned} \tag{2}$$

The dual linear programming problem can be represented as:

$$
\begin{aligned}
&\min\ \theta - \varepsilon\left[\sum_{l=1}^{m} s_i^- + \sum_{\phi=1}^{s} s_\phi^+\right] \\
&st.\theta w_{lo} - \sum_{f=1}^{n} w_{lf}\lambda_f - s_l^- = 0 \\
&t_{\phi o} = \sum_{f=1}^{n} t_{\phi f}\lambda_f - s_l^+ \\
&0 \le \lambda_f, s_l^-, s_\phi^+ \\
&l = 1,\dots s; \phi = 1,\dots s; f = 1,\dots n
\end{aligned}
\tag{3}
$$

Finally the optimal solution derived from (3) is illustrated below as:

$$
e_o^* = \theta^* - \varepsilon\left(\sum_{l=1}^{m} s_l^{-*} + \sum_{\phi=1}^{s} s_\phi^{+*}\right) = \sum_{\phi=1}^{s} u_\phi^* t_{\phi o} \tag{4}
$$

In (4) $\theta^* = 1$ does not imply that $e_o^* = 1$ unless $s_\phi^{+*}, s_l^{-*} = 0$ for all φ and l. Therefore, it is necessary for DMU_o to be characterized fully efficient (1 or 100%) if we have both $\theta^* = 1$ and zero slack values. In order to calculate the return to scales we need to use the BCC model provided by Banker *et al.* (1984) model. The major difference from CCR and BCC model is that CCR model bases the evaluation on constant returns to scale, whereas the BCC model allows variable returns to scale.

This can be obtained by adding in (3) the restriction illustrated below:

$$
\sum \lambda_f = 1 \tag{5}
$$

This restriction has the effect of removing the constraint in the CCR model that DMUs must be scale efficient. The BCC model allows variable returns to scale and measures only the technical efficiency of a DMU. In conclusion, for a DMU to be considered as CCR efficient, it must be both scale and technical efficient. For a DMU to be consider as BCC efficient, it only needs to be technical efficient. By adding the restriction (5) into (3) u_o^* indicates (for the BCC case) the return to scale possibilities.

If $u_o^* < 0$ implies increasing returns to scale, whereas $u_o^* > 0$, implies decreasing returns to scale. Finally, if $u_o^* = 0$ implies constant returns to scale. Inefficiencies due to decreasing returns to scale (DRS) indicate that a doubling of all inputs will lead to less than doubling of the output, whereas inefficiencies due to increasing returns to scale (IRS) indicate that a doubling of all inputs will lead to more than doubling of the output.

2.3 Efficiency bias correction

Following the bootstrap algorithm introduced by Simar and Wilson (1998, 2000) we perform the bootstrap procedure on the results of input oriented efficiency measurements. The bootstrap procedure is a data-based simulation method for statistical inference (Daraio and Simar 2007, p.52). Suppose we want to investigate the sampling distribution of an estimator $\hat{\theta}$ of an unknown parameter θ, where P is a statistical model (data generating process, or DGP) and $\hat{\theta} = \hat{\theta}(X)$ is a statistical function of X. Therefore by the proposed procedure we try to evaluate the sampling distribution of $\hat{\theta}(X)$ to evaluate the bias, the standard deviation of $\hat{\theta}(X)$ and to create confidence intervals of any parameter θ. By generating data sets from a consistent estimator $\hat{\mathrm{P}}$ of P from data $X : \hat{\mathrm{P}} = \mathrm{P}\left(\hat{\Psi}, \hat{f}(.,.)\right)$, we denote $X^* = \left\{\left(X_i^*, Y_i^*\right), i = 1,...,n\right\}$ the data set generated from $\hat{\mathrm{P}}$.

