-Tesi di Laurea Magistrale-

# The Efficiency of Business Schools in Europe: an empirical analysis through Data Envelopment Analysis, and a comparison with Rankings

Author:

Beatrice Cassottana

(matr. 820484)

Academic Tutor:

Prof. Tommaso Agasisti, Politecnico di Milano

POLITECNICO MILANO

Milano, 28th July, 2015

**ABSTRACT**

Even though ranking scores help business schools to build their own reputation and increase their prestige, they lack of guidance to assess the actual value added of education and the cost-effectiveness of operations. We build a different ranking system that classifies business schools and their educational programmes -MBAs, EMBAs and masters in management- in terms of *efficiency*. The DEA -Data Envelopment Analysis- methodology will allow us to compute efficiency scores for each business school and programme, giving input and output data. Therefore, we first compare the efficiency score of each business school with the one of its programmes, and then the efficiency score of each unit of analysis -business school, MBA, EMBA and master in management- with the rank score assigned by the traditional rankings. The findings reveal areas of incoherence between efficiency measures and rankings.

*Keywords*: Business schools; MBA ranking; Data Envelopment Analysis (DEA); Higher education performance; Efficiency.

JEL codes: M16, C14

**AKNOWLEDGEMENT**

*“Knowledge is the perfect investment that does not depreciate with time. On the contrary – it grows in value”* (Zygimantas Mauricas)

I would like to thank my parents for having supported me during my studies and in life, both economically and with their affection. I hope I can reward their effort and care with the results of my studies and with the decisions I will take in the next steps of my life.

I thank my elder brother, Francesco, who has been a guide and a consultant. He has opened to me the perspective of studying abroad and has helped me to ponder the decisions concerning my career.

I am especially grateful to my academic tutor, Professor Tommaso Agasisti, who has supervised my work and gave me the opportunity to discover the beauty of research. Thanks to him, who has involved me in this project, I had the possibility to spend a period of time in EFMD, an international membership organisation recognised globally as an accreditation body, and to meet many interesting and encouraging people in the field of research, first of all Professor Andrew Pettigrew.

Last but not least, I am mostly thankful to Professor Ulrich Hommel, who has welcomed me in EFMD and who has been a life coach and has inspired me on the next steps to undertake in my life.

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## 1. MOTIVATION AND OBJECTIVES

Within the European business education two trends can be observed: the increasing demand for highly educated managers by corporations and the increasing number of higher education programmes and business schools that aim at satisfying this need. In this context, students can be seen as the workforce offer that fills the gap in the labour market by applying the academic skills in the workplace. We therefore identified three groups of stakeholders within the business education industry: students, corporate recruiters and educational institutions. Our study starts from the assumption, which will be further discussed, that traditional rankings are insufficient to supply satisfying information to these three groups of interest.

Students enrol in higher education programmes with the expectation of a personal development and educational experience as well as new career opportunities and increased salary (Bickerstaffe & Ridgers, 2007). While rankings provide information on the initial retribution, they lack of guidance in assessing the educational value added by the programme in relation to the student's previous skills. Corporate recruiters look for candidates with analytical skills, team working capability and global view of the business world (Colbert, Levary, & Shaner, 2000). The extent to which current rankings can detect these skills in the graduate students is a rather controversial issue. Some ranking criteria risk of creating some close laps: the Financial Times, for example, attributes a weight of 40% on the total score to the salary on graduation. The salary, however, comes from the recruiter's decision of hiring a candidate who graduated in a particular programme and this decision might have been affected by the Financial Times ranking.

Rankings are the main tool of benchmarking among educational institutions. Nevertheless, while educational institutions want to improve their ranking score, rankings do not offer tools for individualizing weaknesses and driving the investment-decision process. Regarding the Financial Times Global MBA ranking, Köksalan et al. (2010) state that there are two major problems: it brings schools to standardization, since schools are evaluated on twenty criteria with fixed weights, and it is imprecise and subjective, since most of the data are gained through alumni and school surveys that can be subjected to substantial noise, especially because sometimes respondents are trained to answer in such a way to put their own school in the best light.

Hence the need to develop different ranking methods that underline the correlations between resources and results. In order to provide a solution to this need, we will build a ranking system based on the *efficiency* of programmes and business schools: our method will differentiate inputs from outputs, following the approach initiated by Tracy & Waldfogel (1997). Inputs can be associated with causes, while outputs with effects, and the correlation between these two values is the efficiency score. The efficiency ranking will answer to the problems presented above: they will provide information on the actual value added of education and will help master administrators to improve managerial processes, which are a "major handicap" in achieving excellent output in education (EFMD, 2014). With this study we try to give an answer to the criticism that surrounds many educational programmes, exemplified by the statement by Tracy & Waldfogel (1997) "a programme that attracts high quality students may generate high salaries for its graduates without adding value to them".

We will perform a study of the efficiency considering four levels of analysis:

1. Business schools
2. MBA (Master of Business Administration)
3. EMBA (Executive Master in Business Administration)
4. Master in management

Our analysis is limited to the study of European business schools, while the programmes analysed are sometimes offered in jointly provision with non-European schools.

Our work is organized as follows. We first analyse the existing literature relating to both the performance [section 2.1] and the efficiency [section 2.2] of business schools. In session 3 we describe the raking criteria utilised by the main ranking systems, namely the Financial Times, QS Top MBA and BusinessWeek, in order to underline the methodological difference with the *Data Envelopment Analysis* (DEA). In session 4 we try to understand the complexity of the production process of business schools [section 4.1] and we then ignore the internal cause-effect relationships among variables in order to select those at the extreme input and output to compute the efficiency scores [section 4.2]. Section 5 is dedicated to the description of the efficiency model settings [section 5.1], the concept of scale efficiency in DEA [section 5.2], the DEA methodology [section 5.3] and the data utilised [section 5.4]. Results are presented in session 6 first in terms of efficiency according to each level of analysis separately [sections 6.1-6.4] and secondly in terms of scale efficiency [section 6.5]. Moreover we show results in two comparisons: the efficiency of business schools vs. the efficiency of their programmes [section 6.6] and the efficiency of business schools, MBA, EMBA and master in management programmes vs. the ranking score in the respective Financial Times rankings [section 6.7]. In this section we find that the efficiency classification differs substantially from current rankings, moving the focus from the mere performance to the productivity of the activities of a school (that is, the ratio between performances and resources employed). We take a step further in session 7, where we individualise those environmental variables that could potentially explain the efficiency scores. In this session, we find that the second-stage regression analysis does not help towards better insights related to programmes' efficiency, but it offers instead an interesting potential perspective about the performance of most efficient business schools: it is likely that the higher costs

associated with the variables that are positively related with efficiency, are outweighed by the results that they are able to obtain in the marketplace.
In the conclusion [section 8] we summarize the main findings and underline the inevitable limitations of the current study, giving suggestions for further research.

## 1. SOMMARIO

In Europa si possono osservare due tendenze nell'ambito del mercato dell'educazione manageriale: la crescente domanda di manager altamente istruiti da parte delle multinazionali e il crescente numero di scuole di business che mirano a soddisfare questa esigenza. Nel contesto di tale necessità, gli studenti di queste accademie possono essere considerati come offerta di forza lavoro ottimale per le competenze acquisite. Abbiamo quindi individuato tre gruppi di interesse all'interno del settore dell'educazione manageriale: gli studenti, i datori di lavoro e le istituzioni educative. Il nostro studio parte dall'ipotesi, che sarà ulteriormente discussa, che i ranking tradizionali siano insufficienti a fornire informazioni soddisfacenti a questi tre gruppi.
Gli studenti si iscrivono a programmi di istruzione superiore con l'aspettativa di una crescita personale e di un'esperienza educativa, così come di nuove opportunità di carriera e di un aumento di stipendio (Bickerstaffe & Ridgers, 2007). Se da un lato i ranking forniscono informazioni sulla retribuzione iniziale dei laureati, essi non possono essere utilizzati come guida per la valutazione del valore aggiunto dal programma educativo rispetto alle competenze precedenti dello studente. I datori di lavoro cercano candidati con capacità analitiche, una predisposizione al lavoro di squadra e una visione globale del mondo degli affari (Colbert, Levary, & Shaner, 2000). La misura in cui i ranking tradizionali sono in grado di rilevare queste competenze negli studenti universitari è una questione piuttosto controversa. Alcuni sistemi di ranking rischiano di creare un circolo vizioso: il Financial Times, per esempio, attribuisce un peso del 40% del punteggio totale della scuola/programma, allo stipendio percepito immediatamente dopo la laurea. L'entità della retribuzione però, è il risultato della decisione del datore di lavoro di assumere un laureato in una certa scuola/programma, tale scelta può essere stata influenzata a sua volta dalla classifica del Financial Times.
I ranking sono il principale strumento di analisi comparativa tra le scuole. Tuttavia, mentre le scuole ambiscono a migliorare la loro posizione rispetto alle altre, i ranking non offrono sufficienti strumenti all'utente per l'individuazione dei punti di forza e di debolezza di una scuola nè per guidare le decisioni di investimento nelle aree funzionali (ricerca, career service, ecc...) a più alto potenziale. Per quanto riguarda il Financial Times Global MBA ranking, Köksalan et al. (2010) affermano che esistono principalmente due problemi: (i) la standardizzazione delle scuole, che per rispondere a sistemi di valutazione troppo rigidi, si

uniformano nella scelta di azioni volte a migliore il proprio ranking, e (ii) l'imprecisione e la scarsa attendibilità dei dati dovuta al fattore soggettività e all'influenzabilità del giudizio, spesso acquisito da indagini e interviste nelle scuole, le quali cercano di mettersi nella miglior luce possibile.

Nasce perciò la necessità di sviluppare metodi diversi di ranking che sottolineino le correlazioni tra risorse e risultati. Al fine di fornire una soluzione a questo problema, costruiremo un sistema di classificazione basato sull'efficienza dei programmi e delle scuole di business: il nostro metodo differenzia gli input dagli output, seguendo l'approccio inizialmente applicato da Tracy & Waldfogel (1997). Gli input possono essere associati alle cause, mentre gli output agli effetti, e la correlazione tra queste due entità è il punteggio di efficienza. La classifica di efficienza tenterà di risolvere i problemi sopra riportati; essa fornirà informazioni sull'effettivo valore aggiunto dell'istruzione accademica e aiuterà gli amministratori dei programmi a migliorare i processi gestionali, che sono il "maggiore handicap" nel settore dell'istruzione per raggiungere il massimo rendimento (EFMD, 2014) .

Con questo studio si cerca di dare una risposta alle critiche indirizzate a molti programmi educativi, esemplificate dalla dichiarazione di Tracy & Waldfogel (1997) "un programma che attira studenti di alta qualità può generare alti stipendi per i suoi laureati senza altri valori aggiunti" .

Eseguiremo un studio di efficienza considerando quattro livelli di analisi:

1. Scuole di business
2. MBA (Master of Business Administration)
3. EMBA (Executive Master in Business Administration)
4. Master in management

La nostra analisi è limitata allo studio delle scuole di business europee, mentre i programmi da noi analizzati prevedono talvolta collaborazione con scuole non europee.

Il nostro lavoro è organizzato come segue. Per prima cosa analizziamo la letteratura esistente relativa sia alle prestazioni delle scuole di business [sezione 2.1] che alla loro efficienza [Sezione 2.2]. Nel capitolo 3 descriviamo i criteri utilizzati dai principali ranking, vale a dire il Financial Times, QS Top MBA e BusinessWeek, al fine di sottolineare la differenza metodologica con l'approccio da noi usato per calcolare l'efficienza, la *Data Envelopemnt Analysis* (DEA). Nel capitolo 4 cerchiamo di capire la complessità del processo di produzione delle scuole di business [sezione 4.1], dopodichè ignoriamo le relazioni di causa-effetto tra le variabili interne, al fine di concentrarci su quelle posizionate agli estremi (input in ingresso ed output in uscita) per calcolare i punteggi di efficienza [sezione 4.2]. Il capitolo 5 è dedicato alla descrizione delle assunzioni del modello di efficienza [sezione 5.1], del concetto di efficienza di scala nella DEA [paragrafo 5.2], della metodologia DEA [sezione 5.3] e dei dati utilizzati [sezione 5.4]. I risultati sono presentati nel capitolo 6 sia in termini di efficienza in base ad ogni livello di analisi [sezioni 6.1-6.4] che in termini di efficienza di scala [sezione 6.5]. Inoltre mostriamo i risultati in due distinti confronti: l'efficienza delle scuole di business vs. l'efficienza dei loro programmi [sezione 6.6] e l'efficienza delle scuole di business, MBA, EMBA e master in management rispetto alla posizione nei rispettivi ranking del Financial Times [sezione 6.7]. In questa sezione troviamo che la classifica di efficienza da noi costruita differisce sostanzialmente da quella dei ranking; noi infatti, spostiamo l'attenzione dalle sole prestazioni, considerate dai ranking, alla produttività delle attività (cioè al rapporto tra prestazioni e risorse impiegate). Facciamo un ulteriore passo avanti nel capitolo 7, dove individuiamo le variabili ambientali che potrebbero spiegare i punteggi di efficienza. In questa sessione troviamo che l'analisi di regressione di secondo livello non aiuta a comprendere i punteggi di efficienza dei programmi, ma offre invece un'interessante prospettiva sulle prestazioni della maggior parte delle scuole di business: è probabile che i maggiori costi relativi alle variabili positivamente correlate all'efficienza, siano controbilanciati dai risultati che si è in grado di ottenere così investendo.

Nella conclusione [paragrafo 8] riassumiamo i principali risultati dello studio, ne sottolineamo i limiti inevitabilmente presenti e al contempo suggeriamo spunti per un'ulteriore ricerca.

## 2. LITERATURE REVIEW

Performance and efficiency are two different approaches for evaluating business schools. In this chapter we analyse the existing literature for both approaches, in order to underline the most recurring and discussed issues.

On the theme of performance, the main literary source that has been used is the book *The Institutional Development of Business School* by Pettigrew, Cornuel, & Hommel, which provides innovative empirical findings on the causes and consequences of ranking and branding wars around business schools. In this section we underline the importance of rankings as a measure of performance. We describe the process that led to the creation of the first rankings and the successive distortion of their role. Nowadays, rankings are widely criticised; among the most common critics authors report (i) their standardisation that does not allow differentiation among schools, (ii) the possible manipulation of the data on which rankings rely on and (iii) their static nature. The term *Marketization* has been coined in literature to refer to the market-driven approach that business schools are adopting. This approach is often disapproved because it transforms schools into “money making machines” (Jemielniak & Greenwood, 2015) rather than knowledge-intense institutions (Czarniawska & Genell, 2002). Most of the literature concerning performance deals with reputation. In the last part of this subsection we briefly analyse the link between performance and reputation and then we describe the different reputational-related performances in relation to the interests of the different stakeholders. Finally, we report the mostly utilised definitions of reputation and its measurement systems.

While the analysis of the literature concerning performance has a limited interest for our study, since performance is used as a basis for comparison, the literature on the efficiency of business schools is mostly important, since it drives all the choices made on the assumptions of the efficiency model and acts as an example to interpret and comment results.

The papers that we use as a literary base for our study have all been found by typing, among the others, the keyword “DEA”. Indeed all the papers use the DEA methodology, or some variants of the DEA methodology, to compute efficiency scores for either educational institutions (business schools, universities, high schools, departments …) or their programmes (MBAs, EMBAs, masters in management …).

In this section we first underline the existing gaps in the current literature concerning the efficiency of higher education. We then analyse the existing literature by dividing the papers because of geographical area: European literature vs. non-European literature. The European literature lacks of a study of efficiency of the European business schools in a cross-country perspective, instead this kind of study is common in the North American or Australian literature. The non-European literature, and in particular the North American one, is divided between those papers that study the efficiency of institutions and those that are focused on single programmes - mostly the MBA programme -. The present study is intended to offer an example of efficiency analysis in a European cross-country perspective and an analysis of the efficiency of both institutions, and in particular business schools, and their programmes, namely the MBA, the EMBA and the master in management.

A brief dissertation follows about the mostly used variants of DEA and about the most recurring inputs and outputs entering into the efficiency models. Thereafter, the different ways of reporting results are described, with the aim of giving to the reader an overview of the possible managerial applications of the efficiency results and some examples of comparison between efficiency scores and ranking positions are illustrated. Lastly, the innovative contribution of this study in relation to the existing literature is explained.

## 2.1. PERFORMANCE OF BUSINESS SCHOOLS

Rankings have established themselves as a dominant measure of school performance and have turned into a dominant force in the context of higher education in general and business schools in particular (Pettigrew, Cornuel, & Hommel, 2014). External stakeholders, such as students and corporate recruiters, use rankings to compare business schools. Internal stakeholders, such as deans and programme administrators, often look at rankings in order to understand their school's strengths and weaknesses on the marketplace. Doing so, they trigger a process in which rankings act as a cause for school administration to undertake major changes, rather than being an effect of the school own strategy. In this *inverse* process, rankings create, rather than follow from, competition. In the words of Wedlin (2011), rankings are "crafting perceptions and mechanisms for competition among business schools". Wedlin conducted a survey aimed at understanding the most common actions that deans and business school administrators have undertaken in response to their ranking position and it resulted that the major actions have been taken in external relations. Indeed most of the analysed schools have strengthened their alumni relations and career service and have improved their customer interface on the media and invested in marketing and promotion. These actions are aimed at improving the perceptions that external stakeholders (students and corporate recruiters) have of the school, thus leading to positive responses to the ranking surveys and a consequent potential climb in the rankings.

Historically rankings started to be created and diffused pulled by the market demand for more information about business school services and products. Indeed since business school courses can cost up to $100,000 or more, students need guidance on finding value (Wedlin, 2011). At the same time, recruiters look for a guarantee of quality in the curriculum vitae of their applicants. Nevertheless, as Czarniawska & Genell would assert, rankings cover only partially the information requested by these groups of stakeholders. In fact students and recruiters ask for “specificity and differentiation”, aside from “comparability and similarity” (Czarniawska & Genell, 2002). Because in rankings business schools are evaluated on a global setting and removed from their particular environment, such as cultural, political and institutional context (Wedlin, 2011), comparability and similarity is provided. At the same time, since schools are evaluated on a global framework and with a standard methodology, specificity and differentiation is not allowed (Pettigrew, Cornuel, & Hommel, 2014). On the other hand some authors claim that programmes such as MBAs and EMBAs are believed to be globally recognized (Wedlin, 2011), so that they must be evaluated on a commonly-shared set of criteria. Rankings produce homogeneity in the value perception of stakeholders (Pettigrew, Cornuel, & Hommel, 2014) and a commonly shared set of criteria to assess schools. Nevertheless, rankings have been widely criticised for many reasons. According to Pettigrew et al. (2014), ranking’s validity is affected by the subjective weighting given to the different criteria and by the possible manipulation of the data reported by the school. Moreover rankings have a negative effect on the market, since they create *isomorphism*. The inverse process cited above, in which rankings act as a trigger of business school change, entails that deans and school administrators take similar actions in order to place their school high in the rankings. In this way it becomes normal, for example, to employ faculty with PhD and to consider average starting salary when placing students. This standardization would ultimately limit the set of strategies that schools might pursue. A further criticism made to rankings is their static nature. While Pettigrew et al. (2014) state that both top positioned and bottom-end positioned schools tend to be stable in rankings, Collet & Vives (2012) show that the static nature belongs only to the top positioned institutions, since these “are more likely to retain their position in the rankings that low positioned institutions”. Two possible phenomena could explain the static nature of rankings. First, the backward looking nature of data analysed could prevent ranking scores from drastic changes from one year to another. In fact rankings usually take into account a time period of 2 to 3 years to avoid any economic cycles or temporary anomalies. Second, the static nature of stakeholders’ perceptions might slow down any changes in rankings. Indeed since rankings were created on the demand of students and recruiters, rankings reflect their expectations and knowledge (Czarniawska & Genell, 2002). Consequently, while a school might increase its performance from one year to the following, it would take longer to reflect the improvement in stakeholders’ perceptions.

Rankings create a market where customers can evaluate schools (Wedlin, 2011). Different scholars use the word *Marketization* to indicate the market-driven approach that business schools are adopting in response to rankings. If we look at the business school industry as a market, we identify two main groups of customers: students and recruiters. In this acceptation, students buy a service output of business schools, while recruiters a product output (Vidaver-Cohen, 2007). In their paper critically called *"Gone shopping? Universities on their way to the market"*, Czarniawska & Genell (2002) contrast the process of marketization to a knowledge-intense approach. Even more critical are Powell & Owen-Smith (1998), who define business schools as "enterprises driven by arrogant individuals out to capture as much money and influence as possible".

The metaphor between business schools and industries is well explained by Jemielniak & Greenwood (2015) who describe the process of marketization as a transformation of knowledge into a commodity, of students into customers, of administrators into bosses and of research into money machine.

Following all the widespread disapproval that undermines the validity of rankings, the question of the reason why rankings remain relevant is crucial.

Pettigrew et al. (2014) advance the theory of the Prisoners' Dilemma, in which while participating to the rankings might not entail a competitive advantage, not participating might imply falling behind the concurrence. Another suggested answer is that the majority of actors in the field of management education desire rankings as a source of legitimacy (Corley & Gioia, 2000) or as an international recognition (Wedlin, 2011) and an opportunity to build reputation.

*Performance and Reputation*

Following the dissertation about rankings, a brief treatise about performance and reputation is due. Repeating the words of Pettigrew et al. (2014), "rankings have established themselves as a dominant measure of school performance" and they consequently show signals of a school's reputation.

According to the model developed by Vidaver-Cohen (2007), performance is the first predictor of reputation. Reputation and performance are indeed strictly correlated and reputation-related performance indicators can be classified into three categories: intellectual performance, network performance and financial performance. Different groups of stakeholders are interested in different aspects of performance. Intellectual performance entails recruiting and retaining prestigious faculty and a strong record for research, therefore researchers and academics are mostly concerned with it. Network performance reflects the capability to attract high quality students and to obtain lucrative job placements; therefore students and corporate recruiters are mostly interested in it. Financial performance is associated with strong revenues from endowments, tuition fees and value-added programmes, therefore internal stakeholders, such as administrators and deans, are mostly concerned with it. It is clear that performance are merely concerned with the *output* of the business schools, without calibrating it on the resources utilised to produce it. Nevertheless, performance are, nowadays, the most explicit forecast of reputation.

Reputation as a driver of a business school's competitive position is an elusive concept, since it is the "result of perceptions and interpretations of institutional stakeholders" (Clark & Montgomery, 1998). The definition and the measure of reputation is therefore not an easy task. Hommel et al. (2014) adopt an asset-based view in defining reputation and state that "the reputational capital of a school can be interpreted as the portfolio value of its intangible assets, of which the institutional human capital base responsible for delivering educational services and new knowledge figures most prominently". They also remark the time dimension of reputation, adding the capability of a school to maintain its reputation in the future, defined as "the organisational capacity to maintain, nurture, and develop its human capital base in the future as well as the value associated with the school's brand". According to Baden-Fuller et al. (2000), the definition of reputation depends on the functional area where it is applied. In the management field, for example, reputation is defined as a "socially constructed outcome of a legitimation process". In the field of economics and sociology instead, it is an "organizational standing, which is prestige, image and goodwill in other disciplines". A quite similar definition is the one by Rindova et al. (2005). They empirically demonstrate two dimensions of reputation: perceived quality and prominence. The former relates to the "degree to which individuals evaluate positively an organization in relation to certain attributes", the latter refers to the "degree to which an organization receive large-scale collective recognition in its industry". Cornelissen & Thorpe (2002) also individualise two widespread acceptations of reputation: reputation as a "psychological construct relating to the perceptions and evaluations of an institution by a subject" (see, for example Vidaver-Cohen (2007)) and reputation as an "organisational construct referring to a set of assets". Moreover, they theorise a cause-effect relationship between the two acceptations. They suggest that business school deans and administrators should recognise that the cumulative effects of individuals' positive perceptions is the cause that could eventually entail the "brand" of the school to gain value as an institution's asset. Only by deconstructing the term in this manner, administrators could understand the reason why, for example, a favourable perception from the public is not always accompanied by a purchase-related behaviour.

Measurement of reputation can be done either directly, identifying a significant audience and rank business schools based on their perceptions, or indirectly, identifying KPIs that could well represent the answers of a significant audience (Baden-Fuller, Ravazzolo, & Schweizer, 2000). Vidaver-Cohen (2007) defines these two measures as, respectively, qualitative and quantitative. Rankings usually adopt both the methodologies to compute the rank score of each school. BusinessWeek and the Financial Times, for example, compute their rankings summing the results from surveys sent to groups of stakeholders to some relevant KPIs, such as the number of papers published per faculty. The direct method is more costly and time-consuming, but it could better represent the commonly spread perception of a school (even though respondents might be trained to answer in such a way to put their own school in the best light). The indirect measurement method could result to be more subjective, since KPIs could be chosen in such a way to favour certain schools. A famous case is the one of BusinessWeek, which, in 2012, changed the way it calculated its recruiter score to obtain a ranking that was conform to the expectations of the public. Indeed in the first ranking Harvard University resulted only in the 25th position, while Duke University appeared in the 1st position, outcome that had been considered unconvincing in the opinion of the most (Byrne, 2014). Finally, it needs to be noticed that it is not always clear whether KPIs represent an effect rather than a cause of reputation. In the case of citations, for example, it is true that a high number of citations contributes to increasing faculty reputation, but a well-known author is more likely to be cited as well (Baden-Fuller, Ravazzolo, & Schweizer, 2000).