The estimators of the corresponding quantities of $\hat{\Psi}$ and $\hat{\delta}(x, y)$ (in terms of the Shephard (1970) input-distance function) can be defined by the pseudo sample corresponding to the quantities $\hat{\Psi}^*$ and $\hat{\delta}^*(x, y)$. Using the methodology proposed the available bootstrap distribution of $\hat{\delta}^*(x, y)$ will be almost the same with the original unknown sampling distribution of the estimator of interest $\hat{\delta}(x,y)$ and therefore it can be expressed as:

$$\left(\hat{\delta}^*(x,y)-\hat{\delta}(x,y)\right)\Bigg|\hat{\mathrm{P}} \overset{approx.}{\sim} \left(\hat{\delta}(x,y)-\delta(x,y)\right)\Bigg|\mathrm{P} \tag{6}$$

A bias corrected estimator can then be defined as:

$$\tilde{\delta}(x,y)=\hat{\delta}(x,y)-\hat{bias}\left(\hat{\delta}(x,y)\right)=2\hat{\delta}(x,y)-\frac{1}{B}\sum_{b=1}^{B}\hat{\delta}_{\mathrm{b}}^*(x,y) \tag{7}$$

2.4 Testing for returns to scale

In order to choose between the adoption of the results obtained by the CCR (Charnes *et al.,* 1978) and BCC (Banker *et al.,* 1984) models in terms of the consistency of our results obtained we adopt the method introduced by Simar and Wilson (2002). Therefore, we compute the DEA efficiency scores under the CRS and VRS assumption and by using the bootstrap algorithm described previously we test for the CRS against the VRS results obtained such as:

$$H_o:\Psi^{\vartheta} \quad is \quad CRS \quad against \quad H_1:\Psi^{\vartheta} \quad is \quad VRS \tag{9}$$

Following, Simar and Wilson (2002) the test statistic is given by the following expression as:

$$T(X_n)=\frac{1}{n}\sum_{i=1}^{n}\frac{\hat{\theta}\,crs,n(X_i,Y_i)}{\hat{\theta}\,vrs,n(X_i,Y_i)} \qquad (10).$$

Then the *p-value* of the null hypotheses can be approximated by the proportion of bootstrap samples as:

$$p-value=\sum_{b=1}^{B}\frac{I\left(T^{*,b}\leq T_{obs}\right)}{B} \tag{11}$$

where B is 2000 bootstrap replications, I is the indicator function and $T^{*,b}$ is the bootstrap samples and original observed values are denoted by T_{obs}.

2.5 The data

In our analysis we use the data provided by World Investment Report (2006) for the top 10 non-financial transnational corporations (TNCs) from South-East Europe as has been ranked by UNCTAD according to their foreign assets. Table one provides information regarding the names of the corporations, the home country, industry details and variable statistics. Furthermore, looking at the home country information we realize that eight out of ten multinationals come from the Russian Federation, one from Serbia and Montenegro and one from Croatia. Moreover three companies are from the ‘metal and metal product’ sectors, two from ‘petroleum and natural gas’, one from ‘mining and quarrying’, one from ‘transport’, one from ‘pharmaceuticals’, one from ‘motor vehicles’ and one from ‘heavy construction’.

Due to the fact that DEA scores are sensitive to input and output specification and the size of the sample, there are different rules as to what the minimum number of corporations in the sample should be. One rule is that the number of corporations in the sample should be at least three times greater that the sum of the number of outputs and inputs included in the specification (Nunamaker, 1985).

Therefore, in our case we use two inputs and one output. The two inputs used are “foreign assets” (measured in million dollars) and “foreign employment” (measured in number of employees). The output used in our study is “foreign sales” (measured in million dollars). In addition there are three more variables (provided by UNCTAD) regarding information of domestic assets, domestic employment and domestic sales.

However, since our interest is emphasised in the performance of firms’ international activities we use the firms’ foreign aspects in order to calculate their international performance. In addition since we have only a small sample (ten firms) according to Nunamaker (1985) the inputs/ outputs used must not exceed the three variables in order for the DEA results to be valid. Furthermore, in order to measure the effect of internationalization on firm's performance Transnationality Index (TNI) has been used. According to UNCTAD, TNI is calculated as the average of the following three ratios: foreign to total assets, foreign to total sales and foreign to total employment.

Looking at the descriptive statistics in table 1 we observe high levels of standard deviation for all the values used indicating different levels of internationalization among the ten firms. Furthermore, the Pearson correlations between the TNI and the inputs/ outputs used are not correlated and therefore the results are unlikely to be biased (Coelli, *et al.* 2005, p.194).

Table1: Multinational names, industry characteristics and descriptive statistics

Corporation	**Home country**	**Industry**
Gazprom	Russian Federation	Petroleum and natural gas
Lukoil	Russian Federation	Petroleum and natural gas
Norilsk	Russian Federation	Mining & quarrying
Novoship Co.	Russian Federation	Transport
PLIVA Pharmaceuticals industry	Croatia	Pharmaceuticals
Rusal	Russian Federation	Metal and metal products
OMZ	Russian Federation	Motor vehicles
Energoprojekt	Serbia and Montenegro	Heavy construction
Severstal	Russian Federation	Metal and metal products
Mechel	Russian Federation	Metal and metal products
Variables	**Mean**	**StDev**
Foreign Assets (input)	4062	8542
Foreign Employment (input)	8824	10847
Foreign Sales (output)	6915	9988
TNI (external)	41,07	13,93
Variables	**Minimum**	**Maximum**
Foreign Assets (input)	120	27486
Foreign Employment (input)	55	36905
Foreign Sales (output)	108	26408
TNI (external)	25	62,9
Variables	TNI (external)	***Pearson Correlations***
Foreign Assets (input)	vs	-0,172 (0,635)
Foreign Employment (input)	vs	-0,392 (0,262)
Foreign Sales (output)	vs	-0,324 (0,361)
Efficiencies Scores (CRS)	vs	-0,470 (0,171)
Efficiencies Scores (VRS)	vs	-0,399 (0,253)

3. Empirical results

The results in Table 2 illustrate the findings of our analysis. Under the assumption of constant returns to scales (CRS) the results indicate that efficient firms (with score equal to 1) are reported to be Norilsk, Novoship Co. and Severstal, whereas the firms with the lowest efficiency scores are reported to be Energoprojekt (0,11) and OMZ (0,052). The average efficiency score of the sample is 0,595 with standard deviation of 0,4 which indicates a variation of efficiency scores among the firms.

Adopting the approach introduced by Andersen and Petersen (1993) we calculate the 'super efficiency' scores (CRS_SE and VRS_SE) for the firms for CRS and VRS cases. The term 'super efficiency' appears when firms can obtain efficiency scores greater than one because each firm is not permitted to use itself as a peer. The method was developed by Andersen and Petersen (1993) in order to create a ranking system would help them to rank efficient firms. If the value of the super efficiency score is extremely higher than one this may indicate that the firm may be an outlier.

In Table 2 we present the super efficiency scores for the CRS case (CRS_SE) realizing that the most efficient firm is Severstal (2,063). In addition and due to the fact that super efficiency scores are allowed, the sample mean efficiency is 0.864 with standard deviation of 0.774. This indicates that the results can be biased due to extreme higher performances of the firms. This is also indicated by the zero values of inputs and outputs weights (table 2) for the CRS case.

According to Coelli *et al.* (2005) when dealing with small number of data sets one can find that weights assigned to various inputs/ outputs may take unusual values either too large or too small (or even zero values) and may cause questions relying of the applicability of the efficiency measures obtained. In addition, all the nonparametric estimators are sensitive to outliers and extreme values and therefore can have a misleading influence in the evaluation of the performance of other firms. One approach can be a weigh restriction method, however according to Dyson *et al.* (2001) the incorporation of weight restrictions can introduce numerous pitfalls. Another approach may be to identify the outliers in the data and perhaps delete them. But since our sample contains only ten firms it wouldn't be meaningful to delete the outliers.