## 2.2. EFFICIENCY OF BUSINESS SCHOOLS

Our work focuses on the efficiency of business schools rather than on the mere performance. The main difference stands in the fact that while efficiency is computed considering both inputs and outputs, performance-based rankings are focused mainly on the outputs.

The initiative of this study follows the suggestion of Hsu et al. (2009) for performing a "value-added efficiency" analysis of European MBA programmes using the same methodology they applied to US MBA programmes: the Data Envelopment Analysis (DEA). Going beyond their suggestion, we want to assess the efficiency not only of the MBA programmes offered by the best ranked European business schools, but also of the schools themselves and of their Executive MBA programmes and masters in management.

Our study will cover two gaps that exist in the current literature on higher business education. First, a systematic literature review about the efficiency of business schools reveals that there is a lack of contributions that concentrate mainly on European business schools. Second, the assessment of European school performance is widely related to several ranking systems, one of the most significant ones being the Financial Times European business school ranking started in 2004, but it does not take into consideration the efficiency dimension.

We here analyse the literature that applies the DEA methodology to assess the efficiency of higher education institutions. Most of the literature is focused on the US higher educational efficiency. This is probably due to the fact that business schools were created and recognized in the US before anywhere else. The first business schools established in the US during the post-World War II and, after incurring is a first period of scepticism from corporations, already in the 1950s they started to be recognized as “professional schools” by recruiters. In Europe the first business schools were INSEAD, established in 1957, and the London Business School, established in 1964. Nevertheless, it was not until the 1990s that they started to be recognized and to gain prestige, so that a greater number of well-established universities, as Oxford and Cambridge, started to enter into the business higher education market. The development of management education was slower in Asia: China saw a fast growth in the number of MBA graduates only in the 2000s, while India and Japan in the mid-1990s (Collet & Vives, 2013). As a consequence of the spread of business schools the interest of research focused on studying this phenomenon.

Table 1 lists the majority of papers that have worked as literary base for the present study. As one can observe, the DEA methodology is applied in all of the papers described below.

## Table 1 Literature Review

| # | Paper | Country (date) | Unit of analysis | Number of units analysed | Method | Inputs | Outputs |
|---|---|---|---|---|---|---|---|
| 1 | Abbott, M., & Doucouliagos, C. (2003). The efficiency of Australian universities: a data envelopment analysis. Economics of Education review, 22(1), 89-97. | Australia (1995) | Government University (Institutional level) | 36 | DEA | •FTE faculty members •FTE non-faculty members •Expenditure on all inputs beside labour •Value of non-current assets | •FTE students •Undergraduate enrolments •Post-graduate enrolments •Undergraduate degrees conferred •Post-graduate degrees conferred •Research Quantum Allocation (funding from government for research) |
| 2 | Agasisti, T. (2011). Performances and spending efficiency in higher education: a European comparison through non-parametric approaches. Education Economics, 19(2), 199-224. | Europe (2002-2006) | Entire country | 18 | DEA and FDH to check robustness of the model | • Entry rates into tertiary education • Financial resource (public and private) as a % of GDP • Number and quality of students and teachers | • Graduation rates • % of educated population • Employment rate • % of foreign students enrolled |
| 3 | Athanassopoulos, A. D., & Shale, E. (1997). Assessing the comparative efficiency of Higher Education Institutions in the UK by the means of Data Envelopment Analysis. Education Economics, 5(2), 117-134. | UK (1992-1993) | University (Institutional level) | 45 | DEA | •General academic expenditure •Research income •FTE faculty members •FTE undergraduates •FTE post-graduate •Entry qualifications of students | •Number of degrees awarded •Weighted research rating |
| 4 | Colbert, A., Levary, R. R., & Shaner, M. C. (2000). Determining the relative efficiency of MBA programs using DEA. European Journal of Operational Research, 125(3), 656-669. | USA (1997) | MBA (Single Programme level) | 24 | DEA | • Faculty to student ratio • Average GMAT score • Number of electives offered | • % of alumni who donate money to the programme • Level of student satisfaction with teaching, curriculum and placement • Level of recruiter satisfaction with student's analytical skills, team work and global view • Average salary of graduates |
| 5 | Comunale, C. L. & Sexton, T. R. (2004). An efficiency analysis of U.S. business schools. Journal of case studies in accreditation and assessment, 1-19. | USA (2005-2006) | Business School (Institutional level) | 438 | DEA | •Faculty members •Non-faculty members •FTE part-time faculty •Staff and administrators •Budget | •Undergraduate enrolments •FTE MBA enrolments •FTE EMBA enrolments •FTE specialized master enrolments •FTE doctorate enrolments •Endowment |
| 6 | Cooper, W. W., Seiford, L. M., & Zhu, J. (2011). Handbook on data envelopment analysis. Springer, 164(15), 406-413. | Australia (1995) | University (Institutional level) | 36 | DEA | •FTE academic staff •FTE non-academic staff | •Student retention rate •Student progress rate •Employment rate •Overseas fee-paying enrolments •Non-overseas fee-paying enrolments |

| # | Paper | Country (date) | Unit of analysis | Number of units analysed | Method | Inputs | Outputs |
|---|---|---|---|---|---|---|---|
| 7 | Fandel, G. (2007). On the performance of universities in North Rhine-Westphalia, Germany: Government's redistribution of funds judged using DEA efficiency measures. European Journal of Operational Research, 176(1), 521-533. | Germany (1996) | University (Institutional level) | 15 | DEA | •Academic personnel<br>•Students in the first four semesters<br>•Outside funding (1) | •Number of graduates<br>•Number of doctorates<br>•Outside funding (2) |
| 8 | Fisher, D. M., Fisher, S. A., & Kiang, M. (2007). A value-added approach to selecting the best master of business administration (MBA) program. Journal of education for Business, 83(2), 72-76. | USA (2007) | MBA (Single Programme level) | 50 | DEA | • Average GMAT score<br>• Average undergraduate GPA<br>• Tuition<br>• Cost of living<br>• Duration of the programme | • Average starting salary and bonuses<br>• Employment rate at graduation<br>• Employment rate at graduation three months after graduation |
| 9 | Groot, T., & García-Valderrama, T. (2006). Research quality and efficiency: An analysis of assessments and management issues in Dutch economics and business research programs. Research Policy, 35(9), 1362-1376. | Netherlands (1995 and 2001) | Economic, econometric and business administration research programmes (Programme level) | 169 | DEA and Tobit regression to analyse the correspondence between DEA results and research programme's characteristics | • Full-time equivalent research input [hours]<br>• PhD-students<br>• Senior staff members<br>• Funding sources (national or third party) | • Peer review assessment results (based on expert judgment)<br>• Bibliometric information (number of dissertations, number of scientific publications according to quality level of publisher and number of professional publications) |
| 10 | Hirao, Y. (2012). Efficiency of the top 50 business schools in the United States. Applied Economics Letters, 19(1), 73-78. | USA (2006) | Business School (Institutional level) | 50 | DEA and ANOVA test to compare private and public sector | • Average GMAT score<br>• Peer assessment | • Average starting salary<br>• Employment rate at graduation |
| 11 | Hsu, M. K., James, M. L., & Chao, G. H. (2009). An efficiency comparison of MBA programs: Top 10 versus non-top 10. Journal of Education for Business, 84(5), 269-274. | USA (2006) | MBA (Single Programme level) | 58 | DEA and Kolmogorov-Smirnov Z test to compare top 10 vs. non-top 10 MBA programmes | • Average undergraduate GPA<br>• Average GMAT score<br>• Out-of-state tuition<br>• Salary before entering the programme | • Average starting salary and bonus immediately after graduation<br>• Employment rate 3 months after obtaining the MBA<br>• Level of student satisfaction (aims-achieved ratio) |
| 12 | Joumady, O., & Ris, C. (2005). Performance in European higher education: A non-parametric production frontier approach. Education Economics, 13(2), 189-205. | Europe (1998) | Higher education institution (Institutional level) | 209 | DEA | •Entry qualification<br>•Entry grade<br>•Study provision | • Level of competences acquired (vocational and generic) |
| 13 | Kong, W. H., & Fu, T. T. (2012). Assessing the performance of business colleges in Taiwan using data envelopment analysis and student based value-added performance indicators. Omega, 40(5), 541-549. | Taiwan (2004) | Business School (Institutional level) | 21 | AHP -AR -DEA | • Educational background of students during the first job<br>• GPA of graduate at college | • Starting wage - predicted and as a marginal school effect- |

| # | Paper | Country (date) | Unit of analysis | Number of units analysed | Method | Inputs | Outputs |
|---|---|---|---|---|---|---|---|
| 14 | Martín, E. (2006). Efficiency and Quality in the Current Higher Education Context in Europe: an application of the data envelopment analysis methodology to performance assessment of departments within the University of Zaragoza. Quality in Higher Education, 12(1), 57-79. | Spain (1999) | Departments of University of Zaragoza | 52 | DEA | •FTE academic staff with PhD<br>•FTE academic staff without PhD<br>•Operating expenditure<br>•Salaries<br>•Budget funds<br>•Research grant<br>•Annual amortization of assets | •Number of students enrolled<br>•PhD credits offered<br>•PhD completions<br>•Research income<br>•Scientific production index |
| 15 | Palocsay, S.W., & Wood, W.C. (2014). An investigation of US undergraduate business school rankings using data envelopment analysis with value-added performance indicators. Journal of education for Business, 89(6), 277-284. | USA (2013) | Under-graduate Business School (Institutional level) | 124 | DEA | • SAT scores<br>• Student-faculty ratio<br>• Tuition | • Level of employer satisfaction<br>• Average starting salary |
| 16 | Ray, S. C., & Jeon, Y. (2008). Reputation and efficiency: A non-parametric assessment of America's top-rated MBA programs. European Journal of Operational Research, 189(1), 245-268. | USA (2004) | MBA (Single Programme level) | 65 | DEA | • Faculty to student ratio<br>• Average GMAT score<br>• Rejection rate<br>• % of male students<br>• % of US students<br>• School budget per student | • Difference between the annuitized pre- and post- MBA earnings flow adjusted for tuition and fee<br>• Adjusted placement rate (average number of offers received multiplied by the probability that a graduating student has an offer in hand by graduation) |
| 17 | Sacoto, S. A., Cook, W. D., Delgado, H. C., & Castorena, D. G. (2015). Time-staged Outputs in DEA. Omega (Early version of the manuscript). | Mexico, USA (2011) | Business School (Institutional level) | 42 | AR-DEA with one "dual-role" variable | •Academic rating<br>•Admission rating<br>•Financial rating<br>•% top 25% in class | •% students with Internships<br>•% students who find jobs |
| 18 | Sarrico, C. S., & Dyson, R. G. (2000). Using DEA for planning in UK universities—an institutional perspective. Journal of the Operational Research Society, 51(7), 789-800. | UK (until 1996) | Departments of Warwick University | 10 | DEA (results have been compared through the application of the BCG matrix) | •Entry requirements | •Teaching ratings<br>•Research ratings<br>•Employment rates<br>•Accommodation availability<br>•Library spending |
| 19 | Sreekumar, S., & Mahapatra, S. S. (2011). Performance modeling of Indian business schools: a DEA-neural network approach. Benchmarking: an international journal, 18(2), 221-239. | India (2011) | Business School (Institutional level) | 49 | DEA and Neural Network (NN) | • Faculty to student ratio<br>• Teaching experience of faculty [years]<br>• Corporate experience of faculty or students [years]<br>• Percent of PhD students on total students<br>• Faculty with PhD abroad<br>• Number of books, research papers and cases<br>• Infrastructure and facilities<br>• Tuition | • Revenue (from consultancy, programmes, seminars and workshops)<br>• Student and faculty exchange programmes<br>• % of student placed abroad<br>• Median, maximum and minimum salary<br>• Extra-curricular activities<br>• Level of employer satisfaction<br>• Level of student satisfaction<br>• Level of faculty satisfaction<br>• Average starting salary |

| # | Paper | Country (date) | Unit of analysis | Number of units analysed | Method | Inputs | Outputs |
|---|---|---|---|---|---|---|---|
| 20 | Tzeremes, N., & Halkos, G. (2010). A DEA approach for measuring university departments' efficiency. Munich Personal RePEc Archive, Paper No. 24029. | Greece (2008-2009) | Departments of University of Thessaly | 16 | DEA and Bootstrapping | •Faculty members<br>•Auxiliary staff (teaching aid staff, technical and administrative staff)<br>•Number of students (undergraduate, postgraduate, doctorate)<br>•Total income (government funding) | •Number of graduating students<br>•Number of publications |

We here concentrate on researches that study the relative efficiency of business schools. We divide the papers between European and Non-European.

*European Literature*

A first attempt of an efficient analysis related to higher education in a cross-country perspective is provided by Agasisti (2011), nevertheless his units of analysis are European countries rather than single business schools spread on the territory. On the same stream, the paper *"Performance in European higher education: a non-parametric production frontier approach"* by Joumady & Ris (2005) assesses the relative productivity of higher education institutions in a cross-country perspective. Still, it considers only 8 European countries and it is not focused on business schools.

Some efficiency studies have been conducted within single European countries, but their scale is limited to a single nation or region, such as the study made by Athanassopoulos & Shale (1997), which measures the relative efficiency of 45 universities in the UK or the study by Fandel (2007), which measures the relative efficiency of 15 universities in North Rhine-Westphalia, Germany. Some studies are just focused on comparing the efficiency of different departments of a single university, among the others the study by Martín (2006) for the departments of University of Zaragoza and the study by Sarrico & Dyson (2000) for the departments of Warwick University. This last one is interesting for us since it presents an innovative way to show results through the application of the BCG –Boston Consulting Group- matrix. The paper "*A DEA approach for measuring university departments' efficiency"* (Tzeremes & Halkos, 2010) is again focused on comparing the efficiencies of 16 departments of the University of Thesssaly in Greece, but it is mostly important for us since it applies the bootstrapped DEA procedure that will be further explained in the relative chapter.

*Non-European Literature*

American papers are divided among those that compute the efficiency at business school level and at programme level. Examples of the first group are *"Efficiency of the top 50 business schools in the United States"* (Hirao, 2012) and "*An efficiency analysis of U.S. business schools"* (Comunale & Sexton, 2004). In this last paper, the authors, using the AACSB accreditation dataset, analyse 438 schools, an extremely high number comparing to the usual number of schools considered in other works (see table 5 in chapter 4.2). On the other hand, Colbert et al. (2000) compute the relative efficiency of 64 MBA programmes, Ray & Jeon (2008) of 68 MBA programmes, Hsu et al. (2009) of 58 MBA programmes and Fisher et al. (2007) of 50 MBA programmes.

Two studies that are significant for our work have been done in Australia: *"The efficiency of Australian universities: a data envelopment analysis"* (Abbott & Doucouliagos, 2003), which analyses the efficiency of 36 government universities, and *"Application of data envelopment analysis in the service sector: Universities"* (Cooper, Seiford, & Zhu, 2011), which analyses the efficiency of the same group of universities as Abbott & Doucouliagos.

*Applied Methodologies*

All the above-cited papers use the DEA methodology. Tzeremes & Halkos (2010) implement the bootstrapped DEA methodology, as already mentioned. We here describe those works that integrate DEA with different methodologies.

Kong & Fu (2012) analyse the efficiency of 21 business schools in Taiwan. They use the AHP -Analytic Hierarchy Process- method to quantify subjective judgments in order to give weights to inputs and outputs and the AR -Assurance Region- approach to avoid an unreasonable distribution of weights giving upper and lower bounds to weight values.

Sreekumar & Mahapatra (Sreekumar & Mahapatra, 2011) assess the efficiency of 49 business schools using DEA and NN -Neural Network- to predict performance in future scenarios.

An interesting paper is *"Time-staged Outputs in DEA"* (Sacoto, Cook, & Delgado, 2015) in which the authors compute the relative efficency of one Mexican school, namely the ENCSH (Escuela de Negocios, Ciencias Sociales y Humanidades) at ITESM, in respect to 41 US schools. In this paper one variable, students with internship (*I*), has a "dual role", meaning that it can be trated as an input or as an output. Since DEA applies flexible weights to maximize school's efficeincy, when *I* is low, it is treated as an input variable, and when *I* is high it is treated as an output variable, contributing to the other fixed output, job placement.

Hsu et al. (2009) compare efficiency and ranking of MBA programmes using the Kolmogorov-Smirnov Z test.

Hirao (2012) uses the ANOVA test to compare the efficiency of private and public business schools.

Agasisti (2011) implements the DEA both with variable returns to scale (VRS) and with the free disposability hypothesis (FDH[1]) to check the robustness of the model. He finds that the results computed with VRS are in accordance with the results computed with FDH.

*Commonly used inputs and outputs*

*MBA programmes*

All the analysed papers use *average GMAT score* as input to represent the level of skills of the students before attending the programme. Colbert et al. (2000) and Ray & Jeon (2008) use *faculty to student ratio* as a measure of the school investment in the education activity. Hsu et al. (2009) and Fisher et al. (2007) use *average undergraduate GPA* together with *average GMAT score* to quantify student skills and *tuition* as inputs. Fisher et al. also consider the *cost of living*, as a significant factor that students have to take into account when choosing their MBA. Ray & Jeon, differently than the others, include demographic variables among the inputs, such as the *percentage of US students* and the *percentage of male*, to reflect characteristics of students that may affect their salaries without affecting their managerial ability. Fisher et al. consider *duration of the programme* as an input.

All the papers consider *average starting salary* as output. Some elaborate further on this measure, such as Ray & Jeon, who consider the difference between pre and post-MBA salary and adjust it for the tuition fee. Among the outputs, most of the papers consider the *employment rate at graduation* (Hirao, Fisher et al., Ray & Jeon) or *employment rate at three months* after graduation (Hsu et al., Fisher et al.). Colbert et al. and Hsu et al. include *students' satisfaction* among outputs. Colbert et al. also consider the *percentage of alumni who donate money to the programme*, as a measure of students' satisfaction with the programme, and *recruiters' satisfaction*.

[1] FDH is an assumption on the shape of the technological frontier. Compared to VRS, it does not assume convexity, thus limiting the technology frontier (Bogetoft & Otto, 2010).

**Table 2 Inputs and outputs, MBA programmes**

| *Paper* | *Inputs* | *Outputs* |
|---|---|---|
| Colbert, A., Levary, R. R., & Shaner, M. C. (2000). Determining the relative efficiency of MBA programmes using DEA. European Journal of Operational Research, 125(3), 656-669. | • Faculty to student ratio<br>• Average GMAT score<br>• Number of electives offered | • % of alumni who donate money to the programme<br>• Students' satisfaction with teaching, curriculum and placement<br>• Recruiters' satisfaction with student's analytical skills, team work and global view<br>• Average salary of graduates |
| Ray, S. C., & Jeon, Y. (2008). Reputation and efficiency: A non-parametric assessment of America's top-rated MBA programmes. European Journal of Operational Research, 189(1), 245-268. | • Faculty to students ratio<br>• Average GMAT score<br>• Rejection rate<br>• % of male students<br>•% of US students<br>• School budget per student | • Difference between the annuitized pre- and post- MBA earnings flow adjusted for tuition and fee<br>• Adjusted placement rate |
| Hsu, M. K., James, M. L., & Chao, G. H. (2009). An efficiency comparison of MBA programmes: Top 10 versus non-top 10. Journal of Education for Business, 84(5), 269-274. | • Average undergraduate GPA<br>• Average GMAT score<br>• Out-of-state tuition<br>• Salary before entering the programme | • Average starting salary and bonus immediately after graduation<br>• Employment rate three months after obtaining the MBA<br>• Students' satisfaction (aims-achieved ratio) |
| Fisher, D. M., Fisher, S. A., & Kiang, M. (2007). A value-added approach to selecting the best master of business administration (MBA) programme. Journal of education for Business, 83(2), 72-76. | • Average GMAT score<br>• Average undergraduate GPA<br>• Tuition<br>• Cost of living<br>• Duration of the programme | • Average starting salary and bonuses<br>• Employment rate at graduation<br>• Employment rate at graduation three months after graduation |
| Hirao, Y. (2012). Efficiency of the top 50 business schools in the United States. Applied Economics Letters, 19(1), 73-78. | • Average GMAT score<br>• Peer assessment | • Average starting salary<br>• Employment rate at graduation |

*Business Schools*

A commonly used input is a measure of the students' skills before entering the school. Kong & Fu (2012) consider the *average GPA* and *educational background* of students, while Sacoto et al. (2015) consider the *admission rating* and the *percentage of students who graduated in the top quarter* of their high school class. Sacoto et al. also consider *academic rating* and *financial rating* as measures, respectively, of the students' reward for their effort in studying and of financial aid provided by the school. Comunale & Sexton (2004) consider inputs concerning the school effort in education and not the students' characteristics. They consider the *number of staff* and the *budget* of the school.

The outputs utilised are not homogeneous in the literature considered. Kong & Fu consider the *starting salary*. Comunale & Sexton consider the number of *enrolments per programme* and the *endowment*. Sacoto et al. consider the *percentage of students with internship* and *employment rate*, with the observation on the first output previously made (students with internship is a "dual-role" variable). Note that no studies include research among outputs. This is due to the fact that it is highly varied, meaning that research activities can be published and diffused in different ways (referred journals, conference proceedings, books and others) and there is no central database that provide this information (Comunale & Sexton, 2004).

Table 3 Inputs and outputs, Business schools

| *Paper* | *Inputs* | *Outputs* |
|---|---|---|
| Kong, W. H., & Fu, T. T. (2012). Assessing the performance of business colleges in Taiwan using data envelopment analysis and student based value-added performance indicators. Omega, 40(5), 541-549. | • Educational background of students during the first job<br>• GPA of graduate at college | • Starting wage -predicted and as a marginal school effect- |
| Comunale, C. L. & Sexton, T. R. (2004). An efficiency analysis of U.S. business schools. Journal of case studies in accreditation and assessment, 1-19. | •Faculty members<br>•Non-faculty members<br>•FTE part-time faculty<br>•Staff and administrators<br>•Budget | •Undergraduate enrolments<br>•FTE MBA enrolments<br>•FTE EMBA enrolments<br>•FTE specialized master enrolments<br>•FTE doctorate enrolments<br>•Endowment |
| Sacoto, S. A., Cook, W. D., Delgado, H. C., & Castorena, D. G. (2015). Time-staged Outputs in DEA. Omega. | •Academic rating<br>•Admission rating<br>•Financial rating<br>•% top 25% in class | •% students with Internships<br>•% students who find jobs |

*Main Findings*

From the efficiency analysis each author draw conclusions focusing on different aspects and implications. Colbert et al. (2000) prove that the number of efficient schools improves with the number of variables included in the efficiency analysis. This is a consequence of a well-known property of DEA, which is the flexibility in the distributions of weights. All efficiency scores result to be above 0.9. Hence the authors note that a more balanced sample of MBA programmes might have resulted in a wider range of efficiencies, since data was available only for the top ranked MBA programmes.

Ray & Jeon (2008) find that reputational rankings, and in their particular case the BusinessWeek ranking, are primary based on average starting salary and employment rate, but do not relate these outputs to the inputs.

Hsu et al. (2009) explore the main causes of inefficiency. They compute both the input and the output efficiencies. When the source of inefficiency is an output variable, they suggest to increase the performance of that factor, alternatively, when the source of inefficiency is an input variable, they suggest to ease the required standard of that factor to a certain degree (for example, it might be appropriate to lower the selection criteria). Overall, they find that most schools should work on increasing the starting salaries of their graduates, by, for example, developing their network with corporate recruiters who pay high salaries.

Two papers compare public and private business schools. In the US the study by Hirao (2012) demonstrates that private business schools have, on average, higher overall and scale efficiency, while no difference are noted when comparing pure technical efficiencies. This suggests that public schools might want to rescale their activities. In particular, the author finds that most of the public schools have increasing returns to scale (IRS), meaning that their scale of activity is too small, so that an increase in the level of the inputs, namely school quality and students' ability, entails a more than proportional increase in the outputs, namely salary and employment rate.  Kong & Fu (2012) compare the public and private sectors in Taiwan. Differently than the conclusion of Hirao in the US, they find that public business schools are more efficient than private ones. The former have a comparative advantage in students multiple ability cultivation and the latter in starting wage. They also analyse the weights on each output and he finds that there is a greater potential for improvement in the affective abilities of students, rather than in cognitive and psychological abilities. This is because of the greater weight that schools place on the affective abilities.