However, DEA results can be improved using bootstrap techniques introduced by Simar and Wilson (1998, 2000). Since our main pitfall is the sample size then bootstrap technique is the most appropriate in our case since it is testing the sampling variability by providing indication of the degree to which the efficiency estimates are likely to vary when a different sample is randomly selected from the population. Furthermore, Coelli *et al.* (2005, p. 203) suggest that bootstrapping can also be useful as a way of illustrating the sensitivity of DEA efficiency estimates to variations in sample composition.

In Table 2 the biased corrected efficiency scores (Biased Corr.) are being presented along with the estimation of bias and the variance of the bias estimated (std). For the CRS case the unbiased efficiency scores indicate that the firms with the highest performance are Lukoil (0.801) and Rusal (0.785) whereas the firms with the lowest efficiency scores are reported to be Energoprojekt (0,295) and OMZ (0.111). The mean efficiency scores of the sample is 0.559 with a standard deviation of 0.225. The biased corrected results produce different results compared to the original results and indicate that pitfalls of DEA application can lead to measurement errors. Finally, the last column indicates the peer groups of the inefficient firms. For instance Gazprom has as benchmark firms Norilsk and Rusal.

In addition, Table 2 provides results for the VRS case. The DEA VRS model assumes that companies may not operate at optimal scale and compares companies with similar sizes. Looking at the results for VRS six firms appear to be efficient (efficiency score equals to one). Namely these are Lukoil, Norilsk, Novoship Co., Energoproject, Severstal and Mechel. Since VRS specification allows for increasing and decreasing returns to scale then more firms appear to be efficient compared to the CRS case. Again for ranking purposes super efficiency estimates are been presented (VRS_SE). When the word 'big' appears in the super efficiency score means that the DMU remains efficient even if an arbitrary large decrease exists in its outputs.

Since for the VRS case more firms appear efficient the mean efficiency score will be higher compared to the CRS case. In fact under the VRS case the mean value of efficiency score is 0,803 with standard deviation of 0,365. Again when looking at the inputs/ output weights there is the case of biased results. Performing the procedure introduced by Simar and Wilson (1998, 2002) we produce the biased corrected efficiency scores (Biased Corr.) for the VRS case. According to the biased corrected results the firms with the highest efficiency scores are reported to be Rusal (0.935) and Gazprom (0.859), whereas the firm with the lowest performance is OMZ (0.287). Again a small sample size is proven to be a major pitfall for VRS estimates, however when applying the bootstrap techniques unbiased estimates are being obtained. The mean efficiency score for the VRS case is 0.728 (biased corrected efficiency scores) and the standard deviation is 0.169.

However, the question in hand is the choice between the two approaches (CRS and VRS) in order for the efficiency to be adopted and tested against the environmental factors (in our case TNI). According to Daraio and Simar (2007, p.151) under the VRS the attainable set is estimated by the free disposal convex hull of the cloud points compared to the more restrictive CRS model. Using the approach introduced by Simar and Wilson (2002) we obtain for this test (with B = 2000) a p-value of 0.856 > 0.05 hence we accept the null hypothesis of CRS. Therefore, the results derived under the CRS hypothesis are consistent compared to the VRS results.

Table 2: Efficiency scores, rankings and descriptive statistics

Company Names	CRS_SE	CRS	FA (InWeights)	FE (InWeights)	FS (OutWeights)	Biased Corr	Bias	STD	Peers
(1) Gazprom	0,209	0,209	0	0	0	0,440	-2,064	0,823	3, 9
(2) Lukoil	0,758	0,758	0	0	0	0,801	-0,490	0,062	3, 9
(3) Norilsk	1,734	1,000	0	0	0	0,688	-0,454	0,035	0
(4) Novoship Co.	1,890	1,000	0	0,02	0	0,637	-0,571	0,036	0
(5) PLIVA Pharmaceuticals industry	0,176	0,176	0	0	0	0,472	-1,945	0,880	3, 9
(6) Rusal	0,837	0,837	0	0	0	0,785	-0,437	0,033	3, 9
(7) OMZ	0,052	0,052	0	0	0	0,111	-8,923	14,126	3, 9
(8) Energoprojekt	0,110	0,110	0	0	0,01	0,295	-3,282	2,908	3, 9
(9) Severstal	2,063	1,000	0	0	0	0,646	-0,548	0,035	0
(10) Mechel	0,808	0,808	0,01	0	0	0,714	-0,593	0,068	0
Mean	0,864	0,595	0,001	0,002	0,001	0,559	-1,931	1,901	
Minimum	0,052	0,052	0	0	0	0,111	-8,923	0,033	
Maximum	2,063	1,000	0,010	0,020	0,010	0,801	-0,437	14,126	
Standard Deviation	0,774	0,405	0,003	0,006	0,003	0,225	2,641	4,389	
Company Names	**VRS_SE**	**VRS**	**FA (InWeights)**	**FE (InWeights)**	**FS (OutWeights)**	**Biased Corr**	**Bias**	**STD**	**Peers**
(1) Gazprom	0,929	0,929	0	0	0	0,859	-0,235	0,037	2
(2) Lukoil	2,513	1	0	0	0	0,747	-0,339	0,050	0
(3) Norilsk	1,949	1	0	0	0	0,757	-0,322	0,036	0
(4) Novoship Co.	big	1	0	0	0	0,727	-0,375	0,080	0
(5) PLIVA Pharmaceuticals industry	0,176	0,176	0	0	0	0,767	-1,128	0,454	3,8,9
(6) Rusal	0,866	0,866	0	0	0	0,935	-0,203	0,012	2,3,9
(7) OMZ	0,061	0,061	0,01	0	0	0,287	-3,421	4,477	2,9
(8) Energoprojekt	big	1	0	0	0,01	0,731	-0,368	0,080	0
(9) Severstal	2,493	1	0	0	0	0,748	-0,337	0,050	0
(10) Mechel	big	1	0,02	0	0	0,727	-0,376	0,082	0
Mean	1,284	0,803	0,003	0	0,001	0,728	-0,710	0,536	
Minimum	0,061	0,061	0	0	0	0,287	-3,421	0,012	
Maximum	2,513	1,000	0,020	0	0,010	0,935	-0,203	4,477	
Standard Deviation	1,036	0,365	0,007	0	0,003	0,169	0,987	1,391	

Adopting the CRS estimates we further test if the efficiency scores under the CRS assumption have been influenced by the internationalization levels of the firm. Moreover our paper uses the Mann-Whitney U test derived from the results of CCR model and the levels of Transnationality Index of the multinationals. The results of the Mann-Whitney U-test for the efficiency scores obtained from the CCR model are displayed in Table 3. The Mann-Whitney U-test has been recommended for a non-parametric analysis of the DEA results by Grosskopf and Valdamanis (1987) and Brockett and Golany (1996). This test was used in the present analysis because the efficient score results did not fit the standard normal distribution. In addition when using a second two stage procedure Simar and Wilson (2004) suggest that if the DEA efficiency estimates are serially correlated with the external factors make standard methods of inference invalid. Looking at Table 1 we realise that the DEA efficiency scores are not correlated with Transnationality Index and therefore any misspecifications of our approach shouldn't exist.

In table 3 the Mann Whitney result indicates the test is significant at 10% level. The minus sign of the Z scores indicates that the corporations with the highest levels of transnationality are tending to lead to higher efficiency scores than those with lower levels of transnationality. The results indicate that there is a positive link between the internationalization of the firm and firm performance (Contractor *et al.* 2003; Dunning 1977, 1981).