*Efficiency scores vs. rankings*

Some American studies include a comparison between the DEA efficiency estimates and the rankings. Ray & Jeon (2008) divide the schools into three tiers: the best ranked thirty schools according to the BusinessWeek ranking, the following twenty and the rest, and they compare the aggregate efficiency of each tiers. They find that on average the top-tier schools perform better even if there is a high variance within the same tier. Hsu et al. (2009) simply divide schools into top 10 and non-top 10 according to the Financial Times Global MBA ranking and the US news and world report. They find that the top 10 schools have, on average, a higher efficiency. Nevertheless when they decompose the efficiency into pure technical efficiency and scale efficiency, they find that only the scale efficiency is higher for the top 10, but not the pure technical efficiency. Palocsay & Wood (2014) analyse the efficiency of 124 undergraduate business schools and then compare the efficiency scores with the BusinessWeek ranking. They find that out of the seven efficient schools, four position within the top 10 schools, while the other three are distributed with a high rank range. In general, when considering efficiency rather than the BusinessWeek rank, 9% of the analysed schools improve its position by 50%.

## 2.3. INNOVATIVE CONTRIBUTION IN RELATION TO THE EXISTING LITERATURE

Taking the cue from the existing analysed literature, the present study implements the DEA methodology to compute the efficiency of the best known European business schools. While this type of study has been widely applied to US business schools and executive programmes, there is a lack of contributions that concentrates mainly on European executive education in a cross-country perspective.

Our results are presented firstly as a simple description of efficiency scores, as Colbert et al. (2000); then we compare efficiency scores and rankings, as Ray & Jeon (2008) or Hsu et al. (2009). In a second part of the work we try to explain efficiency through different variables, following Kong & Fu (2012) and Sarrico & Dyson (2000). Moreover, we compare efficiency of business schools as a whole and of their programmes; to the best of our knowledge, this comparison has never been done in literature.

Following Tzeremes & Halkos (2010), we implement the bootstrapping procedure (Simar & Wilson, 2000) in order to detect statistical inference and provide confidence intervals for the efficiency scores. Bootstrapping is utilised also to draw statistical conclusions on the returns to scale assumption of the model and to compare the *estimations* of scale efficiency with the assumption on the returns to scale that better suits the reality. This last comparison is new in literature, as most of the authors limit their analysis to the sole estimations of scale efficiency or to the test of robustness on the assumption on the returns to scale.

We also use the literature to select inputs and outputs, details on this are provided in chapter 4.2. We introduce a new variable that has never been used in literature, this is the percentage of enrolled on accepted students as an output at the programme level. Differently than Tracy & Waldfogel (1997), who use acceptance rate as an input, we compute the ratio of enrolled on accepted students in order to measure the degree of priority that accepted students give to the programme they have applied for. Indeed a common problem of schools is the number of vacancies left by accepted students who ultimately turn out not to enrol in the selected programme. This output is significant in terms of efficiency, as it affects the full exploitation of the resources of the school and it eventually suggests actions to be undertaken in order to increase efficiency, such as modifying the application procedure and improving the capability to detect the degree of motivation of the potential students.

Table 4 illustrates the characteristics of the present study according to the scheme used for the analysis of the literature.

**Table 4 Characteristics of the present study**

| ***Title*** | ***Country (date)*** | ***Unit of analysis*** | ***Number of units analysed*** | ***Method*** | ***Inputs*** | ***Outputs*** |
|---|---|---|---|---|---|---|
| The efficiency of business schools in Europe: an empirical analysis through Data Envelopment Analysis, and a comparison with rankings | Europe (2009-2014) | Business School (Institutional level) | 36 | DEA and Bootstrapping | • Number of administrative staff<br>•Number of core faculty members<br>•Number of students offered a place | • Number of students enrolled<br>•Research income<br>•Employment rate |
| | | MBA (Single Programme level) | 25 | | • Average GMAT<br>•Tuition fee | • Starting salary<br>•Employment rate<br>•Enrolled / accepted students |
| | | EMBA (Single Programme level) | 28 | | • Average years of work experience<br>•Tuition fee | • Starting salary<br>•Enrolled / accepted students |
| | | Master in Management (Single Programme level) | 31 | | • Duration<br>•Tuition fee | • Starting salary<br>•Employment rate<br>•Enrolled / accepted students |

## 3. RANKINGS' METHODOLOGIES

The criteria used in the most popular rankings are here explained in order to underline the methodological difference with the DEA approach. Indeed, one of the objective of this study is to test if rankings provided by efficiency scores are consistent with the "traditional" ones or not (and eventually to explore the determinants of the existent differences). The rankings that we are going to analyse are the Financial Times, QS and Bloomberg BusinessWeek. A summary of the characteristics of these rankings is presented in table 5.

**Table 5 Rankings (Source: (Collet & Vives, 2013) (European business schools 2014 ranking: key, 2014) (Lavelle, 2014) (Rodkin, 2014))**

| | ***Financial Times European Business School*** | ***QS*** | ***BusinessWeek*** |
|---|---|---|---|
| **Year of creation** | 2004 | 2004 | 1988 |
| **Frequency of rankings** | Annual | Annual | Annual |
| **Number of schools that took part** | | 500 | 112 (full-time MBA programmes) |
| **Response rate from students** | | | 48.6% |
| **Geographical areas _ guides** | Europe | Global _ World regions and subject areas | Global _ US and non-US schools, graduate and undergraduate |
| **Programmes analysed** | Full-time MBA<br>EMBA<br>Master in management<br>Master in finance<br>Executive education<br>Online MBA | Full-time MBA<br>Part-time MBA<br>EMBA<br>Distance-learning MBA | Full-time MBA<br>Part-time MBA<br>EMBA<br>Executive education<br>Distance-learning MBA |
| **Source of data** | FT Global MBA ranking [1]<br>FT Executive MBA ranking [2]<br>FT Masters in Management [3]<br>FT Executive education - open programmes [4]<br>FT Executive education - customized programmes [5] | Academics' surveys [1]<br>Corporate recruiter surveys [2] | Alumni surveys [1]<br>Corporate recruiter surveys [2]<br>Intellectual capital rating [3] |
| **Minimum requirements to enter ranking** | 1. School must participate in at least one ranking<br>2. Schools that participate with only a joint programme are not eligible | 1. Schools must offer a full-time MBA programme<br>2. Recommendation from an employer in the previous year | 1. Minimum response rate of 30% of the class and 25 students<br>2. A minimum of 5 rating votes from recruiters |
| **Ranking criteria [weight]** | 1. Full-time MBA [25%]<br>2. EMBA [25%]<br>3. Master in Management [25%]<br>4. Executive Education - open programmes [12.5%]<br>5. Executive Education - customized programmes [12.5%] | 1. Employer reputation [85%]<br>2. Academic reputation [15%] | 1. Student surveys [45%]<br>2. Recruiter surveys [45%]<br>3. Intellectual capital rating [10%] |

*Financial Times*

The rank of the European business schools derives from the sum of the indexed scores of the FT Global MBA ranking, FT Executive MBA ranking, FT Masters in Management, FT Open-enrolment executive programmes and FT Customized executive programmes. This sum is divided by the number of rankings in which a school features. A joint programme is weighted accordingly to the number of schools that offer it (if a programme is delivered by four schools, each school would be assigned a weight of 25%). If a school is ranked more than once in the same ranking, the weights are assigned to its programmes so that their sum is equal to one (if one of the four above-cited schools offers another programme in the same ranking, it will assign to it a weight of 75%) (European business schools 2014 ranking: methodology, 2014).

The other FT rankings are based on different criteria with different weights (see table 6) and data are collected through surveys directed to alumni and school administrators.
Responses from surveys taken in the current year (t) account for 50% of the total weight, and those from t-1 and t-2 for 25% each. If only two years of data are available, the weighting is split 60/40 if data are from t and t-1, or 70/30 if from t and t-2. For salary figures, the weighting is 50/50 for two years' data, to negate any inflation-related distortions (Ortmans, 2014).
The FT ranking is a relative ranking. Schools are ranked against each other by calculating for each criterion their Z-score. Z-scores represent the number of standard deviations each school's data is away from the mean. The final score is then computed as the weighted sum of the criteria. After removing the schools that did not have a sufficient response rate from the alumni survey, a first version is calculated using all remaining schools. The school at the bottom is removed and a second version is calculated. The process is reiterated until reaching the top 100 (Ortmans, 2014).

Table 6 Financial Times rankings (Source: (Key to EMBA ranking 2014, 2014) (Palin, 2014) (Masters in management: key to the 2014 ranking, 2014))

| | *Financial Times Global MBA* | *Financial Times Executive MBA* | *Financial Times Masters in management* |
|---|---|---|---|
| **Year of creation** | 1999 | 2001 | 2005 |
| **Frequency of rankings** | Annual | Annual | Annual |
| **Number of schools that took part** | 153 | 134 | 81 |
| **Response rate from students** | 47% | 51% | 37% |
| **Geographical areas _ guides** | Global | Global | Global |
| **Source of data** | School surveys [1-8]<br>Alumni (2010 graduates) surveys [9-19]<br>Number of articles published by full-time faculty in the FT 45 journals [20]<br>Auditing | School surveys [1-5]<br>Alumni (2011 graduates) surveys [6-15]<br>Number of articles published by full-time faculty in the FT 45 journals [16]<br>Auditing | School surveys<br>Alumni (2011 graduates) surveys<br>Auditing |
| **Minimum requirements to enter ranking** | 1. International accredited<br>2. Have their nominated programme running for at least 4 consecutive years<br>3. Minimum students' response rate of 20% | 1. International accredited<br>2. Have their nominated programme running for at least 4 consecutive years<br>3. Minimum students' response rate of 20% | 1. International accredited<br>2. Have their nominated programme running for at least 4 consecutive years<br>3. Minimum students' response rate of 20%<br>4. Specialized programmes are not eligible |
| **Ranking criteria [weight]** | 1. Weighted salary [20%]<br>2. Salary percentage increase [20%]<br>3. Value for money rank [3%]<br>4. Career progress rank [3%]<br>5. Aims achieved rank [3%]<br>6. Placement success rank [2%]<br>7. Employed at three months [2%]<br>8. Alumni recommend rank [2%]<br>9. Female faculty [2%]<br>10. Female students [2%]<br>11. Female board [1%]<br>12. International faculty [4%]<br>13. International students [4%]<br>14. International board [2%]<br>15. International mobility rank [6%]<br>16. International course experience rank [3%]<br>17. Languages [1%]<br>18. Faculty with doctorates [5%]<br>19. FT doctoral rank [5%]<br>20. FT research rank [10%] | 1. Salary today [20%]<br>2. Salary increase [20%]<br>3. Career progress rank [5%]<br>4. Work experience ranks [5%]<br>5. Aims achieved rank [5%]<br>6. Female faculty [3%]<br>7. Female students [3%]<br>8. Female board [1%]<br>9. International faculty [5%]<br>10. International students rank [5%]<br>11. International board [2%]<br>12. International course experience rank [5%]<br>13. Languages [1%]<br>14. Faculty with doctorates [5%]<br>15. FT doctoral rank [5%]<br>16. FT research rank [10%] | 1. Weighted salary [20%]<br>2. Value for money rank [5%]<br>3. Career rank [10%]<br>4. Aims achieved rank [5%]<br>5. Placement success rank [5%]<br>6. Employed at three months [5%]<br>7. Female faculty [5%]<br>8. Female students [5%]<br>9. Female board [1%]<br>10. International faculty [5%]<br>11. International students [5%]<br>12. International board [2%]<br>13. International mobility rank [10%]<br>14. International course experience rank [10%]<br>15. Languages [1%]<br>16. Faculty with doctorates [6%] |

Some notes need to be done about some of the criteria used:

- In the computation of “salary today” salaries of non-profit and public sector workers, as well as full-time students, are removed. Remaining salaries are converted to US dollars using the latest purchasing power parity (PPP) rates supplied by the International Monetary Fund. The very highest and lowest salaries are subsequently removed, and the mean average salary is calculated for each school.
- Salary increase (for MBAs and Executive MBAs) is calculated for each school according to the difference in the average alumni salary before the (E)MBA to three years after graduation – a period of typically four to five years. Half of this figure is calculated according to the absolute increase, and half according to the percentage increase relative to pre-(E)MBA salaries (Ortmans, 2014).
- The calculations for weighted salary (for MBAs and masters in management) apply to schools with 50 or more students’ responses. Based on the main six business sectors of employment in the overall sample, the average salary by sector for each school is computed and the school’s salary is calculated assuming that the school had the same percentage split over sectors as the total sample. The impact is more important for schools with a significantly higher proportion of alumni working in one of these 6 sectors. The salary of the alumni who are not in these six sectors is not weighted (Ortmans, 2014).

*QS*

QS compiles different rankings grouping schools according to world region (North America, Europe, Asia, Latin America and Middle East and Africa) and specialization (corporate social responsibility, entrepreneurship, finance, information management, innovation, international management, leadership, marketing, operations management and strategy). QS ranking is computed as the weighted sum of two indexes: the index of employer votes (85%) and the index of academics’ votes (15%).

The index of employer votes is the sum of the total ‘prompted’ and ‘unprompted’ votes. The former is the total number of times that any recruiters gives a vote to a school from which he would consider hiring a MBA graduate. Recruiters can choose from a list of 500 schools that includes schools recommended by a recruiter in the previous year. The latter is the total number of times that recruiters give a vote to a school from which they have recently attempted to recruit. In order to avoid any inference due to the economic cycle, an average of the total employer votes is taken from the current year’s research and the two previous surveys. The index of employer votes is then computed by giving an index score of 100 to the best performing school and indexing the average total employer votes for the remaining schools against the best performing school.

In the academics' surveys, respondents are asked to identify their areas of expertise - countries, regions, and up to five faculty areas with which they are most familiar. For each of the five faculty areas, they are then asked to list up to 10 domestic and 30 international institutions that they consider excellent for research in that area. The index of academics' votes is computed in the same way as the index of employer votes.

To increase the size of the sample, responses from one year are combined with those from two previous years, and duplicate responses from the same individuals over the three-year period are removed (Lavelle, 2014).

*Businessweek*

Businessweek ranks schools based on their success under three perspectives: the students' opinion (45%), the recruiters' opinion (45%) and the research output (10%). Students and recruiters are interviewed through surveys emailed to the addresses provided by schools.

Student surveys cover the quality of academic and career development offering, the qualities of the student body and school culture and investigate on students' own skills.

Recruiter surveys aim at measuring the school reputation and the recruiters' satisfaction with the graduates' skills. Recruiters are asked to identify up to 10 schools from which they have recently recruited. They are then asked to rate up these schools based on the reputation that they have of them and based on the performance of their employed graduates. The sum of the two types of rating is weighted on the recruiter's size, represented by the number of students hired. Since a part of the interviewed recruiters are alumni of the analysed schools and since they tend to rate their own school more favourably than the rest, the number of ratings based on school's reputation received from its own alumni is excluded from the weighted sum.

The intellectual capital rating is computed as the ratio between all articles published by the school faculty in 20 top business journals in a 5-years period and the number of full-time tenured faculty members (Rodkin, 2014).

Scores for each of the three components are finally standardized, using each score's mean and standard deviation. The resulting scores are then summed up according to their weights (45:45:10). Each school's ranking index is calculated by dividing its weighted sum by the best school's weighted sum and then multiplying by 100.

# 4. BACKGROUND: BUSINESS SCHOOLS' PRODUCTION PROCESS

## 4.1. THE BUSINESS SCHOOLS' PRODUCTION PROCESS

In order to represent the production process of a business school, we use an influence diagram as a tool to underline the cause-effect relationships between variables. This exercise helps us to select the inputs and the outputs to be included in our model of efficiency and to study its determinants.

An influence diagram is a graphic tool to describe the dependences among variables. It is made of nodes and arcs to connect them. The nodes represent the variables. We define three types of nodes:

1. *Decision nodes* to describe the variables under the control of the decision-maker, they are represented by rectangles.
2. *Chance nodes* to describe the variables that are not directly under the control of the decision-maker, thus representing a source of uncertainty. Change nodes are represented by ovals.
3. *Utility nodes* correspond to variables calculated as a mathematical function of other variables. They represent the (expected) utilities that model the decision-maker's preferences for outcomes (Bielza, Gómez, & Shenoy, 2011). Utility nodes are represented by diamonds.

We also use *intermediate chance* nodes, represented by dashed ovals, to better explain the causal relationships. Nonetheless, these nodes are not part of the variables that we measure and analyse.

The main advantages of influence diagrams are the ease of use, the knowledge representation and modelling property and the capability of managing uncertainty (Sedki, Polet, & Vanderhaegen, 2013). The ease of use property derives from the intuitive structure of influence diagrams. They offer a simple and meaningful way to organize information, hence the property of knowledge representation and modelling. Influence diagrams also offer a qualitative method to assess relationship between uncertain variables. On the other hand, the need to keep the influence diagram easy to use has the drawback of eventually ignoring additional influences.

Figure 1 shows the influence diagram of the variables of our interest at the single programme level. Our conclusions on the variables to be considered in the DEA efficiency model are anticipated in the figure: the selected variables are highlighted in different colours for MBAs, EMBAs and masters in management (these three and business schools are the units of analysis selected for the empirical study).

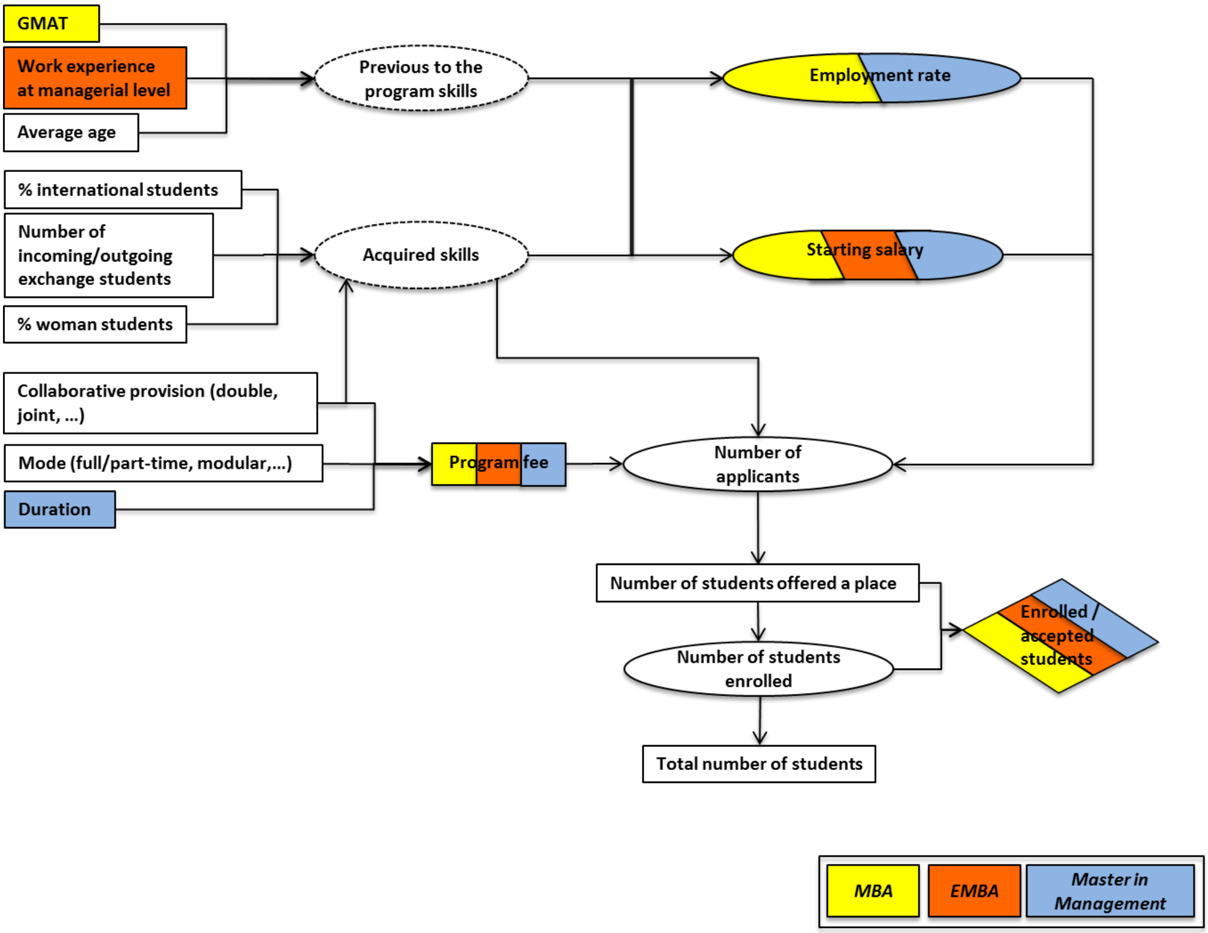


Figure 1 Influence Diagram, Programme level (Source: authors' elaborations)

*Employment rate* and *starting salary*

Employment rate and starting salary are a result of graduate's skills, both acquired from and previous to the educational programme. These assumptions find theoretical support in the Human Capital Theory by Becker (Becker, 1962). Becker states that income is dependent on knowledge and observes that unemployment is negatively related to the level of skills. Since education improves trainees' skills and has a positive impact on workers' productivity, an investment in education has in return an increase in salary due to the increased productivity. For this reason, students are willing to pay for their own education.

Starting salary and employment rate are also the heaviest criteria in the most known rankings: the Financial Times gives a weight of 40% to the salary indicators, while only a weight of 2% to the employment rate; QS ranks schools through the so called “index of employer vote” (with a weight of 85%), which is a measure of the employer’s willingness to hire a graduate of a certain school; Business Week applies a weight of 45% to the recruiter surveys, which represent employer’s satisfaction with the graduate’s skills.

In accordance with the cited rankings, which measure school performance, we use employment rate and starting salary as output variables. These outputs are an indicator of the employer’s satisfaction with the graduate’s skills, since we can consider negligible other factors, such as the particular conditions of the labour market in different time periods and geographical regions (García-Varderrama, 1996). Indeed MBA graduates face a homogeneous global labour market and the data we use belongs to the same time period.

Hence it needs to be noticed that not all graduates get employed in companies, but a small number of them might choose to follow a different path, such as founding their own companies. Unfortunately, we have no available data for this purpose.

*Previous to the programme* and *acquired skills*

Previous to the programme and acquired skills are qualitative variables that can be approximated with measurable ones. We consider previous to the programme skills as an indicator of the programme selectivity: average GMAT score and average years of work experience at managerial level (the averages are computed on the class) are the result of the entry requirements and of the selection process. Previous to the programme skills are in general positively related to the average age of the class, since we assume that the higher the age, the higher the experience that students have.

Acquired skills result from a larger number of variables, which might contribute to the student skills in different proportion, according to his learning capability and other particular and individual factors, such as personality and background. We consider acquired skills to be a result of the level of internationalization of the class, represented by the percentage of international students, the number of exchange students and the collaborative provision, since, particularly in the business and managerial field, the capability of adapting to different cultures is key in the development of global leadership (Adler & Bartholomew, 1992).

Recently the attention of programme administrators is focusing on covering the gender gap. Even in the Financial Times, the percentage of female students in the class has a weight of 2% on the overall score (Palin, 2014) and those schools with a ratio of male to female students of 50:50 are favoured. A balanced gender mix in the class might contribute to increase students’ interpersonal skills.

*Programme Fee*

Becker defines net earnings as the difference between actual earnings and direct school costs. Similarly, we consider the programme tuition fee as an input. In this way educational costs appears in the efficiency formula as a denominator, though explicating their inversely proportion to efficiency. Programme fees are more often determined observing the market prices rather than computed on a cost-base. The tuition fee of a programme is mainly affected by its duration, the mode in which it is delivered (full or part-time, modular, blended, distance-learning and others), the presence of collaborative provisions and other variables that are not highlighted in the diagram, such as the prestige of the school.

*Number of applicants*

Programme tuition fee should reflect the expectations of students for enrolling in the programme, thus affecting the number of applicants. The higher the expectations on the programme, the higher the willingness students are to pay for it, with the constraint of the maximum budget available. Students enrol in higher education programmes with the expectation of a personal development and educational experience as well as new career opportunities and increased salary (Bickerstaffe & Ridgers, 2007). The former are represented by the acquired skills, the latter by the employment rate and the starting salary. Given other things equal, it is clear that tuition fee and the number of applicants are inversely proportional.

*Number of students enrolled*

The number of enrolments is a function of the number of students offered a place. This number might or might not be a function of the number of applicants and in any case it is difficult to establish the direction of the proportion between these two variables. Indeed it might be that lowering the number of students offered a place would increase the exclusivity of the programme, thus attracting more ambitious students to apply for it. We compute the ratio of enrolled on accepted students in order to measure the preference that candidates give to the programme they apply for: a ratio of enrolled on accepted students equal to 1 indicates that the programme has been the first choice for the accepted candidates, while a low ratio means that candidates have enrolled in other programmes or finally refused the offer for other reasons.

Figure 2 shows the influence diagram of the variables of our interest at the business school level. Our conclusions on the variables to be considered in the DEA efficiency model are anticipated in figure 2. The selected variables are highlighted in green.