Table 3: Mann-Whitney test of differences in efficiency

Reference	Mann-Whitney U test	Z	Asymptotic significance (two-tailed)
High levels of Transnationality vs. lower levels of Transnationality for the case of CRS	4	-1,706	0,088*

* Indicates significance at the 10% level.

4. Conclusions

According to Sullivan (1994) the link between internationalization and firm performance is the key issue in international business research. This relationship has been researched by several authors trying to provide empirical and theoretical evidence. Among others, Annavarjula and Beldona (2000) and Ruigrok and Wagner

(2003) provide evidence to support such a relationship which appears to be the main element of firms' superior financial success.

In this study using data envelopment analysis the performance of ten multinational corporations from South-East Europe has been examined relative to their level of internationalization. In order to test the internationalization levels of the firm, the Transnationality Index (TNi), published by UNCTAD (World Investment Report, 2006), has been used. The results indicate that firms with higher levels of efficiency are the ones with higher levels of internationalisation.

Given the fact that internationalization refers to the process through which a firm increases its reliance on foreign markets and countries as a means of growth and financial performance improvement, this study captures only one angle of internationalisation as has been indicated by the Transnationality Index. However further investigation is needed in order to capture the three main components of a firm's internationalization degree and their effects on firms' performance. These are the number of countries in which the firm has foreign business operations (Tallman & Li, 1996), the number of diverse social cultures of the countries in which the firm operates (Hofstede, 1980) and the geographic diversity of the foreign markets (Sambharya, 1995).

Thus, when evaluating the degree of internationalization it is necessary to reflect the various differences across the countries and markets in which the firm undertakes foreign operations in order to fully justify its effect on firm performance. Nevertheless, this study provides empirical evidence of positive influence of internationalization on firm performance.

References

Allen, R., Athanassopoulos, A., Dyson, R. G. and Thanassoulis, E., 1997, "Weights Restrictions and Value Judgements in Data Envelopment Analysis: Evolution, Development and Future Directions", *Annals of Operational Research* 73, 13-34.

Andersen, P. and Petersen, N. C., 1993, "A Procedure for Ranking Efficient Units in Data Envelopment Analysis,"*Management Science*, 39, 1261–1264.

Annavarjula, M. and Beldona, S., 2000, "Multinationality-Performance Relationship: A Review and Reconceptualization", *International Journal of Organizational Analysis*, 8, 48-67.

Banker, R. D., Charnes, A. Cooper, W. W., 1984, "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis", *Management Science* 30, 1078-1092.

Banker, R.D., Morey, R.C., 1986, "The use of categorical variables in Data Envelopment Analysis," *Management Science,* 32, 1613–1627.

Barkema, H.G. and Vermeulen, F., 1998, "International expansion through start-up or acquisition: A learning perspective", *Academy of Management Journal* 41(1), 7-26.

Bauer, P.W., Berger, A.N., Ferrier, G.D., Humphrey, D.B., 1998, "Consistency conditions for regulatory analysis of financial institutions: A comparison of frontier methods," *Journal of Economics and Business*, 50, 85–114.

Bernard, A and Jensen, B., 1999, "Exceptional Exporter Performance: Cause Effects or Both?", *Journal of International Economics* 47, 1-26.

Brockett, P. L., Golany, B., 1996, "Using rank statistics for determining programming efficiency differences in data envelopment analysis", *Management Science* 42, 466-472.

Buckley, P.J. and Casson, M., 1976, *The Future of Multinational Enterprise*, London: Holmes & Meier.

Buhovac, A.R. and Slapnicar, S., 2007, "The role of balanced, strategic, cascaded and aligned performance measurement in enhancing firm performance", *Economic and Business Review* 9 (1), 47-78.

Caves, R.E., 1971, "International corporations: The industrial economics of foreign investment", *Economica* 38, 1-27.

Charnes, A., Cooper, W. W. and Rhodes, E., 1978, "Measuring the Efficiency of Decision Making Units", *European Journal of Operational Research*. 2, 429-444.