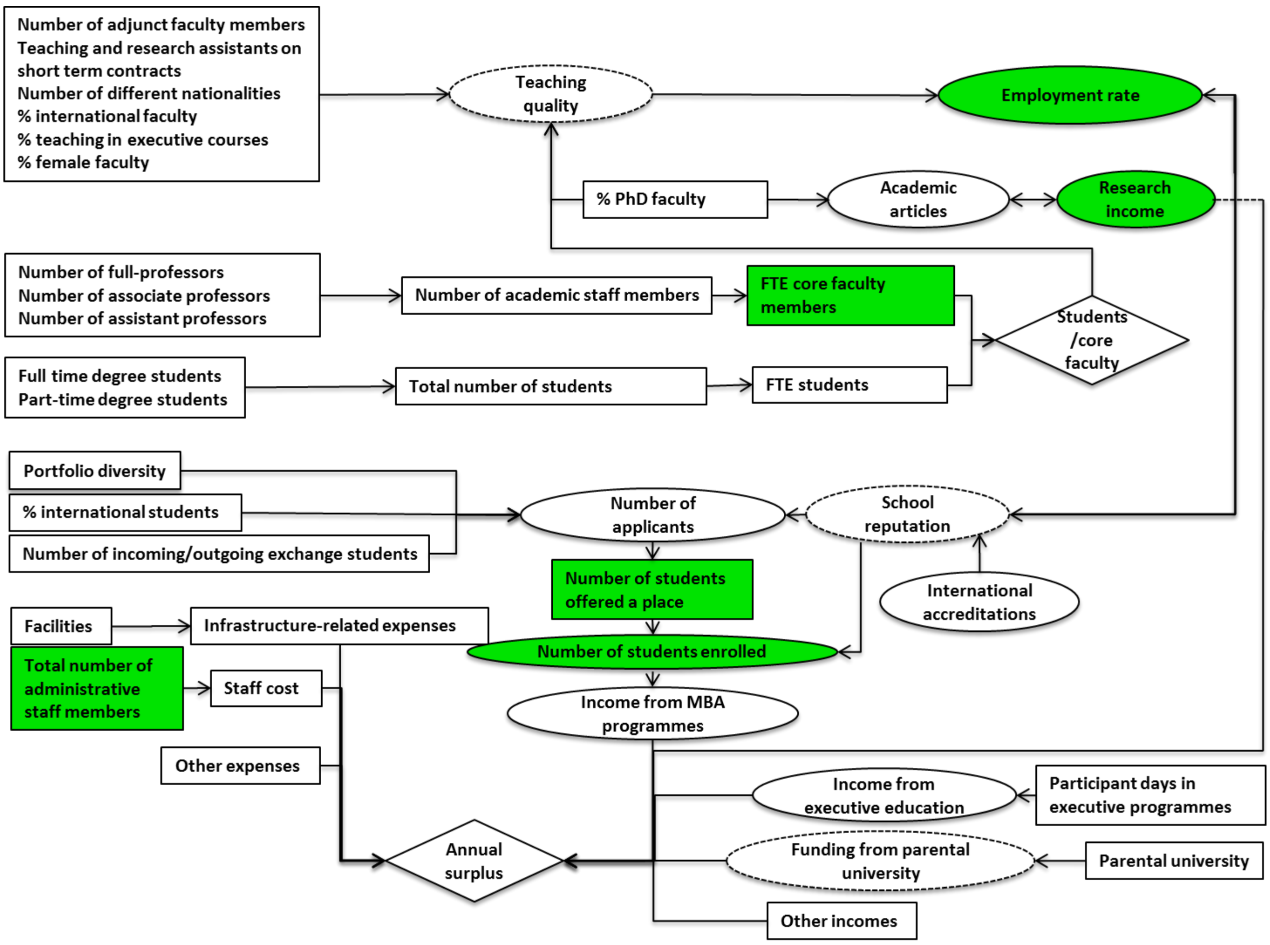


**Figure 2 Influence diagram, Business school level (Source: authors' elaborations)**

*Teaching quality*

The quality of teaching is the main intangible asset of business schools. It increases the skills that students will use once entered the labour market. For this reason teaching quality affects employers' satisfaction with candidates who have studied in a certain school and their willingness to employ them, thus affecting the average employment rate of that school. A high degree of satisfaction contributes to increase the school reputation, while a high school reputation also contributes to increase employment rate. Corporate recruiters select candidates based on their average expected skills, which are supposed to correspond to a high reputation of the school. School reputation might be well represented by its position in the most common rankings, first of all the Financial Times, but might also be affected from the word on mouth among corporate recruiters.

The intangible nature of teaching quality makes it difficult to measure it. We approximate it with a number of variables expressing the quantity and the quality of the teaching staff. Among those variables expressing quantity, the ratio of full-time equivalent (FTE) students to FTE core faculty members is assumed to be inversely proportional to the teaching quality, since the bigger the class, the lower the average individual attention students receive. Among those variables expressing quality, the percentage of international faculty, of PhD faculty and of female faculty are suggested by the Financial Times; the percentage of faculty teaching in executive education is instead a measure of the effort that the school put in this segment.

*Number of students offered a place* and *number of students enrolled*

Hence the same observations formulated at the programme level are valid. The priority given by applicants to the specific school is here represented by the correlation between school reputation and number of students enrolled. Instead of the number of students enrolled, for executive education we measure the number of participant days in executive programmes, computed as the product of the number of participants and the number of days of the programme. Both measures affect the income of the school, since we assume that, except for those who receive scholarships awarded by the school itself, enrolled students and participants in executive programmes, or their sponsors, are paying for their education.

*Number of applicants*

At the business school level we can individualize some general drivers that partially determine the degree of attractiveness of a certain school, thus the number of applicants. These drivers are, among the others, the school reputation and the degree of internationality of the school, represented by the percentage of international students and the number of exchange students. Business schools are favoured by a high number of applicants since in this way they can increase their selectivity, though increasing the level of previous to the programme skills and the probability of success of graduates once they enter the labour market.

*Portfolio diversity*

The total number of applicants is most of all a function of the portfolio diversity. A high number of programmes offered is expected to decrease the efficiency, since each programme requires dedicated resources and entails increasing costs for the business school. Besides the generalist programmes, as MBAs and masters in management, business schools might offer a range of specialized programmes. Specialization might occur based on three main criteria: industry, field and options. An industry-specialized programme covers the main issues of a particular industry, such as health-care or energy. A field-specialized programme focuses predominantly on one subject, such as finance or marketing. An options-specialization gives to enrolled students the possibility to specialize through the attendance of elective courses. Diversity can be also achieved targeting different markets. According to this classification, educational programmes can be defined as

- Pre-experience, typically bachelors,
- Post-experience, as masters and MBAs,
- Doctoral, as PhDs,
- Executive or non-degree, meaning company-based programmes.

Pre-experience and doctoral programmes are mostly offered by public institutions, post-experience and executive or non-degree programmes are offered by private entities. While some business schools collaborate with parental universities, they usually are private entities eventually funded by public institutions and they mainly offer post-experience and executive and non-degree programmes.

*Scholarly articles in international newspapers*

The issue of the selection of indicators that could properly approximate the output of the research activity has been dealt in various ways in literature. The main problem is to find a variable that expresses both the quantity and the quality of research. The number of scholarly articles in international top journals is a fair measure of both the quantity and the quality of the research output (Groot & Garcia-Valderrama, 2006), but it is difficult to measure, since each school has a different method to categorize the class of "international top journals". As shown in the diagram, the number of academic articles affects the research income, including funding from private or public institutions, but research funds themselves impact the number of scholarly articles published, thus we expect the two measures to be correlated. We use research income as research output for our efficiency study, since it is the most homogeneous data among schools.

*Core faculty members*

To obtain publications in international journals, business schools have to invest in human resources. A difference needs to be underline in this respect between core faculty members who have a doctorate and those who do not. Academic staff that holds a PhD degree has full teaching and research capabilities, while usually non-doctoral staff concentrates on teaching (Martín, 2006). We consider the number of full-time-equivalent (FTE) core faculty members as the general input for business schools affecting both teaching quality and research output.

*Annual surplus*

Lastly, the annual surplus is computed as the difference of all the revenues and all the expenses. Total revenue is computed as the sum of the incomes from MBA programmes, executive education, research and others as well as eventual funding coming from parental schools. The main costs are related to the human resources of the school, meaning salaries of academic faculty members and administrative staff members, plus the investments and the costs for running the facilities and other minor costs.

## 4.2. THE CONCEPT OF EFFICIENCY AND THE STUDY OF ITS DETERMINANTS

After the description of the complexity of the production process of business schools, we want to select the most significant inputs and outputs in order to compute the efficiency scores for each school. In this step we look at the production process as a “black box”, meaning that we are not interested in the explanation of the transformation process of the inputs into outputs. Lately we compare the efficiency scores, considered as standardized transformation rates, with the variables that could explain the process of transformation of the inputs into the outputs.

Referring to the influence diagram in figure 1 and 2, we have inputs as those variables that are under the control of the decision-maker (represented by rectangles) and outputs as those variables that are not (represented by ovals). Due to the properties of DEA, the higher the number of inputs and outputs, the higher is the number of efficient schools, since they distribute weights in such a way to avoid comparison with other schools. Since we are interested in exploring eventual sources of inefficiency, it is important that we select a limited and relevant number of inputs and outputs. Researchers suggest using the mathematical relationship between the number of inputs ($m$) and outputs ($n$) and the number of schools ($K$) expressed by the rules of thumb (Bogetoft & Otto, 2010):

$$K > 3(m + n) \text{ and } K > m \times n$$

Table 7 lists a subset of papers that we consider significant when choosing inputs and outputs for our efficiency model. As stated by Sacoto et al. (2015), outputs and inputs can be thought as belonging to business schools or to students. The difference between these two approches lays in the meaning of the resulting efficiency scores: in the first case efficiency is measured as the return on the school’s investment in resources, in the second case efficiency is measured as the effect that the activity of business schools has on students. Comunale & Sexton (2004) focus on inputs and outputs related to business schools only. They use faculty members and budget as a measure of the school’s investment and number of enrolments and endowment as results of this investment. Kong & Fu (2012) focus on students' attributes only and they consider students' educational background and GPA as inputs and starting salary as outputs. Most of the papers mix school's and student's attributes, such as Colbert et al. (2000), who use faculty to student ratio, GMAT and number of electives offered as inputs and students' and recruiters' satisfaction as outputs. We also use variables belonging to students, such as GMAT, starting salary and employment rate and variables belonging to the school, such as tuition fee, faculty members and number of enrolments.

**Table 7 Literature Review: Significant papers for the selection of inputs and output**

| *Paper* | *Country (date)* | *Unit of analysis* | *Number of units analysed* | *Method* | *Inputs* | *Outputs* |
|---|---|---|---|---|---|---|
| Ray, S. C., & Jeon, Y. (2008). Reputation and efficiency: A non-parametric assessment of America's top-rated MBA programmes. European Journal of Operational Research, 189(1), 245-268. | USA (2004) | MBA | 65 | DEA | • Faculty to students ratio<br>• Average GMAT score<br>• Rejection rate<br>• % of male students<br>•% of US students<br>• School budget per student | • Difference between the annuitized pre- and post- MBA earnings flow adjusted for tuition and fee<br>• Adjusted placement rate |
| Hsu, M. K., James, M. L., & Chao, G. H. (2009). An efficiency comparison of MBA programmes: Top 10 versus non-top 10. Journal of Education for Business, 84(5), 269-274. | USA (2006) | MBA | 58 | DEA and Kolmogorov-Smirnov Z test to compare top 10 vs. non-top 10 MBA programmes | • Average undergraduate GPA<br>• Average GMAT score<br>• Out-of-state tuition<br>• Salary before entering the programme | • Average starting salary and bonus immediately after graduation<br>• Employment rate three months after obtaining the MBA<br>• Students' satisfaction (aims-achieved ratio) |
| Kong, W. H., & Fu, T. T. (2012). Assessing the performance of business colleges in Taiwan using data envelopment analysis and student based value-added performance indicators. Omega, 40(5), 541-549. | Taiwan (2004) | Business School | 21 | AHP -AR – DEA | • Educational background of students during the first job<br>• GPA of graduate at college | • Starting wage -predicted and as a marginal school effect- |
| Fisher, D. M., Fisher, S. A., & Kiang, M. (2007). A value-added approach to selecting the best masterù of business administration (MBA) programme. Journal of education for Business, 83(2), 72-76. | USA (2007) | MBA | 50 | DEA | • Average GMAT score<br>• Average undergraduate GPA<br>• Tuition<br>• Cost of living<br>• Duration of the programme | • Average starting salary and bonuses<br>• Employment rate at graduation<br>• Employment rate at graduation three months after graduation |
| Palocsay, S.W., Wood, W.C. (2014). An investigation of US undergraduate business school rankings using data envelopment analysis with value-added performance indicators. Journal of education for Business, 89(6), 277-284. | USA (2013) | Under-grad. Business School | 124 | DEA | • SAT scores<br>• Student-faculty ratio<br>• Tuition | • Recruiters' satisfaction<br>• Average starting salary |
| Hirao, Y. (2012). Efficiency of the top 50 business schools in the United States. Applied Economics Letters, 19(1), 73-78. | USA (2006) | Business School | 50 | DEA and ANOVA test to compare private and public sector | • Average GMAT score<br>• Peer assessment | • Average starting salary<br>• Employment rate at graduation |

| *Paper* | *Country (date)* | *Unit of analysis* | *Number of units analysed* | *Method* | *Inputs* | *Outputs* |
|---|---|---|---|---|---|---|
| Tracy, J., & Waldfogel, J. (1997). The best business schools: a market-based approach. Journal of business, 70 (1), 1-31. | USA (1991) | Business School | 63 | Regression | •Average GMAT score<br>•% of students with at least 1 year of working experience<br>•GPA<br>•% of students with a graduate degree<br>•Acceptance rate<br>•High faculty salary<br>•% of faculty with PhD<br>•Access to computers<br>•Tuition | •Adjusted starting salary |
| Comunale, C. L. & Sexton, T. R. (2004). An efficiency analysis of U.S. business schools. Journal of case studies in accreditation and assessment, 1-19. | USA (2005-2006) | Business School | 438 | DEA | •Faculty members<br>•Non-faculty members<br>•FTE part-time faculty<br>•Staff and administrators<br>•Budget | •Undergraduate enrolments<br>•FTE MBA enrolments<br>•FTE EMBA enrolments<br>•FTE specialized master enrolments<br>•FTE doctorate enrolments<br>•Endowment |
| Sacoto, S. A., Cook, W. D., Delgado, H. C., & Castorena, D. G. (2015). Time-staged Outputs in DEA. Omega. | Mexico, USA (2011) | Business School | 42 | AR-DEA with one "dual-role" variable | •Academic rating<br>•Admission rating<br>•Financial rating<br>•% top 25% in class | •% students with Internships<br>•% students who find jobs |

Table 8 shows the selected inputs and outputs that are used to compute the efficiency scores for each business school and single programme. The values of the variables of the single programmes are computed on the average of the class, more details on the data sources is given in the following chapter (subsection 5.4). The selection derives from the suggestion of the literature as well as from the availability of data, following the discussion in the previous section. While all the other variables appear in literature, we use the number of students enrolled as an input for business schools and the percentage of enrolled on accepted students as an output for programmes. Differently than Tracy & Waldfogel (1997), who use acceptance rate as an input, we compute the ratio of enrolled on accepted students in order to measure the priority that accepted students give to the programme they apply for.

**Table 8 Inputs and outputs**

| Unit (U) of analysis: | ***Business School*** | ***MBA*** | ***EMBA*** | ***Master in Management*** |
|---|---|---|---|---|
| Inputs: | 1. Number of administrative staff<br>2. Number of core faculty members<br>3. Number of students offered a place | 1. Average GMAT<br>2. Tuition fee | 1. Average years of work experience<br>2. Tuition fee | 1. Duration<br>2. Tuition fee |
| Outputs: | 1. Number of students enrolled<br>2. Research income<br>3. Employment rate | 1. Starting salary<br>2. Employment rate<br>3. Enrolled / accepted students | 1. Starting salary<br>2. Enrolled / accepted students | 1. Starting salary<br>2. Employment rate<br>3. Enrolled / accepted students |
| Min. number of U: | 18 | 15 | 12 | 15 |
| Analysed U: | 36 | 25 | 28 | 31 |

According to table 8 we can give the following definitions of an efficient business school and of an efficient programme in an output-oriented model:

A business school is efficient when it maximizes its teaching and research outputs, represented the former by the employment rate and the number of enrolled students, the latter by the research income, given the number of administrative staff, the number of core faculty members and the total number of students offered a place.

A single programme is efficient when it maximizes the success on the labour market of its graduates and the priority that accepted students give to it (ratio of enrolled on accepted students), given the degree of selectivity in entrance (GMAT for MBA and work experience for EMBA) and its tuition fee.

The master in management is a quite different case, since entry requirements are usually lower than for MBA and EMBA programmes. A master in management is therefore efficient when it maximizes the success on the labour market of its graduates and the priority that accepted students give to it (ratio of enrolled on accepted students), given its duration and tuition fee.

## 5. METHODS AND DATA

### 5.1. ASSUMPTIONS OF THE EFFICIENCY MODEL

Even in the common language, efficiency is the ratio between input and output. Nevertheless the use of DEA methodology requires some further specifications on the type of efficiency to be computed.

*Input-oriented and output-oriented efficiency*

First of all, we have to choose if the organization's objective is to reduce the input, given a fixed level of output, or maximize the output, given a fixed level of input. According to Farrell, we can distinguish between two types of efficiency: input-oriented or output-oriented.

In an input-oriented framework the efficiency score ranges from 0 to 1 and any score below 1 gives an idea of the inefficiency of the school under investigation. If, for example, a school scores 0.80, it means that it can save up to 20% of its input to obtain the same output. Graphically, it means that the input (x) multiplied by 0.80 is a point on the input isoquant corresponding to the fixed output level. The input-oriented efficiency (E) can be defined as the smallest number that we multiply the input (x) for and remain on or above the isoquant. We take the smallest number with the constraint for all of the inputs of reaching the isoquant: if input A needs to be reduced by 10% and input B by 20% in order to reach the isoquant, then a reduction of 20% would be enough for both of the inputs to reach the isoquant. Reductions of 10% and 20% correspond respectively to E(A)=0.90 and E(B)=0.80; we then consider E=min {E(A), E(B)}= E(B).

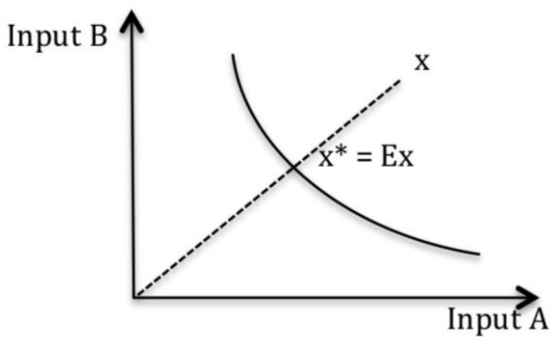


Figure 3 Input efficiency in a multiple-input model (Source: authors' elaborations)

An analogous discussion can be done for the output-oriented efficiency. In an output-oriented framework the efficiency score is greater or equal to 1 and any score above 1 gives an idea of the potential output that the school under investigation could produce with the fixed level of input. If, for example, a school scores 1.2, it means that it can expand its output of 20% without spending additional resources. Graphically, it means that the output (y) multiplied by 1.2 is a point on the output isoquant corresponding to the fixed input level. The output-oriented efficiency (F) can be defined as the largest number that we multiply the output (y) for and remain on or below the isoquant. We take the largest number with the constraint for all the outputs of reaching the isoquant: if output A needs to be expanded by 10% and output B by 20% in order to reach the isoquant, then an expansion of 20% would be enough for both of the outputs to reach the isoquant. Expansions of 10% and 20% correspond respectively to F(A)=1.10 and F(B)=1.20; we then consider F=max {F(A), F(B)}= F(B). For the same reason, in the optimization model of DEA, the objective function representing the output-oriented efficiency is maximized (similarly the objective function representing the input-oriented efficiency is minimized).

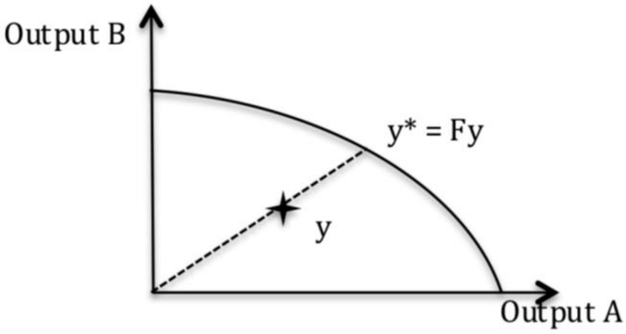


Figure 4 Output efficiency in a multiple-output model (Source: authors' elaborations)

While in a multiple-input or multiple-output model we talk about isoquants, in a single-input and single-output model we talk about efficient frontier, defined, in any case, as the set of points with efficiency equal to 1. The simplification of the problem to a single-input and single-output problem allows an easy representation of the frameworks described above.
In this example (figure 5), school P uses x input to produce y output. As we can observe, P is inefficient, since it is not on the efficient frontier. In an input-oriented framework P would become efficient by reducing its input to the level Ex. In an output-oriented framework the school would become efficient by increasing its output to the level Fy.

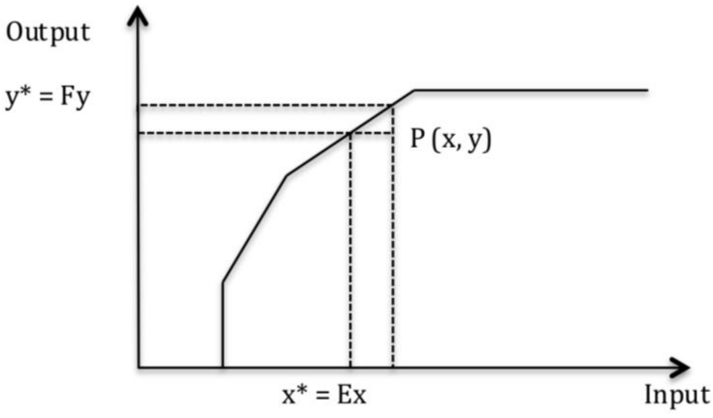


Figure 5 Input and output efficiency in a single-input and single-output model (Source: authors' elaborations)

In order to choose between the two approaches, it is important to consider the actions that the decision-makers might take to improve the efficiency score of a school. In the case of business schools, the decision-makers are deans and programme administrators. Especially in the short-term time horizon, the actions they can undertake in order to modify the inputs are limited: inputs such as administrative staff and core faculty members are pretty static in the short-term. Moreover, it is not always clear which inputs are controllable and which ones are not: partnerships with other schools or other types or agreements might limit their possibilities to modify inputs such as entry requirements and number of accepted students. For all these reasons, we assume an output-oriented efficiency model.

*Technology frontier*

The technology frontier (T) can be defined as the smallest set of values that contains all the data, the upper border of which is the efficient frontier.

We formulate three main assumptions on the technology frontier:

1. Free disposability of inputs and outputs, meaning that if a school produces y outputs with x inputs, then it can also produce, respectively, y outputs with more than x inputs and less than y outputs with x inputs. In other words, the decision-maker can freely dispose the surplus of input or output. Mathematically:

$$(x, y) \in T, x' \geq x, y' \leq y \Rightarrow (x', y') \in T$$

2. Convexity, meaning that any weighted combinations of two feasible production plans is also feasible. Mathematically:

$$(x^\circ, y^\circ) \in T, (x', y') \in T, 0 \leq \lambda \leq 1 \Rightarrow (1 - \lambda)(x^\circ, y^\circ) + \lambda (x', y') \in T$$

Graphically, considering a single-input and single-output model, the free disposability assumption enlarges the technology frontier to all the points below and the right of the observed points and the convexity assumption enlarges the technology frontier to all the plans on the lines between two observed points.

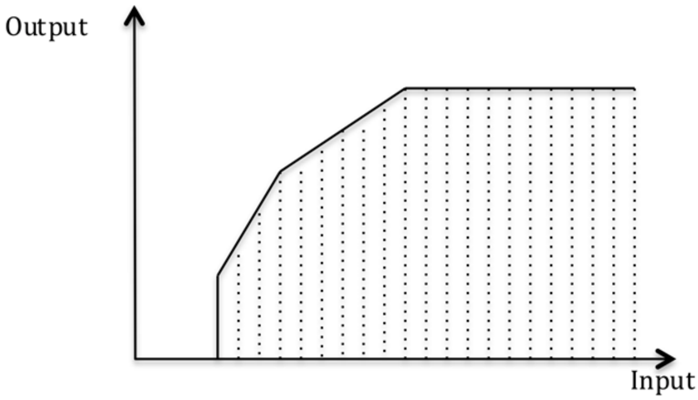


Figure 6 Technology frontier in a single-input and single-output model (Source: authors' elaborations)

3. Returns to scale. Returns to scale can be increasing or decreasing (or, more specifically, not-decreasing and not-increasing) if for each additional unit of input the output grows more than proportionally or less than proportionally to the input. When the proportion is linear and for each unit of input the output always increases of a certain factor, then we have constant returns to scale (CRS). According to most of the literature, we assume variable returns to scale (VRS), allowing the returns to scale to be increasing, decreasing or constant.

Graphically, variable returns to scale narrow the technology frontier and allow more schools to position on the efficient frontier, as the figure below shows.

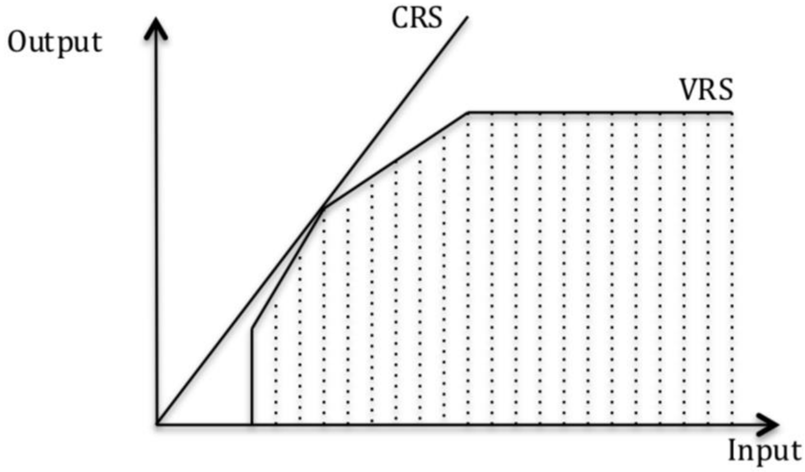


Figure 7 Technology frontier under CRS and VRS in a single-input and single-output model (Source: authors' elaborations)

### 5.2. SCALE EFFICIENCY

Many studies compute the output-oriented efficiency scores under both assumptions of CRS and VRS in order to analyse the scale efficiency of each school. In figure 8 it is easy to see that the returns to scale are first increasing (from point A to point B), then constant (in point B) and finally decreasing. In point B, where the returns to scale are constant, we have the most productive scale size, where the output is maximized at the minimal cost. Scale efficiency (SE) can be computed as the ratio between the efficiency computed under CRS and the efficiency computed under VRS. Mathematically:

$$\text{SE} = \frac{F_{CRS}}{F_{VRS}}$$

If $F_{CRS} = F_{VRS}$, then SE= 1 and the school considered is producing at the most productive scale size. Graphically, SE is a measure of the distance between the projection of a point on the CRS efficient frontier and the projection of a point on the VRS efficient frontier.

The scale efficiency does not tell us if any deviations from the most productive scale is due to the school's being too small or too large. This can be easily understood by comparing the efficiency obtained under decreasing returns to scale (DRS) with the efficiencies obtained under CRS and VRS (Bogetoft & Otto, 2010). In particular:

1. If $F_{CRS} = F_{DRS} \Longrightarrow$ the school is below optimal scale size
2. If $F_{VRS} = F_{DRS} \Longrightarrow$ the school is above optimal scale size

Graphically it means that if $F_{CRS} = F_{DRS}$, the point considered is at the left side of B, indeed it will need to expand its input in order to reach the optimal scale in B. If $F_{VRS} = F_{DRS}$, the point considered lays at the right side of B, indeed it will need to reduce its inputs to reach the optimal scale in B.

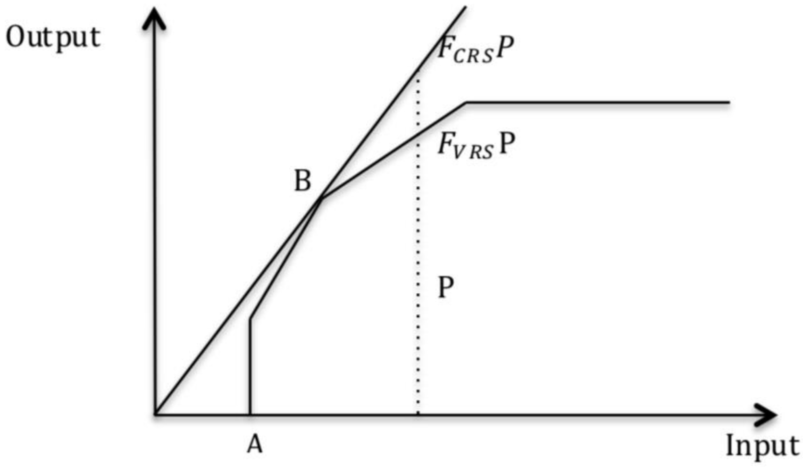


**Figure 8 Output scale efficiency in a single-input and single-output model (Source: authors' elaborations)**

This analysis will give to deans and programme administrators a useful information in order to take decisions and improve their overall efficiency. Note that scale efficiency might be greater than 1 even for those schools that have an efficiency score -computed with VRS- equal to 1.

### 5.3. DATA ENVELOPMENT ANALYSIS AT A GLANCE

DEA -Data Envelopment Analysis- is a non-statistical, non–parametric and deterministic technique (Johnes J. , 2006). Since it is non-statistical, efficiency scores do not follow a statistical distribution; since it is non-parametric, the efficiency frontier is computed from the data using linear programming rather than being derived from a mathematical function; and since it is deterministic deviations from the efficiency frontier are solely due to inefficiency rather than measurement errors, shocks and statistical errors.

The main characteristic of DEA is its ability to compute the efficient frontier as the smallest set of data with efficiencies equal to 1 that *envelop* all the other data.

Since the efficient frontier is the set of efficient observed points and their weighted sums (for the property of convexity), then DEA offers to deans and programme administrators a real benchmark to emulate. Schools on the efficient frontier represent a target in the decision-making process of school administrators.

DEA is also suitable to deal with multiple-inputs and multiple-outputs. Unlike Farrell's measure of efficiency that does not weight the different dimensions, DEA efficiency is computed as the ratio of the weighted sum of outputs on the weighted sum of inputs.

Weights are flexible and are computed for each school in a way that maximizes its efficiency score (F) through the application of linear programming. This allows differentiating among schools that pursue a different strategy. If, for example, school A invests most of its budget (input) in research (Output 1) and school B in education (Output 2), then school A would put a heavier weight on the research output and school B on education output. While weights are in general different for each school, when DEA maximizes the efficiency score for one particular school, the weights applied to its inputs and outputs are universally applied to all the other schools, so that its efficiency would be evaluated against those schools that undertake a similar strategy. In other words, let's assume that the above-described schools, A and B, have both efficiency scores equal to 1, so that they lay on the output isoquant. We consider and analyse a third school, C, which invests the mayor part of its budget in research and the rest in education. This school would give a greater weight to the research output and, assumed that school C is inefficient, its benchmark would be school A rather than school B. Graphically, it means that the projection of C onto the output isoquant would lay closer to A than to B.

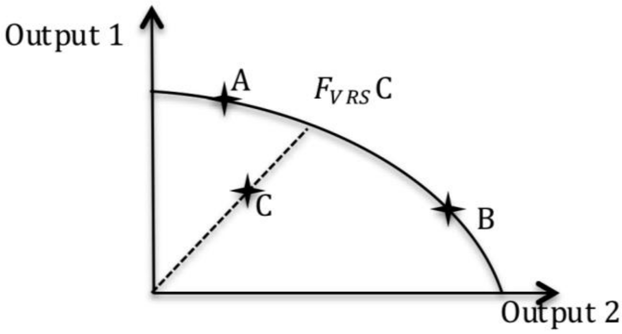


**Figure 9 Efficiency computed with DEA in a single-input and multiple-output model (Source: authors' elaborations)**

Mathematically, it means that the point $F_{VRS}$C is equal to the weighted combination of A and B, where the weight of A is greater than the weight of B:

$$F_{VRS}\text{C} = \lambda_A A + \lambda_B B,\ \lambda_A > \lambda_B$$

A and B are called peer units and they are efficient even when evaluated with the weights of an inefficient unit (C).

A last observation needs to be done about those schools that are positioned on the lines parallel to the main axis (see figure below).

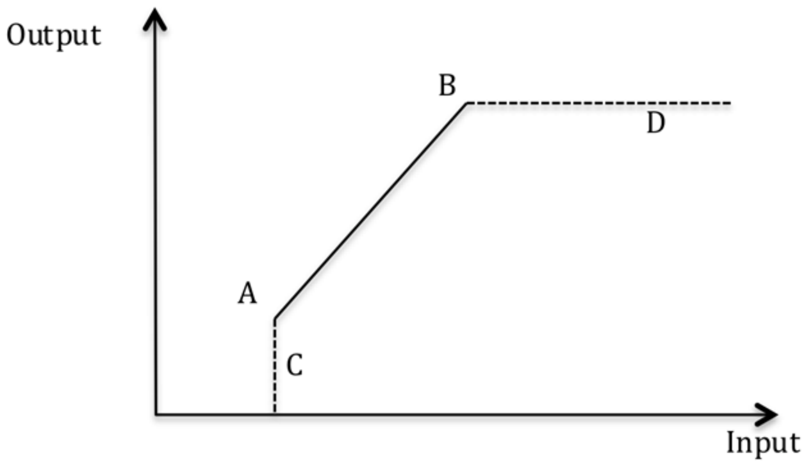


Figure 10 Input slack and output slack (Source: authors' elaborations)

Schools C and D have an efficiency score of 1, since they lay on the efficient frontier. Nonetheless, it is clear that C could increase its output until reaching A using the same input and that D could decrease its input until reaching B and still producing the same output. We therefore introduce some slack measures, respectively output slack ($s_r$) and input slack ($s_i$), in order to take into account the inefficiency of those types of units.

The output efficiency of a given school *K*, which uses *m* inputs to produce *s* outputs, relative to *n-1* other institutions is calculated as:

$$\max \quad F_K + \varepsilon \left( \sum_{r=1}^{s} s_r + \sum_{i=1}^{m} s_i \right)$$

$$s.t. \quad F_K y_{rK} - \sum_{j=1}^{n} \lambda_j y_{rj} + s_r = 0 \qquad r = 1, \dots, s$$

$$x_{iK} - \sum_{j=1}^{n} \lambda_j x_{ij} + s_i = 0 \qquad i = 1, \dots, m$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j, s_r, s_i \geq 0 \qquad \forall\, \mathrm{j} = 1, \dots, \mathrm{m} \quad \mathrm{r} = 1, \dots, \mathrm{s} \quad \mathrm{i} = 1, \dots, \mathrm{m}$$

where:

- $y_{rj}$ and $x_{ij}$ are respectively the amount of output *r* and the amount of input *i* used by school *j*,
- $\lambda_j$ the weight given to school *j,*
- $s_r$ and $s_i$ are respectively the output and inputs slacks,
- $\varepsilon$ is an infinitesimal small number in order to take into account eventual slacks without affecting the output efficiency.

DEA has been widely used in the studies of efficiency in the education industry because of its advantages, in particular:

1. It does not require any a priori assumptions regarding the weights of inputs and outputs, but it computes them through linear programming. This property makes DEA especially suitable for dealing with multiple inputs and outputs in the education industry, where it is difficult to assign prices (Martín, 2006).
2. It takes into account the different strategies and circumstances in which a school can operate, since weights are flexible (Johnes & Johnes, 2004).
3. Since the efficient frontier is computed from observed data, each school is benchmarked against existing schools, giving to deans and programme administrators an example of best practices in the real world.
4. It allows distinguishing between technical efficiency and scale efficiency.

On the other hand, the results of DEA should be interpreted carefully, since it has some drawbacks. The efficiency score of each school depends on the set of schools considered. Since the efficiency score computed through DEA is relative to the efficiency scores of the other units analysed, it might happen that some schools appear to be efficient only because they are the best of the set (Abbott & Doucouliagos, 2003). Similarly, some schools might appear efficient only because they compete in a niche market where no other schools in the set are present. These schools put a heavier weight on the output that represents their point of strength while no other schools do (Johnes & Johnes, 1993).

*Bootstrapping*

Lastly, we will use the bootstrapping procedure in order to overcome the inability of DEA to detect statistical inference by providing confidence intervals for the efficiencies (Simar & Wilson, 2000).

The efficiency scores computed through the simple DEA are *estimations* of efficiency, since all we can observe are inputs and outputs, while the efficient frontier is estimated based on a limited sample of observations and corresponds to a subset of practices that are not necessarily the best practices. That is the same to say that the *Data Generation Process*

(DGP) is unknown (Simar & Wilson, 2002). Indeed there can always be a new school entering into the sample and expanding the efficient frontier. For this reason, the estimated output-oriented efficiency scores computed through the simple DEA (F) are biased-downwards, meaning that their value is always weakly smaller than the true inefficiencies ($\phi$). In this sense, the DEA-based estimators are cautious, since they put schools in a positive light. However as we asymptotically increase the size of the sample to infinity, the bias is reduced to zero. With the number of observations going to infinity, the distribution of the estimated efficiency F can be considered a fair approximation of the distribution of the actual efficiency $\phi$.

Bootstrapping is a technique that allows resampling, thus increasing the number of observations. Different samples are created with replacements from one data set, thus creating new "random" data sets of the same size as the original one (Bogetoft & Otto, 2010). Based on the different samples, the statistical distribution of the actual efficiency $\phi$ can be estimated without making a priori assumptions regarding the form of the population and without deriving the sampling distribution explicitly (Fox, 2002). We repeat this process 2000 times, as suggested by the literature. This number is sufficiently large to avoid having a significant sampling error that can incur when failing to enumerate all bootstrap samples.

### 5.4. DATA

For our empirical analysis, we built an innovative dataset that integrates information from several sources. The main reference dataset is that provided by EQUIS. EQUIS –EFMD Quality Improvement System- is an accreditation system run by EFMD –European Foundation for Management Development- that is specialized in business schools as a whole. As December 2014, there are 152 EQUIS accredited business schools in 40 countries, 22 of which out of Europe (EFMD, 2014). We selected a subset of 53 schools EQUIS accredited schools in the Financial Times European Business School Ranking 2014. Since some data are not provided by the EQUIS dataset, some data have been taken from other sources, in particular:

- *Employment rate* and *starting salary* from the Financial Times rankings,
- *Programme fee*, *average GMAT score* and *percentage of women students* from the QS topMBA dataset,
- *Percentage of women students* for masters in management from the Financial Times Master in Management ranking, since QS topmba only provides information for MBA programmes.

Where EQUIS, Financial Times and QS data were not available, we have extracted data from Businessweek and, in the last few cases, from business schools' own brochures.

Nevertheless, we made sure that data from different sources are homogeneous. Indeed evaluating non-homogeneous units may invalidate the results of the DEA analysis (Tzeremes & Halkos, 2010).

Seven schools (school 2, 5, 40, 41, 45, 49 and 53) have been removed from the selected subset since complete data were not available for any levels. The final sample (schools for which complete data are available for at least one level of analysis) counts 46 schools.

All the data from sources other than the EQUIS dataset belongs to the year 2014, since rankings are considered for the last available year. The EQUIS dataset is instead fragmented in terms of time-period. The EQUIS accreditation is granted for either three or five years. In order to be considered for the accreditation, the candidate school has to submit a self-assessment document, from which we collected the data. For this reason the data available as December 2014 might range in a five-years time period (2009-2014). The analysed schools are distributed as follow: 1 school submitted the self-assessment document in 2009, 5 schools in 2010, 4 schools in 2011, 14 schools in 2012, 19 schools in 2013, 10 schools in 2014. Overall, we can interpret our results as dealing with an average for the period 2012/2014.

As shown in table 8, due to data availability constraints, out of the 53 analysed schools we have been able to compute the efficiency scores for 36 business schools, 25 MBA programmes, 28 EMBA programmes and 31 masters in management.

Moreover, the following technical notes need to be underlined:

- For two schools the number of administrative staff (headcounts) has been approximated to the number of FTE administrative staff, due to the availability of the data.
- Employed at three months for business schools has been computed as the sum of the employment rates of their MBA and master in management weighted on the number of students enrolled in the respective programmes.
- We have considered the maximum duration of the programme as a proxy for the actual programme’s duration.
- Where more data are available (e.g. tuition fee for different MBA specialization), their mode has been considered.
- Tuition fee for EMBA programmes excludes VAT and is considered for individuals, not companies.
- Católica Lisbon School of Business and Economics and Nova SBE offer The Lisbon MBA as a joint programme. Essec Business School and Mannheim Business School offer the Essec & Mannheim EMBA as a joint programme. The data from the most recent self-assessment document are considered.

## 6. RESULTS

Table 9 summarizes the main results, which are then graphically represented in the next subsections (while detailed data are provided in the technical appendices 1-8). For an easier interpretation, the output-oriented efficiency scores are expressed in terms of 1/F, where F is the value returned by DEA in an output-oriented framework. Since $F \geq 1$, then $0 \leq 1/F \leq 1$. In other words, the reported results express the efficiency in a scale that goes from 0 to 1, with 1 being the maximum efficiency. The units that score 1 lie on the efficient frontier, while the difference between 1 and the efficiency score (1/F) represents the percentage of inefficiency with which a school or a programme produces its outputs. The lower the efficiency score (1/F), the higher the percentage of inefficiency and, consequently, the higher is the potential for improvement of a school or a programme in comparison with the other schools competing in the market.

Since the data have been collected under the EFMD license, for privacy issues we are not allowed to disclose the names of the schools. Therefore, we have assigned to each school a univocal number, which we use to refer to particular schools. If a school is analysed for more levels of analysis, namely the MBA, the EMBA and the master in management, then the respective number indicates, respectively, the MBA, the EMBA and the master in management programme offered by the school.

Table 9 shows a summary of the estimated efficiencies for each level of analysis, obtained after the simple implementation of DEA. In particular the descriptive variables refer to:

- The number of units analysed;
- The number of efficient units, also as a percentage of the total number of units analysed;
- Some indicators of the distributions of the estimations of efficiency: the minimum (min), the 1$^{st}$ quintile (1$^{st}$ quint.), the median, the mean and the 3$^{rd}$ quintile (3$^{rd}$ quint.);
- The slacks on the inputs (x slacks), which characterises those units that lie on the efficient frontier without having an efficiency score of 1, due to the relative greater level of input utilised to produce a certain level of output;
- The slacks on the outputs (y slacks) , which characterises those units that lie on the efficient frontier without having an efficiency score of 1, due to the relative lower level of output produced with a certain level of input.

**Table 9 Summary of results**

| Unit of analysis | Business School | MBA | EMBA | Master in Management |
|---|---|---|---|---|
| Number of units analysed | 36 | 25 | 28 | 31 |
| Number of efficient units (%) | 12 (33%) | 11 (44%) | 7 (25%) | 9 (29%) |
| Min | 0.710 | 0.868 | 0.704 | 0.722 |
| 1st quint. | 0.880 | 0.951 | 0.786 | 0.878 |
| Median | 0.930 | 0.995 | 0.868 | 0.939 |
| Mean | 0.916 | 0.970 | 0.858 | 0.923 |
| 3rd quint. | 1 | 1 | 0.978 | 1 |
| x slacks | 24 | 10 | 8 | 15 |
| y slacks | 23 | 12 | 15 | 21 |

Even though the simple DEA estimators are not significant in statistical terms, they offer a better insight about the distributions of the efficiency scores in the different levels of analysis. On average the MBA is the best performing programme in terms of efficiency, with an average score of 0.97. On the other hand, the EMBA is the worst performing programme, with the lowest average efficiency and the greatest potential for improvement, equal to 0.14 on average. The EMBA programme is also the level of analysis for which the lowest number of schools (25%) assumes an efficiency score of 1. This might be due to the fact that we have considered only 4 input and output variables, while for the other levels of analysis 5 to 6 input and output variables enter into the efficiency model. Indeed, when a higher number of variables is considered, then the probability that a school will perform better than another in at least one of the dimensions is greater, thus obtaining a higher efficiency score.

The distributions are mostly similar for business schools and masters in management, with average efficiency around 0.93 and all the efficiency scores being included in [0.71; 1].

In general the efficiency scores are high, since the minimum value that the estimations of efficiency assume never reduces under the level of 0.71. This phenomenon may be due to the homogeneity of the subset of schools analysed. Indeed the sample of business schools considered represents the top ranked schools in the Financial Times, while a more balanced sample might have resulted in a wider range of efficiencies (Colbert, Levary, & Shaner, 2000).

In the following subsections we analyse the results for each level of analysis separately, commenting both the simple DEA efficiency scores and the bias-corrected scores obtained after the implementation of the bootstrapping procedure. For each level of analysis, the study of the distribution of the weights among the outputs will be conducted in order to underline those factors with a higher potential. Note that this analysis is useful even for the efficient units, which can improve their efficiency and enlarge the efficient frontier.

### 6.1. BUSINESS SCHOOL

At this point it is useful to recall the definition of efficiency given for business school: a business school is efficient when it maximizes its teaching and research outputs, represented the former by the employment rate and the number of enrolled students, the latter by the research income, given the number of administrative staff, the number of core faculty members and the total number of students offered a place.

From the simple implementation of DEA, 12 schools (out of 36) have an efficiency score of 1. The sample is distributed as shown in table 9, with median value 0.930 and mean efficiency 0.916. Most of the schools analysed present slacks, in particular 23 schools have slacks both on inputs and outputs and one school has slack only on the inputs.

The bias-corrected results and the simple DEA estimators are in accordance, since the 12 schools with an estimated efficiency score of 1 appear among the first 16 schools when results are ordered because of bias-corrected results (see appendix 2). The other four schools that appear among the first 16 (when results are ordered because of bias-corrected results) are school 17, 10, 1 and 4. Nevertheless, a closer look is needed on the lower and upper bounds before any conclusions can be made.

The 95% confidence intervals are shown in figure 11: on average the confidence intervals have a larger range for schools that score higher, besides schools 1 and 4, for which variance is lower than 0.0002. Looking at the confidence intervals, we can only state that some schools perform better than other with a certain degree of confidence (95%). For example, the last three schools, which are school 33, 46 and 19, are the most inefficient of the sample with a confidence of 95%, since their upper bound does not exceed the lower bounds of all the other schools. Similarly, the first two schools, which are school 30 and 17, perform better than the last fifteen schools with a probability of 95%. Therefore, the first two schools are not necessarily the top ones when we consider the confidence intervals, but we can only assert that they position among the top sixteen schools with a probability of 95%.

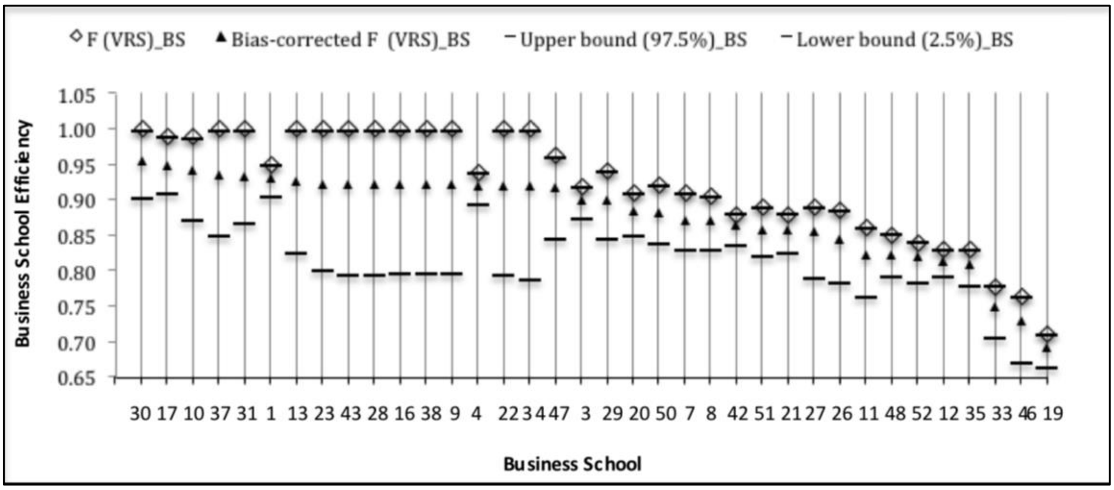


**Figure 11 Efficiency analysis results, Business School**

No schools have more than four peers, meaning that the efficiency of each school is evaluated against maximum four schools, which result to be efficient even when evaluated with the weights of the -inefficient- school considered. The most recurring peer is school 28, meaning that it can be thought as the most recurring target for inefficient schools. In appendix 1 the values λ1, λ2, λ3 and λ4, the sum of which is 1, are indicators of how close the strategy of the school considered is to the strategy of each of its peers.

Appendix 1 shows the strategies of the different schools in terms of the weights attributed to their outputs, where v1, v2 and v3 are respectively the weight on the number of students enrolled, on the research income and on the employment rate at three months. In general schools put a heavier weight on the employment rate, this can be easily seen by summing up the values of each weight for all the schools. This sum is 30.810 for v3, while only 0.002 and 0.790 for v1 and v2 respectively. School 16, 28 and 35 assign the maximum weight to the first output (v1=0.0002), school 13, 34, 37 and 51 assign the maximum weight to the second output (v2=0.104 and v2=0.109 respectively). Since no schools use these outputs to maximize the efficiency, then these schools result to be efficient.