Coelli, T. J., Rao, P. D. S. and Battese, G. E., 2005, A*n introduction to efficiency and production analysis*, Springer Science: New York.

Contractor, F.J., Kundu, S. and Hsu, C., 2003, "A Three-Stage Theory of International Expansion: The Link Between Multinationality and Performance in the Service Sector", *Journal of International Business Studies* 34, 5–18.

Daraio, C. and Simar, L., 2007, *Advanced robust and nonparametric methods in efficiency analysis*. Springer Science: New York.

Denis, D.J., Denis, D.K. and Yost, K., 2002, "Global diversification, industrial diversification, and firm value", *Journal of Finance*, 57, 1951-1979.

Depperu, D. and Cerrato, D., 2005, Analyzing International Competitiveness At The Firm Level: Concepts And Measures. Working Paper No. 32, Dipartimento Scienze Sociali - Sezione Economia Aziendale, Universita Cattolica Del Sacro Cuore, Piacenza.

Doms, M.E. and Jensen, J.B., 1998, "Comparing wages, skills, and productivity between domestically and foreign-owned manufacturing establishments in the United States", In Baldwin, R. Lipsey, R. and Richardson, J.D. eds., *Geography and Ownership as Bases for Economic Accounting,* Chicago: Chicago University Press, 235-255.

Dunning, J.H., 1977, Trade location of economic activity and the multinational enterprise: a search for an eclectic approach, in B. Ohlin, P. Hesselborn and P.M. Wijkman (eds.), *The International Allocation of Economic Activity*, London and New York: Macmillan, pp. 395-418.

Dunning, J.H., 1981, "Explaining the international direct investment position of countries: towards a dynamic or developmental approach", *Weltwirtschaftliches Archiv*, 119 (1), 30-64.

Dyson, R.G., Allen, R., Camanho, A.S., Podinovski, V.V., Sarrico,C.S., Shale, E.A., 2001, "Pitfalls and protocols in DEA," *European Journal of Operational Research,* 132, 245–259.

Errunza, V.R. and Senbet, L.W., 1984, "International corporate diversification, market valuation, and size-adjusted evidence", *Journal of Finance*, 39, 727-743.

Fried, H.O., Lovell, C.A.K., Schmidt, S.S., Yaisawarng, S., 2002, "Accounting for environmental effects and statistical noise in Data Envelopment Analysis," *Journal of Productivity Analysis*, 17, 157–174.

Grant, R.M., 1987, "Multinationality and performance among British manufacturing companies", *Journal of International Business Studies*, 18(3), 79-89.

Grosskopf, S., Valdamanis, A., 1987, "Measuring hospital performance: a non-parametric approach", *Journal of Health Economics*, 6, 89-107.

Halkos, G.E. and Tzeremes, N.G., 2007, "Productivity efficiency and firm size: An empirical analysis of foreign owned, companies", *International Business Review*, 16, 713-731.

Hassel, A., Höpner, M., Kurdelbusch, A., Rehder, B., and Zugehöret, R., 2003, "Two Dimensions of the Internationalization of Firms", *Journal of Management Studies,* 40(3), 705-723.

Hitt, M.A., Hoskisson, R.E. and Kim, H., 1997, "International diversification: Effects on innovation and firm performance in product-diversified firms", *Academy of Management Journal*, 40(4), 767-768.

Hofstede, G., 1980 C*ulture's Consequences: International Differences in Work-Related Values*. London: Sage Publications.

Hsu, C. and Boggs, D. J., 2003, "Internationalization and Performance: Traditional Measures and their Decomposition", *Multinational Business Review*, 11, 23–49.

Hymer, S.H., 1976, *The International Operations of National Firms: A Study of Direct Foreign Investment*, Cambridge (MA): MIT Press.