The analysis of the distribution of the weights is a powerful tool to individualise those factors that have the greatest potential for improvement. Indeed each school should invest in those outputs with the highest associated weight, thus maximising its efficiency score at the minimum cost, since any additional unit of output produced is translated into a higher productivity by means of the associated weight. In the case of business schools considered as a whole, if the purpose of the school is increasing its efficiency, then most of the schools should reinforce their network with corporate recruiters or undertake similar actions in order to increase the employment rate of their graduates. Note that only four schools, which are school 13, 34, 37 and 51, follow a substantial different strategy in relation to the others. Indeed these schools put the heaviest weight on the research income. Following the reasoning of Vidaver-Cohen (2007), it can be said that business schools produce two “product-outputs”, namely research output and students, and one “service-output”, namely educational programmes. While the academic audience is mostly concerned with research output, students are concerned with educational programmes and corporate recruiters with the selection of the best students, intended as a “product-output” of schools. In this perspective, we can state that only these four schools answer to the need of the academic audience, focusing their activities in research, thus competing in a niche market and obtaining higher efficiency scores.

### 6.2. MBA –MASTER IN BUSINESS ADMINISTRATION

An MBA programme is efficient when it maximizes the success on the labour market of its graduates and the priority that accepted students give to it (ratio of enrolled on accepted students), given the degree of selectivity in entrance (GMAT score) and its tuition fee.

From the simple implementation of DEA, 11 schools (out of 25) have an efficiency score of 1. The sample is distributed as shown in table 9, with median value 0.995 and mean efficiency 0.970. Nine schools have slacks on both inputs and outputs, one school has slack only on the inputs and three only on the outputs.

The bias-corrected results and the simple DEA estimators are in accordance, since the 11 schools with an estimated efficiency score of 1 appear among the first 14 schools when results are ordered because of bias-corrected results (see appendix 4). The other three schools that appear among the first 14 (when results are ordered because of bias-corrected results) are school 7, 21 and 4.

The 95% confidence intervals are shown in figure 12: the highest variances are in the schools in the middle of the graph, meaning schools 1, 14, 22, 34 and 46. The first nine schools have an higher efficiency than the last six schools, since the upper bounds of the last ones does not pass the lower bound of the first ones.

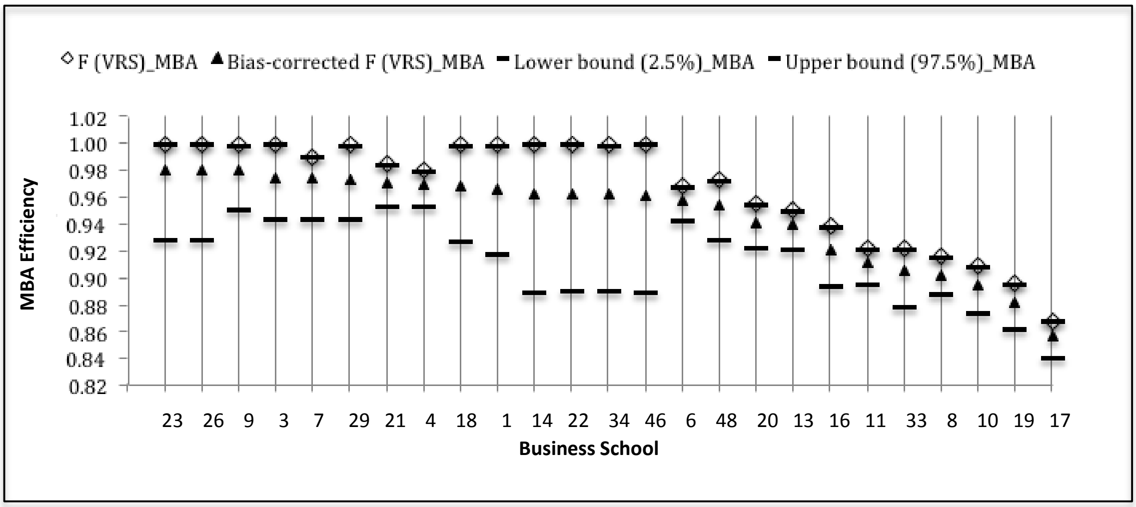


**Figure 12 Efficiency analysis results, MBA**

One school has five peers and the rest does not have more than four peers. The most recurring peer is school 14 with twelve occurrences, school 18 occurs eleven times, school 23 occurs ten times and school 3 nine times. As one can observe, differently than in the case of business schools, in the case of MBAs there is not only one school that appears as the most recurring peer with a substantial higher number of occurrences as compared to the others. Instead we can think about schools 14, 18, 23 and 3 as the four players in the marketplace that own a competitive advantage as they are examples of best practises for the other schools.

Appendix 3 shows the strategies of the different schools in terms of the weights attributed to their outputs, where v1, v2 and v3 are respectively the weight on the average starting salary of graduates, on the employment rate at three months and on the ratio of enrolled on accepted students. In general schools put a heavier weight firstly on the employment rate and secondly on the ratio of offered on accepted students. The sum of the values of each weight for all the schools is 14.667 for v2 and 6.111 for v3, while only 0.072 for v1, with school 10 and 46 having the maximum weight on the starting salary, but only school 46 positioning on the efficient frontier.

The same observations made at the business school level hold true. Indeed, as in the case of business schools, most of the units – this time intended as MBA programmes - put the heaviest weight on employment rate. The set of actions and initiatives to improve the employment rate substantially differs at the business school level and at the single programme level. Hence we consider again the influence diagrams drawn in chapter 4 in order to understand the production processes of business schools. While at the business school level employment rate results from the teaching quality and from the school reputation, instead, at the single programme level, employment rate merely results from the skills of the students. Possible actions aimed at maximising the employment rate at a programme level - given a certain level of input- are therefore all related to the value added in terms of acquired skills of the students (since previous to the programme skills are related to the inputs and are fixed).

### 6.3. EMBA –EXECUTIVE MASTER IN BUSINESS ADMINISTRATION

An EMBA programme is efficient when it maximizes the success on the labour market of its graduates and the priority that accepted students give to it (ratio of enrolled on accepted students), given the degree of selectivity in entrance (work experience) and its tuition fee.

From the simple implementation of DEA, 7 schools (out of 28) have an efficiency score of 1. The sample is distributed as shown in table 9, with median value 0.868 and mean efficiency 0.858. Five schools have slacks on both inputs and outputs, three schools have slacks only on the inputs and ten only on the outputs.

The bias-corrected results and the simple DEA estimators are in accordance, since the 7 schools with an estimated efficiency score of 1 appear among the first 9 schools when results are ordered because of bias-corrected results (see appendix 6). The other two schools that appear among the first 9 (when results are ordered because of bias-corrected results) are school 24 and 5.

The 95% confidence intervals are shown in figure 13: schools 9, 27, 2, 25, 7 and 14 have the highest variance. The first three schools have an higher efficiency than the last eighteen schools, since the upper bounds of the last ones does not pass the lower bound of the first ones. Similarly the first twelve schools score better than the last seven schools with a probability of 95%.

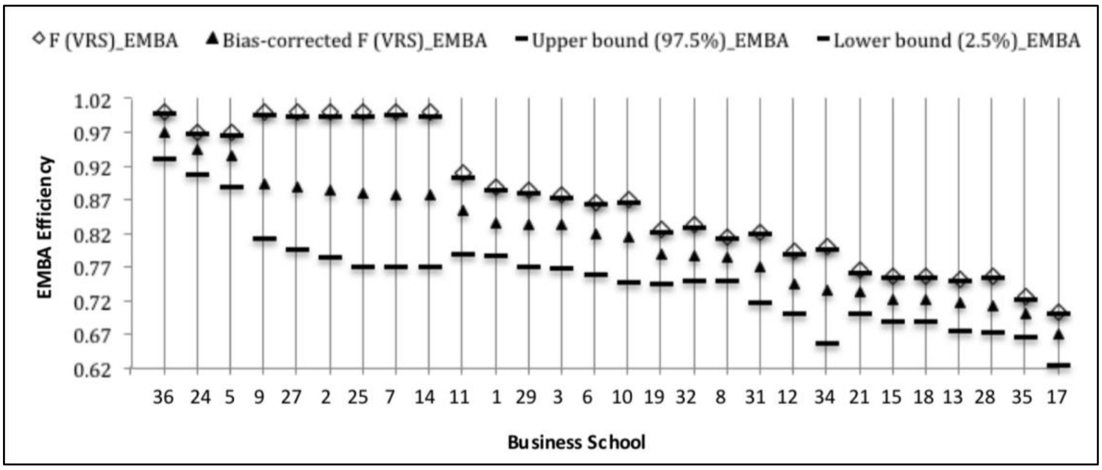


Figure 13 Efficiency analysis results, EMBA

No schools have more than four peers. The most recurring peer is school 9 with twenty-one occurrences, school 37 occurs fifteen times and school 25 occurs fourteen times.

Appendix 5 shows the strategies of the different schools in terms of the weights attributed to their outputs, where v1 and v2 are respectively the weight on the average starting salary of graduates and on the ratio of enrolled students on those who have been offered a place. In general schools put a heavier weight on the ratio of offered on accepted students. The sum of the values of each weight for all the schools is 20.428 for v2, while only 0.067 for v1. School 19, 22 and 24 put the maximum weight on the starting salary, but only school 24 position on the efficient frontier. Hence it needs to be noticed that the lowest number of efficient units, intended as the percentage of efficient units on the total number of units analysed, could be due to a well-known property if DEA, that is the inverse proportion between the probability of a unit of being efficient and the number of inputs and outputs analysed. Indeed for the EMBA we have considered only four input and output variables, so that schools compete in a theoretical market characterised by a lower number of possible differentiation strategies. This means that schools either focus on improving the starting salary of their graduates, or they maximise the ratio of enrolled on accepted students, no other strategies are possible. As explained previously, the variable “enrolled on accepted students” represents the priority given by students to the specific programme they apply for. Therefore schools compete in retaining those students who have applied for their EMBA programme. The reasons for renouncing to the offer made by the school could be many and different, such as the reception of a new job offer. Nevertheless, in general candidates renounce to an offer because they have been accepted into a programme that better suits their needs. This phenomenon eventually increases the degree of competition among schools offering EMBA programmes. Schools should understand the most recurring reasons of renounce in relation to the candidates’ needs and undertake actions that go in the direction of minimising the gap left by withdrawn students. It could be the case, for example, that a school should better understand the motivations of its applicants or change its EMBA curriculum.

## 6.4. MASTER IN MANAGEMENT

A master in management is efficient when it maximizes the success on the labour market of its graduates and the priority that accepted students give to it (ratio of enrolled on accepted students), given its duration and tuition fee.

From the simple implementation of DEA, 9 schools (out of 31) have an efficiency score of 1, the rest is distributed as shown in table 9, with median value 0.939 and mean efficiency 0.923. Fourteen schools have slacks on both inputs and outputs, one school has slack only on the inputs and seven only on the outputs.

The bias-corrected results and the simple DEA estimators are in accordance, since the 9 schools with an estimated efficiency score of 1 appear among the first 14 schools when results are ordered because of bias-corrected results (see appendix 8). The other five schools that appear among the first 14 (when results are ordered because of bias-corrected results) are school 17, 1, 14, 23 and 15.

The 95% confidence intervals are shown in figure 14: schools 18, 16, 35, 3 and 44 have the highest variance, so that the high estimated efficiency has to be interpreted with caution. School 20, 17 and 14 have low variance and high efficiency scores, meaning that with a probability of 95% their efficiency is higher than the last seventeen schools. On the opposite side, the two least efficient schools, which are school 33 and 24, are the worst performing schools also in statistical terms, since their upper bounds is lower than the lower bounds of the rest.

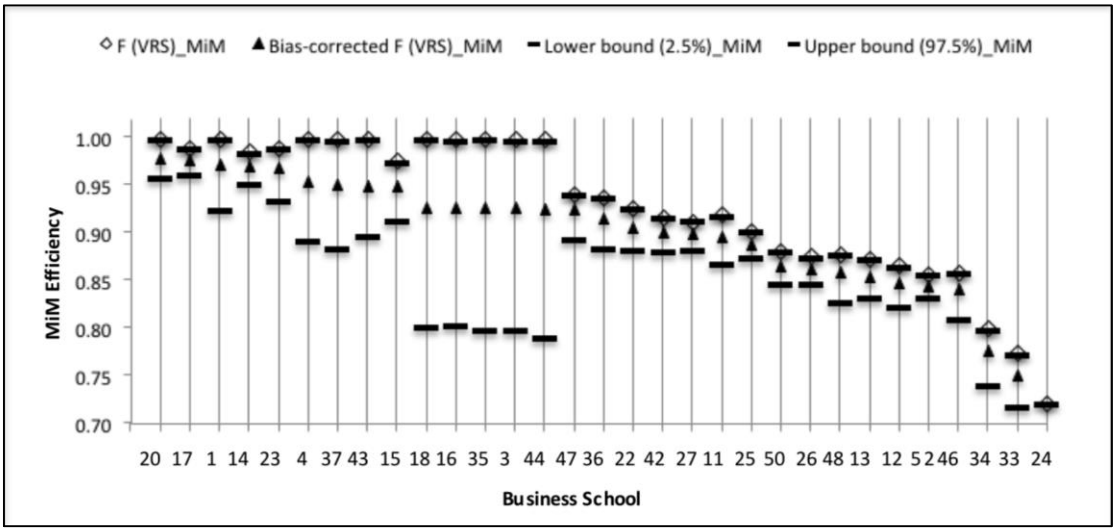


**Figure 14 Efficiency analysis results, Master in Management**

No schools have more than four peers. The most recurring peer is school 37 with eighteen occurrences.

Appendix 7 shows the strategies of the different schools in terms of the weights attributed to their outputs, where v1, v2 and v3 are respectively the weight on the average starting salary of graduates, on the employment rate at three months and on the ratio of enrolled students on those who have been offered a place. In general schools put a heavier weight on the employment rate. The sum of the values of each weight for all the schools is 27.831 for v2, while only 0.069 for v1 and 0.749 for v3, with school 3 and 18 having the heaviest weight on output 1 and school 43, 44 and 35 on output 3, thus positioning on the efficient frontier. The actions that master in management administrators should undertake in order to improve the employment rate of their graduates are similar to those commented for the MBA programme.

## 6.5. SCALE EFFICIENCY

The issue on the returns to scale is critical to school administrators, since, based on this information, they might decide to take actions in order to rescale the activities of their business schools or programmes, thus improving their overall efficiency (O). Indeed the DEA efficiency estimators can be decompose into two factors: technical efficiency (TE) and scale efficiency (SE). A scale efficient unit (business school, MBA, EMBA or master in management) operates at a point in which the average output produced per unit of input is maximal, and if the school employs any additional unit of input, the output produced would grow less than proportionally to the input. Technical efficiency is instead the ability to use best practices in the VRS technology (Bogetoft & Otto, 2010), that is the same of the efficiency score $F^{VRS}$ that we have used for analysing the efficiency of schools so far. As explained in the methodology, in the case that the efficiency computed with Constant Returns to Scale (CRS) ($F^{CRS}$) coincides with the efficiency computed with Variable Returns to Scale (VRS) ($F^{VRS}$), the scale efficiency is equal to 1, thus not affecting the overall efficiency.

$$O = SE * TE, \text{where } SE = \frac{F^{CRS}}{F^{VRS}}$$

In this session we use the simple DEA efficiency estimators computed under the CRS assumption and the VRS assumption to assess the scale efficiency of each unit. Nevertheless this test lacks of statistical significance, since it is based on a limited sample of schools that define the technology frontier (that is the same to say that the Data Generation Process is unknown). For this reason we integrate the scale efficiency assessment for each unit with the test suggested by Simar & Wilson (2002) in order to draw statistical conclusions on the returns to scale assumption. Simar and Wilson develop a bootstrapped procedure in order to test two hypothesis:

1. $\mathrm{H}_0$: the technology frontier is CRS vs. $\mathrm{H}_1$: the technology frontier is VRS
2. $\mathrm{H}_0'$: the technology frontier is DRS vs. $\mathrm{H}_1'$: the technology frontier is VRS

Obviously, the second hypothesis is tested only in the case that the first null hypothesis ($\mathrm{H}_0$) is rejected. The null hypothesis is rejected for a small value of the *p-value*[2] (<0.05).

---

[2] We consider the p-value for the test statistic 4.6 in Simar & Wilson (2002): $S_{2n}^{CRS} = n^{-1} \sum_{i=1}^{n}(F_i^{CRS} / F_i^{VRS})$.

Table 10 Simar & Wilson's test on the return to scale assumption of the efficiency model

| ***Unit of Analysis*** | ***$H_0$ rejected*** | ***p-value (1)*** | ***$H'_0$ rejected*** | ***p-value (2)*** |
|---|---|---|---|---|
| Business School | TRUE | 0.0005 | FALSE | 0.7400 |
| MBA | TRUE | 0.0270 | TRUE | 0.0120 |
| EMBA | TRUE | 0.0155 | FALSE | 0.7485 |
| MiM | TRUE | 0.0005 | FALSE | 0.1245 |

When both $\mathrm{H}_0$ and $\mathrm{H}'_0$ are rejected, we can accept $\mathrm{H}_1$ with a certain degree of confidence (represented by the p-value), as in the case of MBA. Alternatively, when we can reject $\mathrm{H}_0$ but not $\mathrm{H}'_0$, we can assume $\mathrm{H}'_0$. That is the case for business school, EMBA and master in management.

In summary, the implementation of the Simar & Wilson's test shows that the technology frontier is one of DRS for business school, EMBA and master in management and VRS for MBA. Consequently, we expect that for business school, EMBA and master in management, the scale efficient units are those with a smaller scale size in a given direction if the input and output space.

Table 11 shows the scale efficiency (SE) computed as ratio of $F^{CRS}$ on $F^{VRS}$, where F≤1, according to the notation used so far, and consequently SE ≤ 1 (differently than what explained in the methodology, since $F^{CRS} \leq F^{VRS}$). The highlighted cells underline those schools that are efficient when evaluated under the assumption of VRS, but result to be inefficient when evaluated under CRS, meaning that the only source of inefficiency is their scale size.

Table 11 Scale Efficiency

| School | SE_BS | Scale_BS | SE_MBA | Scale_MBA | SE_EMBA | Scale_EMBA | SE_MiM | Scale_MiM |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.5663 | Above | 1 | Efficient | 0.9181 | Above | 0.8734 | Above |
| 3 | 0.7024 | Above | 1 | Efficient | 0.8912 | Above | 1 | Efficient |
| 4 | 0.5071 | Above | 0.9968 | Below | | | 0.9458 | Above |
| 6 | | | 0.9947 | Below | | | | |
| 7 | 0.5689 | Above | 0.9966 | Below | 1 | Efficient | | |
| 8 | 0.9769 | Above | 0.9968 | Above | 0.8071 | Above | | |
| 9 | 1 | Efficient | 1 | Efficient | 1 | Efficient | | |
| 10 | 0.8497 | Above | 0.9857 | Above | 0.8581 | Above | | |
| 11 | 0.6216 | Above | 0.9904 | Below | 0.9424 | Above | 0.7396 | Above |
| 12 | 0.6793 | Above | | | 0.9833 | Above | 0.4302 | Above |
| 13 | 1 | Efficient | 0.9898 | Below | 0.9683 | Below | 0.8501 | Above |
| 14 | | | 1 | Efficient | 1 | Efficient | 0.8476 | Above |
| 15 | | | | | 0.9844 | Above | 0.3027 | Above |
| 16 | 1 | Efficient | 0.8844 | Below | | | 1 | Efficient |
| 17 | 0.7985 | Above | 0.9902 | Below | 0.8816 | Above | 0.3778 | Above |
| 18 | | | 1 | Efficient | 0.9844 | Above | 1 | Efficient |
| 19 | 0.7377 | Above | 0.9858 | Below | 0.9863 | Below | | |
| 20 | 0.5281 | Above | 0.9961 | Above | | | 0.8565 | Above |
| 21 | 0.5956 | Above | 0.9977 | Above | 0.9678 | Above | | |
| 22 | 1 | Efficient | 1 | Efficient | | | 0.8509 | Above |
| 23 | 1 | Efficient | 1 | Efficient | | | 0.7719 | Above |
| 24 | | | | | 0.8004 | Above | 0.5959 | Above |
| 25 | | | | | 1 | Efficient | 0.5680 | Above |
| 26 | 0.9836 | Above | 1 | Efficient | | | 0.7443 | Above |
| 27 | 0.7099 | Above | | | 1 | Efficient | | |
| 28 | 1 | Efficient | | | 0.9308 | Above | | |
| 29 | 0.9779 | Above | 1 | Efficient | 0.9948 | Below | | |
| 30 | 0.9134 | Above | | | | | | |
| 31 | 0.9353 | Above | | | 0.9991 | Below | | |
| 32 | | | | | 0.9948 | Below | | |
| 33 | 0.4282 | Above | 0.9811 | Below | | | 0.8465 | Above |
| 34 | 1 | Efficient | 0.8467 | Below | 0.9972 | Above | 0.8346 | Above |
| 35 | 0.2490 | Above | | | 1 | Efficient | 0.9511 | Above |
| 36 | | | | | 0.9025 | Above | 1 | Efficient |
| 37 | 1 | Efficient | | | 0.8745 | Above | 0.8461 | Above |
| 38 | 0.9856 | Above | | | 0.5955 | Above | | |
| 39 | | | | | 0.7909 | Above | | |
| 42 | 0.9590 | Above | | | | | 0.8468 | Above |
| 43 | 0.6748 | Above | | | | | 0.8468 | Above |
| 44 | | | | | | | 0.6312 | Above |
| 46 | 0.7650 | Above | 1 | Efficient | | | 0.4348 | Above |
| 47 | 0.9717 | Above | | | | | 0.8488 | Above |
| 48 | 0.7114 | Above | 0.9928 | Below | | | 0.6767 | Above |
| 50 | 0.6764 | Above | | | | | 0.7602 | Above |
| 51 | 1 | Efficient | | | | | | |
| 52 | 0.5196 | Above | | | | | 1 | Efficient |

In the case of business schools and masters in management, all the units are either scale efficient or above the optimal scale. This is in accordance with the result of the Simar & Wilson's test that shows decreasing returns to scale. Indeed the DRS and the CRS technologies coincide for those units with a smaller scale size in a given direction of the input and output space. Graphically, it can be easily understood by looking at a single-input and single-output space, where the two technologies coincide in the segment OB.

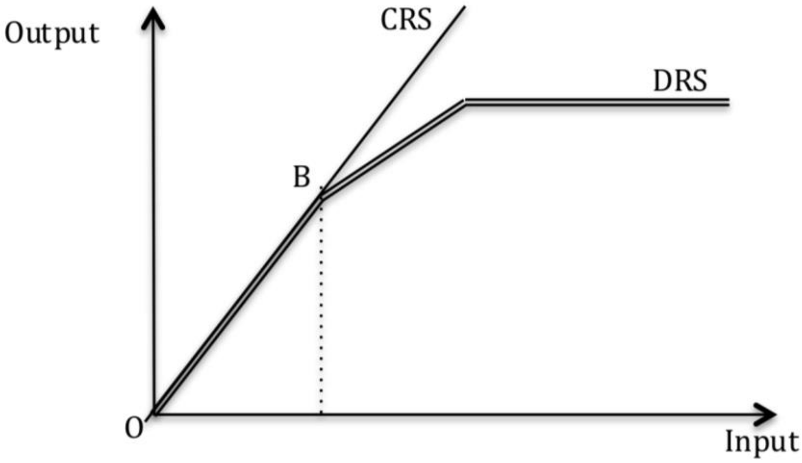

Figure 15 CRS vs. DRS in a single-input and single-output model (Source: authors' elaborations)

In particular, the efficient school 30, 31 and 35 should decrease the scale of their activities by reshaping the level of their inputs, which are human resources (administrative staff and faculty members) and students offered a place. This actions would eventually lead to a decrease in the output level as well, but the school will operate at the most productive point. Similarly, the administrators of the masters in management offered by school 4, 35 and 48 may wish to reshape the scale of their activities by decreasing the duration and/or the tuition fee of their programmes.

In the case of MBA, most of the schools are below the optimal scale and only four schools are above. This is in accordance with the result of the Simar & Wilson's test that shows variable returns to scale. Indeed in a single-input and single-output model the VRS and the CRS technologies coincide for those units lying on a segment such as AB in the figure below.