Ietto-Gillies, G., 1998, "Different conceptual frameworks for the assessment of the degree of internationalization: an empirical analysis of the various indices for the top 100 transnational corporations", *Transnational Corporations*, 7(1), 17–39.

Kogut, B., 1985, "Designing global strategies: Comparative and competitive value-added chains", *Sloan Management Review*, Fall, 27-38.

Lu J.W. and Beamish P.W., 2004, "International diversification and firm performance: the S-Curve Hypothesis", *Academy of Management Journal*, 47(4), 598-609.

Lu, J.W. and Beamish, P.W., 2001, "The Internationalisation and Performance of SMEs", *Strategic Management Journal*, 22, 565-586.

Markowitz, H., 1952, "Portfolio Selection", *Journal of Finance* 7, 77-91.

McDougall, P.P. and Oviatt, B.M., 1996, "New Venture Internationalization, Strategic Change, and Performance: A follow-up study", *Journal of Business Venturing*, 11(1), 23-40.

Morck, R. and Yeung, B., 1991, "Why investors value multinationality", *Journal of Business*, 64(2), 165-187.

Nunamaker, T. R., 1985, "Using data envelopment analysis to measure the efficiency of non-profit organisations: a critical evaluation" *Managerial and Decision Economics* 6(1), 50-58.

Ramaswamy, K., Kroeck, G.K. and Renfort, W., 1996, "Measuring the degree of internationalization of a firm: a comment", *Journal of International Business Studies*, 27(1), 167-177.

Rugman, A. M., 1982, *New Theories of the Multinational Enterprise*, New York, St. Martin's Press.

Ruigrok, W. and Wagner, H., 2003, "Internationalization and Performance: An Organizational Learning Perspective", *Management International Review*, 43, 63-83.

Sambharya, R., 1995, "The Combined Effect of International Diversification and Product Diversification Strategies on the Performance of US-Based Multinational Corporations", *Management International Review*, 35, 197-218.

Shephard, R. W., 1970, *Theory of Cost and Production Function*. Princeton University Press, Princeton, NJ.

Simar, L. and Wilson, P.W., 1998, "Sensitivity analysis of efficiency scores: how to bootstrap in non parametric frontier models," *Management Science*, 44, 1, 49-61.

Simar, L. and Wilson, P.W., 2000, "A general methodology for bootstrapping in non-parametric frontier models," *Journal of Applied Statistics*, 27,6, 779 -802.

Simar, L. and Wilson, P.W., 2002, "Non parametric tests of return to scale," *European Journal of Operational Research*, 139, 115-132.

Simar, L., & Wilson, P. W., 2004, "Estimation and inference in two-stage, semi-parametric models of production processes," Discussion Paper, Institut de Statistique, Universite´Catholique de Louvain, Belgium.

Staat, M., 2001, "The effect of sample size on the mean efficiency in DEA: Comment', *Journal of Productivity Analysis,* 15,129–137.

Sullivan, D., 1994, "Measuring the degree of internationalization of a firm", *Journal of International Business Studies*, 25(2), 325-342.

Tallman, S. & Li, J., 1996, "Effects of International Diversity and Product Diversity on the Performance of Multinational Firms", *Academy of Management Journal*, 39, 179-196.

Teece, D.J., 1980, "Economies of scope and the scope of the enterprise", *Journal of Economic Behavior and Organization*, 1, 223-247.

Vernon, R., 1971, *Sovereignty at Bay: The Multinational Spread of US Enterprises*, New York: Basic Books.

Wernerfelt, B., 1984, "A Resource-Based View of the Firm", S*trategic Management Journal*, 5, 171-180.

World Investment Report, 2006, *FDI from developing and transition economies: Implications for development*, New York and Geneva, UNCTAD.

Zhang, Y., Bartels, R., 1998, “The effect of sample size on the mean efficiency in DEA with an application to electricity distribution in Australia, Sweden and New Zealand,”*Journal of Productivity Analysis,* 9, 187–204.