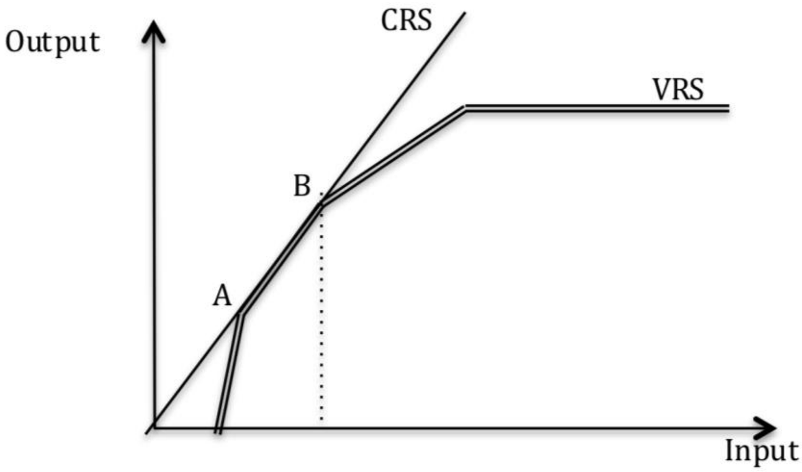

Figure 16 CRS vs. VRS in a single-input and single-output model (Source: authors' elaborations)

Only one efficient school, namely school 34, is not scale efficient. The management of the MBA offered by school 34 may want to increase the level of resources utilised. The possibilities for an MBA administrator to increase the level of the inputs are twofold, corresponding to the two inputs considered in the efficiency model. These are average GMAT score of the students who form the class and the tuition fee of the MBA programme.
The case of EMBA cannot be treated in the same way as the case of business school or master in management, even if the Simar and Wilson's test shows the same hypothesis for the three models (DRS). Indeed five schools are below the optimal scale. This incongruence might be due to the fact that the DEA efficiency estimators are bad approximations of the real efficiencies and therefore the scale efficiency scores, computed as a ratio between the DEA efficiency estimators, are not reliable.

### 6.6. EFFICIENCY OF BUSINESS SCHOOLS AND THEIR PROGRAMMES

After having analysed the results for business schools, MBAs, EMBAs and masters in management separately, we compare them in a cross-functional view. Table 12 shows the bias-corrected efficiencies for business schools, their MBA, EMBA and master in management in a single glance. Gaps are left either because of the lack of data or of the fact that the school does not offer all the three programmes.

Table 12 The efficiency of business schools and their programmes

| School | Bias-corrected F (VRS)_BS | Bias-corrected F (VRS)_MBA | Bias-corrected F (VRS)_EMBA | Bias-corrected F (VRS)_MiM |
|---|---|---|---|---|
| **1** | 0.931 | 0.966 | 0.837 | 0.972 |
| **3** | 0.899 | 0.974 | 0.833 | 0.926 |
| **4** | 0.920 | 0.970 | | 0.954 |
| **6** | | 0.957 | | |
| **7** | 0.871 | 0.974 | 0.879 | |
| **8** | 0.870 | 0.903 | 0.785 | |
| **9** | 0.920 | 0.980 | 0.895 | |
| **10** | 0.942 | 0.896 | 0.815 | |
| **11** | 0.822 | 0.912 | 0.855 | 0.896 |
| **12** | 0.813 | | 0.744 | 0.848 |
| **13** | 0.925 | 0.940 | 0.718 | 0.855 |
| **14** | | 0.963 | 0.879 | 0.971 |
| **15** | | | 0.722 | 0.950 |
| **16** | 0.921 | 0.922 | | 0.927 |
| **17** | 0.949 | 0.857 | 0.670 | 0.977 |
| **18** | | 0.969 | 0.722 | 0.927 |
| **19** | 0.691 | 0.882 | 0.788 | |
| **20** | 0.883 | 0.941 | | 0.978 |
| **21** | 0.856 | 0.971 | 0.734 | |
| **22** | 0.920 | 0.962 | | 0.907 |
| **23** | 0.922 | 0.981 | | 0.968 |
| **24** | | | 0.945 | 0.697 |
| **25** | | | 0.881 | 0.888 |
| **26** | 0.844 | 0.981 | | 0.863 |
| **27** | 0.855 | | 0.889 | 0.900 |
| **28** | 0.921 | | 0.712 | |
| **29** | 0.899 | 0.974 | 0.834 | |
| **30** | 0.954 | | | |
| **31** | 0.933 | | 0.772 | |
| **32** | | | 0.788 | |
| **33** | 0.748 | 0.906 | | 0.751 |
| **34** | 0.918 | 0.962 | 0.736 | 0.776 |
| **35** | 0.808 | | 0.701 | 0.927 |
| **36** | | | 0.971 | 0.916 |
| **37** | 0.934 | | 0.885 | 0.951 |
| **38** | 0.921 | | 0.935 | |
| **39** | | | 0.820 | |
| **42** | 0.864 | | | 0.901 |
| **43** | 0.921 | | | 0.950 |
| **44** | | | | 0.925 |
| **46** | 0.729 | 0.962 | | 0.841 |
| **47** | 0.918 | | | 0.925 |
| **48** | 0.822 | 0.955 | | 0.859 |
| **50** | 0.880 | | | 0.866 |
| **51** | 0.857 | | | |
| **52** | 0.819 | | | 0.845 |

We are interested in seeing on whether or not there is a correlation between the efficiency of a business school and its programmes –MBA, EMBA, master in management- and to individualize, for each school, the most efficient programme. Obviously, when the efficiency score is missing for either the business school or its programme, there is not a comparison.
Observing figure 17 it is clear that the efficiency of a business school is not always related to the efficiency of its programmes. In the graphs of figure 17 we divide the schools in four quadrants delimited by the axis that cross at point (0.878; 0.878), where 0.878 is the average efficiency of business schools.
In general, EMBAs are less efficient than schools as a whole, since most of the schools (45%) lay in the left upper quadrant, meaning that most of the schools with high efficiency score low when evaluated in terms of efficiency of their EMBA programme. The contrary is true when we compare business schools and their MBA programme: most of the schools lay in the right upper and right lower quadrant, meaning that on average the relative efficiency of their MBA programme is approximately equal (right upper quadrant) or greater (right lower quadrant) than the relative efficiency of the school as a whole. More precisely, the MBA programme has the highest efficiency –higher than the efficiency of its business school- for seventeen schools; six of this group do not offer a master in management.
Efficiencies seem to be mostly similar when we compare business schools and their masters in management (see the higher densities in the right upper and left lower quadrants).
Overall, the master in management programme has the highest efficiency for eight schools; four of this group do not offer a MBA. This suggests that business schools can consider, on average, their MBA or alternatively their master in management programme as an internal example of best practices that can be implemented in the management of the other programmes, especially the EMBA.

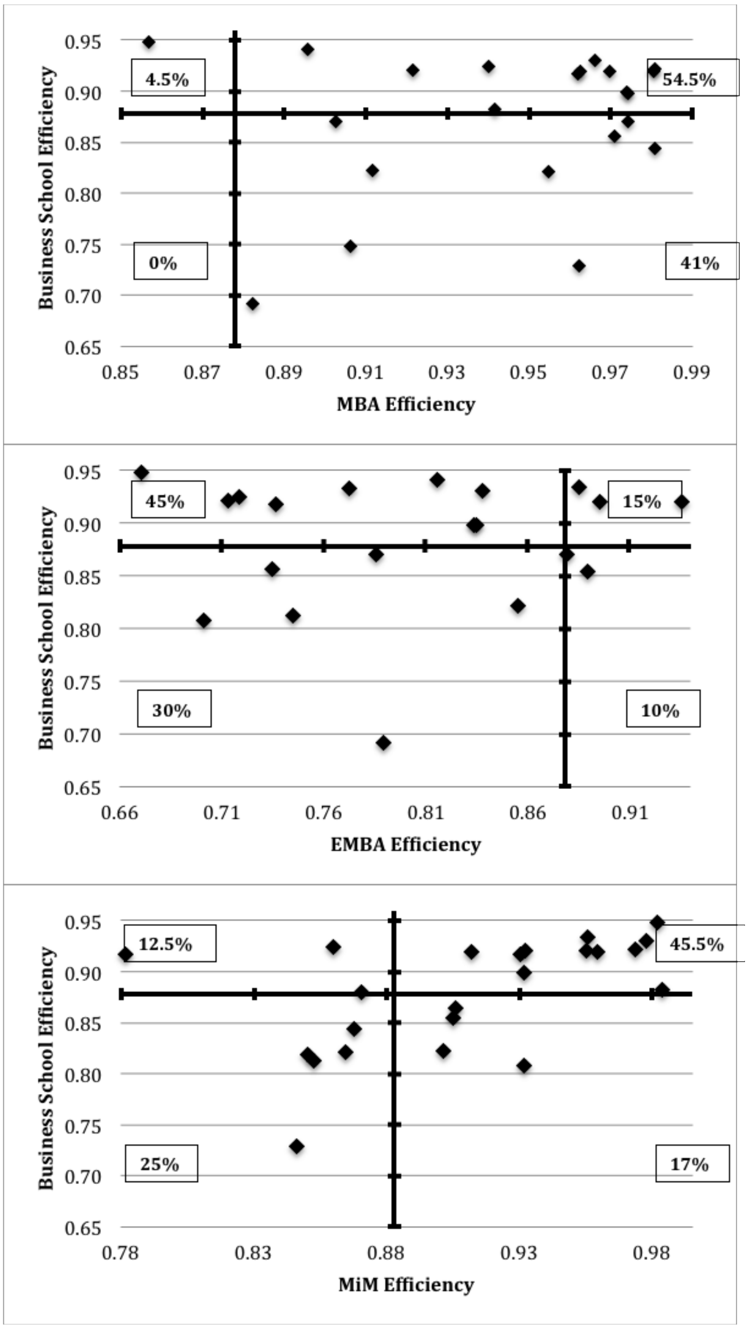


Figure 17 The efficiency of business schools and of their programmes

## 6.7. EFFICIENCY AND RANKINGS: IS THERE A CORRELATION?

In order to compare the results obtained through the efficiency analysis and the ranking positions of each school, we group schools into four tiers according to the order they appear in the Financial Times rankings (Ray & Jeon, 2008). Schools that do not appear in the rankings are not considered and when the number of schools is odd, we keep the first group(s) smaller. We will then compute the aggregate efficiency results for each tier in each of the levels considered. According to the level of analysis, we compare results with the FT

European Business school ranking, the FT Global MBA ranking, the FT Executive MBA ranking and the FT Masters in Management.

Aggregate results are shown in table 13 and figure 18-19. Table 13 reports, for each level of analysis, the correlation coefficients between efficiency scores and ranking indexes, and for each tier the mean efficiency and its standard deviation.

**Table 13 Comparison of efficiency and rankings**

| | Correlation coeff. | 1ST TIER | | 2ND TIER | | 3RD TIER | | 4TH TIER | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | $\sigma$ | Mean | $\sigma$ | Mean | $\sigma$ | Mean | $\sigma$ |
| Business school | -0.208 | 0.887 | 0.0442 | 0.879 | 0.0740 | 0.886 | 0.0647 | 0.859 | 0.0592 |
| MBA | -0.053 | 0.974 | 0.0046 | 0.974 | 0.0275 | 0.956 | 0.0380 | 0.952 | 0.0154 |
| EMBA | +0.041 | 0.834 | 0.0485 | 0.814 | 0.0614 | 0.801 | 0.0749 | 0.828 | 0.0828 |
| Master in mng (MiM) | -0.293 | 0.928 | 0.0398 | 0.904 | 0.0474 | 0.898 | 0.0843 | 0.865 | 0.0662 |

The mean efficiency does not always decrease as the tier increases (see figure below), meaning that there might not always be correlation between efficiency and ranking index. This is in accordance with the correlation coefficients close to zero, which are negative when we compare business schools, MBAs and masters in management with their respective rankings.

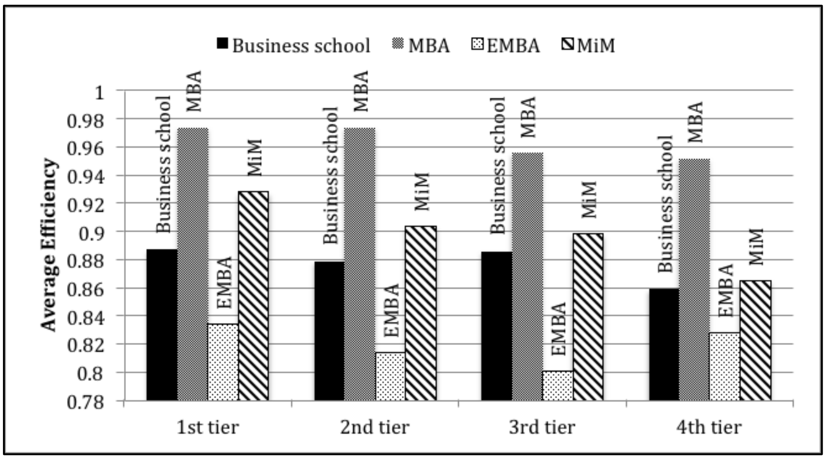


**Figure 18 Comparison of efficiency and rankings**

For business schools the average efficiency of the third tier is higher than the average efficiency of the second tier. The first tier includes two schools with the highest efficiencies, while the fourth tier also includes one of the schools with the highest efficiency.

For MBA programmes the average efficiencies of the first two tiers coincide, with the first tier having a much smaller standard deviation. All the schools with the highest efficiencies appear in the first two tiers.

For EMBAs the average efficiency of the fourth tier of EMBAs is higher than the ones of the second and third tier. In general the highest and lowest efficiencies are evenly distributed among the four tiers.

For masters in management, the average efficiencies decrease as the number of tier increases, but the higher dispersion of data indicates that there might be schools distant from the average efficiency of their tiers. Nevertheless, most of the schools with the highest efficiency scores are in the first two tiers, while no school with the lowest efficiency scores appear in the first tier.

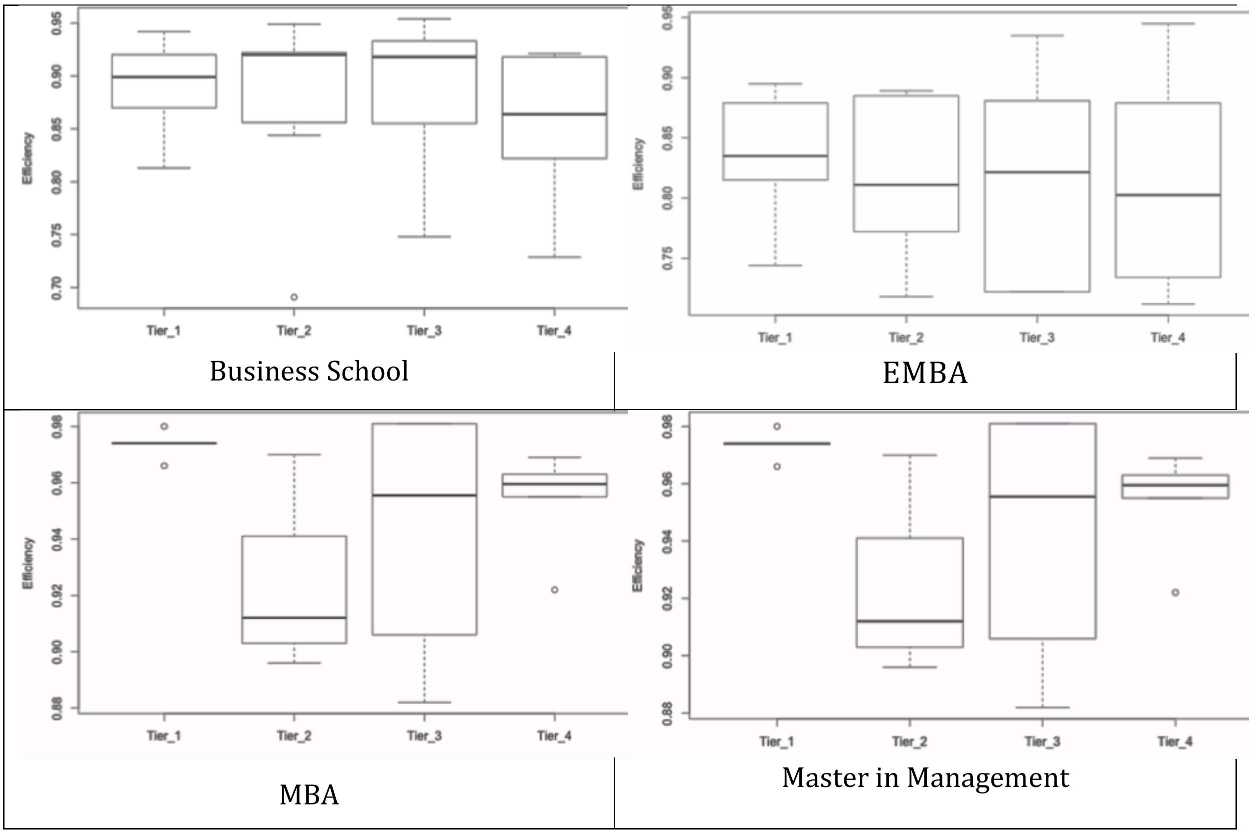


**Figure 19 Comparison of efficiency and rankings (box-plot)**

In conclusion, we observe no strict correlation between the efficiency scores and the ranking indexes, with the only exception of masters in management to some extent. This is a turning point of our study, as we empirically show the contrast between the performance-based ranking and the efficiency-based ranking. The dissimilarity results from two main components related to the methodologies:

- The Financial Times measures performance vs. efficiency is computed as performance net of the resources utilised,
- The Financial Times measurement method is rigid, since weights on the variables are fixed vs. DEA efficiency measurement allows flexible weights.

## 7. SECOND STAGE REGRESSION ANALYSIS

The second step of our analysis consists in individualizing those variables that could explain the efficiency scores obtained through the bootstrapped DEA. These variables are defined as "environmental variables". The technique we use is the second-stage regression analysis described by Simar and Wilson (2007). They elaborate a bootstrapped second-stage regression analysis to overcome the problems entailed by the commonly used regression techniques, namely the censored (tobit) regression and the Ordinary Least Squares (OLS) technique. These problems arise from the serial correlation and bias of the efficiency estimators ($F_i$), and the correlation between the errors ($\varepsilon_i$) and the environmental variables ($z_i$). We compute the correlation coefficients between each environmental variable (independent variable) and the efficiency scores (dependent variable).

Mathematically we find a correlation coefficient $\beta$ for each environmental variable $z_i$ so that:

$$F_i = z_i\,\beta + \varepsilon_i, \qquad \forall\ \mathrm{i} = 1 \dots \mathrm{n}$$

where *i* denotes a specific school and n is the number of schools. Moreover the bootstrapped procedure allows computing confidence intervals for each $\beta$.

The environmental variables used in the second-stage regression are the variables defined as decision nodes in the influence diagrams of figure 1 and 2. We do not consider those variables that enter in the efficiency model (Simar & Wilson, 2007). Moreover some of the remaining variables could not be used because of availability constraints.

The mainly used source of data for the values of the environmental variables is the EFMD dataset, built on the EQUIS datasheets. Where specified (see table 15), data have been taken from the ranking dataset published online, in particular:

- *Percentage of women students* for MBA and master in management from the Financial Times,
- *Percentage of women students* for EMBA from the QS top MBA.

### 7.1. REGRESSION MODEL SETTINGS

*Business School*

The list of variables included for investigating business schools' efficiency differentials is reported in the table 14. *Portfolio diversity* is computed as the total number of different programmes offered by the school. We consider *participant days in executive programmes* equal to zero when the school declares this activity as of minor importance. Since some data are not available for all the schools, we prefer to eliminate the environmental variable rather than eliminate the school. For this reason some of the variables that appear in the influence diagram in figure 2 do not appear in the second-stage regression analysis. In only one case we eliminate one school, school 9, because it is the only one for which *FTE students* and *students/core faculty* are missing.

**Table 14 Environmental variables, Business School**

| Unit of analysis: | ***Business School*** |
|---|---|
| Environmental variables: | 1. Portfolio diversity<br>2. Number of applicants<br>3. % of international students<br>4. Total number of students<br>5. Students/Core faculty,<br>6. Participant days in open executive programmes<br>7. Participant days tailored executive programmes<br>8. Number of academic staff members<br>9. FTE core faculty<br>10. PhD faculty<br>11. % of non-national faculty<br>12. Number of adjunct faculty members |

*Programmes*

The list of variables included for investigating programs' efficiency differentials is reported in the table 15. We do not consider the *mode* (full-time, part-time, modular, etc.…) since all the MBA and master in management programmes analysed are full-time and all the EMBA programmes are part-time. We do not consider *collaborative provision* (double degree, joint degree, etc.…) since it is a qualitative variable that is difficult to be transformed into a numerical one without incurring in subjective evaluation. Moreover for EMBA programmes we do not consider *average age* since this data is missing for five schools, and neither *average years of work experience* since it already enters into the efficiency analysis. We eliminate school 35 for the EMBA-level analysis since *percentage of women students* is not available. For masters in management we do not consider *average years of work experience* and *average age* since this information is quite homogeneous among master students, and neither *duration* since it already enters into the efficiency analysis.

**Table 15 Environmental variables, Programmes**

| Unit of analysis: | ***MBA*** | ***EMBA*** | ***Master in Management*** |
|---|---|---|---|
| Environmental variables: | 1. Average years of work experience<br>2. Average age<br>3. % of international students<br>4. % of women students (FT)<br>5. Max duration<br>6. Number of applicants | 1. % of international students<br>2. % of women students (QS)<br>3. Max duration<br>4. Number of applicants | 1. % of international students<br>2. % of women students (FT)<br>3. Number of applicants |

## 7.2. SECOND STAGE ANALYSIS RESULTS

*Business Schools*

At the business school level, the factors that are playing a positive and statistically significant correlation with efficiency are (i) *portfolio diversity*, (ii) *number of applicants* and (iii) *percentage of PhD faculty* – all indirect signs of well-established reputation and attractiveness.

In order to understand the relationship between these environmental variable and the efficiency score, the following mathematical proportionalities should be analysed:

$$Portfolio\ diversity \propto \frac{v_1 * Students\ enrolled\ +\ v_2 * Reserach\ income\ +\ v_3 * Employment\ rate}{u_1 * Administrative\ staff\ +\ u_2 * Faculty\ members\ +\ u_3 * Students\ offered\ a\ place}$$

$$Number\ of\ applicants \propto \frac{v_1 * Students\ enrolled\ +\ v_2 * Reserach\ income\ +\ v_3 * Employment\ rate}{u_1 * Adm.\ staff\ +\ u_2 * Faculty\ members\ +\ u_3 * Students\ offered\ a\ place}$$

$$\%\ of\ PhD\ faculty \propto \frac{v_1 * Students\ enrolled\ +\ v_2 * Reserach\ income\ +\ v_3 * Employment\ rate}{u_1 * Administrative\ staff\ +\ u_2 * Faculty\ members\ +\ u_3 * Students\ offered\ a\ place}$$

Note indeed the positive correlation –differently than what expected- between portfolio diversity and efficiency. It seems that a wide offer of programmes entails a greater number of students (*Students enrolled*) and a better success in the labour market (*Employment rate*), eventually due to the fact that there are some economies of scale because recruiters prefer to hire graduates in diverse disciplines coming from a school they are familiar with.

The number of applicants, as well as portfolio diversity, has a positive impact on the efficiency, probably due to similar reasons to the ones seen above. The greater costs that a school needs to support in order to offer a diverse range of programmes and therefore to accept more applicants has a return in terms of output that more than compensates the effort in terms of inputs, expressly the number of administrative staff and faculty members and the number of students offered a place.

The percentage of PhD faculty also has a positive impact on the school's overall efficiency.

In particular this variable could affect the research production of the school, thus contributing to the research output (*Research income*).

Table 16 Second-stage regression analysis, Business School

| *Environmental variable* | ***β*** *(after the 1st loop)* | ***β*** *(after the 2nd loop)* | *Lower bound (2.5%)* | *Upper bound (97.5%)* |
|---|---|---|---|---|
| (Intercept) | 0.710 | 0.262 | -0.147 | 0.612 |
| **Portfolio diversity** | **0.418** | **0.482*** | **0.041** | **0.937** |
| **Number of applicants** | **0.000** | **0.005*** | **0.001** | **0.009** |
| % of international students | 0.000 | 0.000 | 0.000 | 0.000 |
| Total number of students | -0.163 | -0.158 | -0.353 | 0.030 |
| Students/Core faculty | 0.000 | 0.000 | 0.000 | 0.000 |
| Participant days in open executive programmes | 0.000 | 0.000 | 0.000 | 0.000 |
| Participant days tailored executive programmes | 0.000 | 0.000 | 0.000 | 0.000 |
| Number of academic staff members | -0.001 | 0.000 | -0.001 | 0.001 |
| **FTE core faculty** | **0.003** | **0.001*** | **0.000** | **0.003** |
| **% of PhD faculty** | **0.194** | **0.734*** | **0.386** | **1.138** |
| % of non-national faculty | -0.021 | -0.067 | -0.293 | 0.142 |
| Number of adjunct faculty | 0.000 | 0.000 | 0.000 | 0.000 |
| (Sigma) | 0.04773849 | 0.07588636 | | |

*Programmes*

At single programme level, it is hard to find any significant statistical relationships between efficiency and any specific environmental characteristics. It is interesting to notice that the intercepts for the three regression models (MBA, EMBA and master in management) are positive, meaning that a lack of activity of the environmental factors corresponds to a positive efficiency score.

The only relationship that is statistically significant is the negative correlation between efficiency and international students for EMBAs, probably due to the (higher) costs associated to this type of students in executive programmes. Indeed the following proportion should be considered:

$$\%\ of\ international\ students \propto \frac{u_1 * Average\ years\ of\ work\ experience\ +\ u_2 * Tuition\ fee}{v_1 * Starting\ salary\ +\ v_2 * \frac{Enrolled}{accepted} students}$$

This means that the EMBA programmes with a higher percentage of international students are associated with classes where students have more years of work experience and higher tuition fees. Indeed the EMBAs that are more international are more competitive, therefore programmes' administrators can increase the selection criteria (*Average years of work experience*) and the prices (*Tuition fee*). Nevertheless, these actions are not outweighed by higher salaries and by a more favourable ratio of enrolled on accepted students.

Table 17 Second-stage regression analyses, Programmes

| *Program* | *Environmental variable* | *β (after the 1st loop)* | *β (after the 2nd loop)* | *Lower bound (2.5%)* | *Upper bound (97.5%)* |
|---|---|---|---|---|---|
| **MBA** | (Intercept) | 0.937 | 1.137* | 0.725 | 1.567 |
| | % of women students (QS) | 0.124 | 0.049 | -0.208 | 0.314 |
| | Average years of work experience | -0.057 | -0.023 | -0.051 | 0.001 |
| | Duration | -0.009 | -0.005 | -0.015 | 0.006 |
| | Number of applicants | 0.000 | 0.000 | 0.000 | 0.000 |
| | % of international students | 0.092 | 0.076 | -0.026 | 0.206 |
| | Average age | 0.015 | 0.002 | -0.008 | 0.012 |
| | (Sigma) | 0.04571186 | 0.04402916 | | |
| **EMBA** | (Intercept) | 1.148 | 1.273* | 0.950 | 1.611 |
| | **% of international students** | **-0.189** | **-0.314*** | **-0.517** | **-0.148** |
| | % of women students (QS) | 0.570 | 0.661 | -0.036 | 1.419 |
| | Max duration | -0.001 | -0.003 | -0.016 | 0.008 |
| | Number of applicants | 0.000 | 0.000 | 0.000 | 0.001 |
| | (Sigma) | 0.1091094 | 0.1188568 | | |
| **MiM** | (Intercept) | 0.754 | 1.007* | 0.484 | 1.356 |
| | % of international students | 0.072 | 0.116 | -0.091 | 0.382 |
| | % of women students (FT) | 0.000 | 0.000 | 0.000 | 0.000 |
| | Number of applicants | 0.157 | -0.024 | -0.905 | 0.797 |
| | (Sigma) | 0.1961435 | 0.1344055 | | |

Summarizing, the second-stage regression analysis does not help towards better insights related to programmes' efficiency. Instead, it offers an interesting potential perspective about the performance of the most efficient business schools. It is likely that the higher costs associated with portfolio diversity, number of applicants and percentage of PhD faculty are outweighed by the results that they are able to obtain. Efficiency, then, is not necessarily pursued through cost reductions, but by obtaining good results in the market for business education.

## 8. CONCLUSIONS

### 8.1. RESULTS

Our work follows a circular path: (i) first we study the complexity of the production process of business schools; (ii) then we consider the business school as a "black box" receiving inputs and outputs in order to compute its efficiency; (iii) finally we try to explain the so obtained efficiency scores in terms of the variables that determine and affect the production process of business schools.

The results computed in the second phase are presented both for each level of analysis (Colbert, Levary, & Shaner, 2000) and in two comparison: efficiency of business schools vs. efficiency of their programmes and efficiency scores vs. ranking positions (Ray & Jeon, 2008). We find that the MBA is on average the best performing programme in terms of efficiency. For most of the schools, the efficiency of the MBA is not only higher than the efficiency of the other programmes offered, but it is also greater than the efficiency of the school considered as a whole. This means that in general business school deans and administrators should look at their MBA programme as an internal example of best practices and that all the other programmes should be benchmarked against the MBA. On the other hand, the EMBA programme is on average the worst performing one in terms of efficiency.

Since we use an output-oriented model, the source of inefficiency is always an output variable (Hsu, 2009). In order to increase their efficiency, business schools should increase the performance of the output with the highest potential, identified as the output on which business schools place the greatest weight (Kong & Fu, 2012). In general, the factor with the highest potential is the *employment rate* for business schools, MBA and master in management programmes and the *ratio of enrolled on accepted students* for EMBA programmes. In the light of these results, the actions that schools might undertake to improve their efficiency are, for example, strengthening their teaching quality (to improve the employment rate of their graduates) and improving their selection process for the EMBA programme (to maximise the ratio of enrolled on accepted students).

From the analysis of the scale efficiency, we can draw important conclusions and give to school administrators indications on the optimal scale in order to obtain the highest efficiency with the minimum effort in terms of resources. In particular, we find that for business schools, EMBAs and masters in management the returns to scale are decreasing. This means that, from a certain level of input and forward, the investment in any additional unit of input corresponds to a less than proportional increase in the level of output. It needs to be noticed that for some schools we have suggested to reduce the level of input utilised in order to reach the optimal scale. Nevertheless, this reduction entails a more than proportional drop of the level of the output. While in an efficiency perspective this change would be advisable, it negatively affects performance.

The comparison between efficiencies and ranking positions is the turning point of this study. The lack of a strong correlation between the efficiency scores and the Financial Times rankings underlines the existing discrepancy between efficiency and performance. At this point a reflection on the most appropriate methodology to evaluate business schools is due. We are not going to reply to this question, but would like to invite the reader to consider the significance of efficiency in relation to the strategy of the school. In some cases, the efficiency perspective should be integrated as an internal and operational benchmarking system and as a tool for accountability about costs and results, rather than as a decision-making instrument. In this perspective, being inefficient –in relation to other schools- could be a strategic choice, rather than the effect of a mismanagement.

The results computed in the third phase of this study look at the efficiency scores as a possible consequence of the production process of business schools. In particular we find that *portfolio diversity*, *number of applicants* and the *percentage of PhD faculty* are all factors that are positively related to the efficiency of business schools (considered as a whole). It is likely that the higher costs associated to these factors are overweighed by the results that they are able to obtain. We then conclude that efficiency is not necessary pursued through cost reduction, but by obtaining good results in the market for business education.

## 8.2. LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The results of the analysis we have conducted are obviously affected by data availability. In some cases, due to the lack of data, we had to decrease the number of schools analysed. The impossibility to disclose the names of the schools, because of privacy issues due to the data source we have used, makes it more laborious the comment of the results and their understanding by the reader. For example, we are not able to compare efficiency score and ranking position in a one-to-one comparison, but we have to divide the schools into tiers and subsequently analyse the aggregate efficiency of the tier.

Since often a country is associated with only one globally known business school that appears within the first schools in the Financial Times ranking, then we are not able to study the efficiency in relation to the geographical, demographical, political and economic factors that characterise the country.

Moreover, the sample of business schools considered represents the top ranked schools in the Financial Times, while a more balanced sample might have resulted in a wider range of efficiencies (Colbert, Levary, & Shaner, 2000).

Some authors vary the inputs and the outputs considered (Colbert, Levary, & Shaner, 2000), the number of units considered and compute both the input-oriented and the output-oriented efficiency scores (Hsu, 2009) in order to analyse the variation of the efficiency scores in relation to the mutation of the model settings.

Further comparisons to obtain a better insight on the efficiency scores could also be conducted, such as the comparison between independent business schools and those that are affiliated to a parental university.

This study is intentionally missing a further discussion on the most proper methodology to assess business schools. This kind of dissertation finds its foundation in the discrepancy between efficiency scores and ranking positions and would worth another paper and would need the opinions of the experts in the industry.

## 9. REFERENCES


Abbott, M., & Doucouliagos. (2003). The efficiency of Australian universities: a data envelopment analysis. *Economics of Education review, 22*(1), 89-97.

Adler, N. J., & Bartholomew, S. (1992). Managing globally competent people. *The Executive*, 6(3), 52-65.

Agasisti, T. (2011). Performances and spending efficiency in higher education: a European comparison through non-parametric approaches. *Education Economics, 19(2)*, 199-224.

Athanassopoulos, A. D., & Shale, E. (1997). Assessing the comparative efficiency of higher Education institutions in the UK by the means of Data Envelopment Analysis. *Education Economics, 5(2)*, 117-134.

Baden-Fuller, C., Ravazzolo, F., & Schweizer, T. (2000). Making and measuring reputations: the research ranking of European business schools. *Long Range Planning, 33(5)*, 621-650.

Becker, G. S. (1962). Investment in human capital: a theoretical analysis. *The University of Chicago press, 70 (5)*, 9-19.

Bennis, W. G., & O'Toole, J. (2005). How business schools lost their way. *Harvard business review, 83(5)*, 96-104.

Bickerstaffe, G., & Ridgers, B. (2007). Ranking of business schools. *Journal of management development, 26(1)*, 61-66.

Bielza, C., Gómez, M., & Shenoy, P. (2011). A review of representation issues and modeling challenges with influence diagrams. *Omega*, 39(3), 227-241.

Bogetoft, P., & Otto, L. (2010). *Benchmarking with DEA, SFA, and R* (Vol. 157). Springer.

Byrne, J. A. (2014, November 2014). *Poets & Quants*. Retrieved from How Duke Achieved Its No. 1 Businessweek Ranking: http://poetsandquants.com/2014/11/12/how-duke-achieved-its-no-1-ranking/

Clark, B. H., & Montgomery, D. B. (1998). Deterrence, reputations, and competitive cognition. *Management Science, 44(1)*, 62-82.

Colbert, A., Levary, R. R., & Shaner, M. C. (2000). Determining the relative efficiency of MBA programs using DEA. *European Journal of Operational Research, 125(3)*, 656-669.

Collet, F., & Vives, L. (2013). From preeminence to prominence: the fall uf US business schools and the rise of european and Asian business schools in the Financial Times global MBA rankings. *Academy of management learning and education*, *12(4),* 540-563.

Comunale, C. L., & Sexton, T. R. (2004). An efficiency analysis of U.S. business schools. *Journal of case studies in accrediattion and assessment*, 1-19.

Cooper, W. W., Seiford, L. M., & Zhu, J. (2011). Application of data envelopment analysis in the service sector: Universities. In *Handbook on data envelopment analysis, 164,* 406-413. Springer .

Corley, K., & Gioia, D. (2000). The rankings game: Managing business school reputation. (Chicago, Ed.) *Corporate Reputation Review, 3(4)*, 319-333.

Cornelissen, J., & Thorpe, R. (2002). Measuring a Business School's Reputation: Perspectives, Problems and Prospects. *European Management Journal, 20(2)*, 172-178.

Czarniawska, B., & Genell, K. (2002). Gone shopping? Universities on their way to the market. *Scandinavian Journal of Management, 18(4)*, 455-474.

EFMD. (2014, December). *EQUIS Accredited Schools*. Retrieved February 16, 2015, from www.efmd.org/equis: http://www.efmd.org/accreditation-main/equis/accredited-schools

EFMD. (2014). *EQUIS Guides.* Retrieved 2014 йил 26-November from EFMD: https://www.efmd.org/images/stories/efmd/EQUIS/2014/EQUIS_Standards_and_Criteria.pdf

Fandel, G. (2007). On the performance of universities in North Rhine-Westphalia, Germany: Government's redistribution of funds judged using DEA efficiency measures. *European oJurnal of Operational Research, 176(1)*, 521-533.

Financial Times. (2014, November 30). *European business schools 2014 ranking: key*. Retrieved February 11, 2015, from ft.com: http://www.ft.com/intl/cms/s/2/e3d33a42-6e6d-11e4-afe5-00144feabdc0.html#axzz3RQrbUiSM

Financial Times. (2014, November 30). *European business schools 2014 ranking: methodology*. Retrieved February 11, 2015, from ft.com: http://www.ft.com/intl/cms/s/2/dad745fa-6e6d-11e4-afe5-00144feabdc0.html#axzz3RQrbUiSM

Financial Times. (2014, October 19). *Key to EMBA ranking 2014*. Retrieved February 11, 2015, from ft.com: http://www.ft.com/intl/cms/s/2/f7c2f066-4d6f-11e4-bf60-00144feab7de.html#axzz3RQrbUiSM

Financial Times. (2014, September 14). *Masters in management: key to the 2014 ranking*. Retrieved February 11, 2015, from ft.com: http://www.ft.com/intl/cms/s/2/39d2f93c-37c8-11e4-971c-00144feabdc0.html#axzz3RQrbUiSM

Fisher, D. M., Fisher, S. A., & Kiang, M. (2007). A value-added approach to selecting the best master of business administration (MBA) program. *Journal of education for Business, 83(2)*, 72-76.

Fox, J. (2002, January). Bootstrapping Regression Models. *Appendix to An R and S-PLUS Companion to Applied Regression*.

García-Varderrama, T. (1996). La medida y el control dela eficiencia en instituciones universitarias. *In: Martín, E. (2006). Efficiency and Quality in the Current Higher Education Context in Europe: an application of the data envelopment analysis methodology to performance assessment of departments within the University of Zaragoza. Quality in Higher Education, 12(1), 57-79.*

Groot, T., & Garcia-Valderrama, T. (2006). Research quality and efficiency: An analysis of assessments and management issues in Dutch economics and business research programs. *35(9)*, 1362-1376.

Hirao, Y. (2012). Efficiency of the top 50 business schools in the United States. *Applied Economics Letters, 19(1)*, 73-78.

Hsu, M. K. (2009). An efficiency comparison of MBA programs: Top 10 versus non-top 10. *Journal of Education for Business, 84(5)*, 269-274.

Jemielniak, D., & Greenwood, D. J. (2015). Wake Up or Perish Neo-Liberalism, the Social Sciences, and Salvaging the Public University. *Cultural Studies↔ Critical Methodologies, 15(1)*, 72-82.

Johnes, G., & Johnes, J. (1993). Measuring the research performance of UK economics departments: an application of data envelopment analysis. *Oxford economic papers*, 332-347.

Johnes, G., & Johnes, J. (2004). *International handbook on the economics of education.* Edward Elgar publishing Ltd.

Johnes, J. (2006). Data envelopment analysis and its application to the measurement of efficiency in higher education. *Economics of Education Review, 25(3)*, 273-288.

Joumady, O., & Ris, C. (2005). Performance in European higher education: a non-parametric production frontier approach. *Education Economics, 13(2)*, 189-205.

Köksalan, M., Büyükbaşaran, T., Özpeynirci, Ö., & Wallenius, J. (2010). A flexible approach to ranking with an application to MBA programs. *European Journal of Operational Research, 201(2)*, 470-476.

Kong, W. H., & Fu, T. T. (2012). Assessing the performance of business colleges in Taiwan using data envelopment analysis and student based value-added performance indicators. *Omega, 40(5)*, 541-549.

Lavelle, L. (2014, November 19). *Methodology: QS Global 200 Business Schools Report 2014/15*. Retrieved February 6, 2015, from topmba.com: http://www.topmba.com/mba-rankings/methodology-qs-global-200-business-schools-report-201415

Martín, E. (2006). Efficiency and Quality in the Current Higher Education Context in Europe: an application of the data envelopment analysis methodology to performance assessment of departments within the University of Zaragoza. *Quality in Higher Education, 12(1)*, 57-79.

Ortmans, L. (2014, October 19). *Methodology: executive MBA rankings 2014*. Retrieved February 11, 2015, from ft.com: http://www.ft.com/intl/cms/s/2/5fed70b8-4d6f-11e4-bf60-00144feab7de.html#axzz3RQrbUiSM

Palin, A. (2014, January 26). *MBA ranking 2014: key and methodology*. Retrieved February 11, 2015, from ft.com: www.ft.com/intl/csm/s/2/5728ac98-7c7f-11e3-b514-00144feabdc0.html#axzz3RQrbUISM

Palocsay, S., & Wood, W. (2014). An investigation of US undergraduate business school rankings using data envelopment analysis with value-added performance indicators. *Journal of education for Business, 89(6)*, 277-284.

Pettigrew, A. M., Cornuel, E., & Hommel, U. (2014). *The Institutional Development of Business Schools, 2(9)*. Oxford University Press.

Powell, W. W., & Owen-Smith, J. (1998). Universities and the market for intellectual property in the life sciences. *Journal of Policy Analysis and Management, 17(2)*, 253-277.

Ray, S. C., & Jeon, Y. (2008). Reputation and efficiency: a non-parametric assessment of America’s top-rated MBA programs. *European Journal of Operational Research, 189(1)*, 245-268.

Rindova, V. P., Williamson, I. O., Petkova, A. P., & Sever, J. M. (2005). Being good or being known: An empirical examination of the dimensions, antecedents, and consequences of organizational reputation. *Academy of Management Journal, 48(6)*, 1033-1049.

Rodkin, J. (2014, November 10). *Best Business Schools 2014: How They Were Ranked*. Retrieved February 6, 2015, from bloomberg.com: http://www.bloomberg.com/bw/articles/2014-11-10/best-business-schools-2014-methodology-for-ranking-schools

Sacoto, S. A., Cook, W. D., & Delgado, H. C. (2015). Time-staged outputs in DEA. *Omega (Early version of the manuscript)*.

Sarrico, C. S., & Dyson, R. G. (2000). Using DEA for planning in UK universities—an institutional perspective. *51(7)*, 789-800.

Sedki, K., Polet, P., & Vanderhaegen, F. (2013). Using the BCD model for risk analysis: an influence diagram based approach. *Engineering applications of artificial intelligence, 26*, 2172-2183.

Simar, L., & Wilson, P. W. (2000). A general methodology for bootstrapping in non-parametric frontier models. *Journal of applied statistics, 27(6)*, 779-802.

Simar, L., & Wilson, P. W. (2002). Non-parametric tests of returns to scale. *European Journal of Operational Research, 139(1)*, 115-132.

Simar, L., & Wilson, P. W. (2007). Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of econometrics, 136(1)*, 31-64.

Sreekumar, S., & Mahapatra, S. S. (2011). Performance modeling of Indian business schools: a DEA-neural network approach. Benchmarking: an international journal. *18(2)*, 221-239.

Tracy, J., & Waldfogel, J. (1997). The best business schools: a market-base approach. *Journal of business, 70(1)*, 1-31.

Tzeremes, N., & Halkos, G. (2010). A DEA approach for measuring university departments' efficiency. *Munich Personal RePEc Archive, Paper No. 24029*.

Vidaver-Cohen, D. (2007). Reputation beyond rankings:A conceptual framework for business school research. *corporate Reputation Review, 10(4)*, 278-304.

Wedlin, L. (2011). Crafting competition: media rankings and the forming of a global market for business schools. *Education Inquiry, 2(4)*.

## 10. TECHNICAL APPENDIX

**Appendix 1 Weights and peers, Business school**

| School | λ1 | peer1 | λ2 | peer2 | λ3 | peer3 | λ4 | peer4 | v1 | v2 | v3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0.703 | 28 | 0.297 | 31 | | | | | 0.00000 | 0.00000 | 1.05263 |
| **3** | 0.747 | 28 | 0.253 | 31 | | | | | 0.00000 | 0.00000 | 1.08696 |
| **4** | 0.875 | 28 | 0.125 | 31 | | | | | 0.00000 | 0.00000 | 1.06383 |
| **7** | 0.524 | 28 | 0.352 | 31 | 0.049 | 37 | 0.076 | 51 | 0.00000 | 0.01703 | 1.02920 |
| **8** | 0.455 | 23 | 0.002 | 28 | 0.290 | 31 | 0.253 | 51 | 0.00000 | 0.02211 | 1.12597 |
| **9** | 1.000 | 9 | | | | | | | 0.00000 | 0.00000 | 1.28205 |
| **10** | 0.355 | 34 | 0.645 | 51 | | | | | 0.00000 | 0.10834 | 0.00000 |
| **11** | 0.624 | 28 | 0.146 | 34 | 0.152 | 37 | 0.078 | 51 | 0.00003 | 0.06602 | 0.62263 |
| **12** | 0.882 | 28 | 0.118 | 31 | | | | | 0.00000 | 0.00000 | 1.20482 |
| **13** | 1.000 | 13 | | | | | | | 0.00000 | 0.16340 | 0.00000 |
| **16** | 1.000 | 16 | | | | | | | 0.00117 | 0.00000 | 0.00000 |
| **17** | 0.413 | 28 | 0.373 | 31 | 0.213 | 51 | | | 0.00000 | 0.01534 | 0.96335 |
| **19** | 1.000 | 28 | | | | | | | 0.00000 | 0.00000 | 1.40845 |
| **20** | 1.000 | 28 | | | | | | | 0.00000 | 0.00000 | 1.09890 |
| **21** | 0.426 | 28 | 0.574 | 31 | | | | | 0.00000 | 0.00000 | 1.13636 |
| **22** | 1.000 | 22 | | | | | | | 0.00000 | 0.00000 | 1.14943 |
| **23** | 1.000 | 23 | | | | | | | 0.00000 | 0.00000 | 1.08696 |
| **26** | 0.047 | 16 | 0.726 | 23 | 0.107 | 28 | 0.119 | 31 | 0.00017 | 0.00000 | 1.02739 |
| **27** | 1.000 | 28 | | | | | | | 0.00000 | 0.00000 | 1.12360 |
| **28** | 1.000 | 28 | | | | | | | 0.00023 | 0.00000 | 0.00000 |
| **29** | 0.276 | 22 | 0.401 | 23 | 0.264 | 31 | 0.059 | 51 | 0.00000 | 0.02293 | 1.12728 |
| **30** | 1.000 | 22 | | | | | | | 0.00000 | 0.04171 | 0.87121 |
| **31** | 1.000 | 31 | | | | | | | 0.00000 | 0.00000 | 1.00000 |
| **33** | 0.680 | 28 | 0.310 | 37 | 0.010 | 51 | | | 0.00000 | 0.04887 | 0.95975 |
| **34** | 1.000 | 34 | | | | | | | 0.00000 | 0.10449 | 0.00000 |
| **35** | 1.000 | 35 | | | | | | | 0.00022 | 0.00000 | 0.00000 |
| **37** | 1.000 | 37 | | | | | | | 0.00021 | 0.05043 | 0.00000 |
| **38** | 0.391 | 23 | 0.609 | 28 | | | | | 0.00000 | 0.00000 | 1.35135 |
| **42** | 0.812 | 23 | 0.188 | 28 | | | | | 0.00000 | 0.00000 | 1.11111 |
| **43** | 0.016 | 23 | 0.984 | 28 | | | | | 0.00000 | 0.00000 | 1.17647 |
| **46** | 0.382 | 28 | 0.618 | 31 | | | | | 0.00000 | 0.00000 | 1.12360 |
| **47** | 0.487 | 23 | 0.129 | 28 | 0.187 | 31 | 0.197 | 51 | 0.00000 | 0.02152 | 1.09549 |
| **48** | 1.000 | 28 | | | | | | | 0.00000 | 0.00000 | 1.19048 |
| **50** | 1.000 | 28 | | | | | | | 0.00000 | 0.00000 | 1.13636 |
| **51** | 1.000 | 51 | | | | | | | 0.00000 | 0.10870 | 0.00000 |
| **52** | 1.000 | 28 | | | | | | | 0.00000 | 0.00000 | 1.20482 |
| | | | | | | | | ***Sum:*** | 0.00203 | 0.79089 | 30.8104 |

**Appendix 2 Efficiency analysis results, Business school**

| *School* | *F (VRS)_BS* | *Bias-corrected F (VRS)_BS* | *Var_BS* | *Upper bound (97.5%)_BS* | *Lower bound (2.5%)_BS* |
|---|---|---|---|---|---|
| **30** | 1.000 | 0.954 | 0.001 | 0.997 | 0.902 |
| **17** | 0.990 | 0.949 | 0.001 | 0.987 | 0.908 |
| **10** | 0.989 | 0.942 | 0.001 | 0.986 | 0.870 |
| **37** | 1.000 | 0.934 | 0.002 | 0.997 | 0.849 |
| **31** | 1.000 | 0.933 | 0.002 | 0.997 | 0.867 |
| **1** | 0.950 | 0.931 | 0.000 | 0.948 | 0.903 |
| **13** | 1.000 | 0.925 | 0.004 | 0.998 | 0.824 |
| **23** | 1.000 | 0.922 | 0.005 | 0.997 | 0.800 |
| **16** | 1.000 | 0.921 | 0.005 | 0.997 | 0.795 |
| **28** | 1.000 | 0.921 | 0.005 | 0.997 | 0.793 |
| **38** | 1.000 | 0.921 | 0.005 | 0.997 | 0.794 |
| **43** | 1.000 | 0.921 | 0.005 | 0.997 | 0.792 |
| **4** | 0.940 | 0.920 | 0.000 | 0.938 | 0.892 |
| **9** | 1.000 | 0.920 | 0.005 | 0.997 | 0.794 |
| **22** | 1.000 | 0.920 | 0.005 | 0.997 | 0.792 |
| **34** | 1.000 | 0.918 | 0.005 | 0.997 | 0.786 |
| **47** | 0.963 | 0.918 | 0.001 | 0.960 | 0.845 |
| **3** | 0.920 | 0.899 | 0.000 | 0.918 | 0.872 |
| **29** | 0.942 | 0.899 | 0.001 | 0.939 | 0.844 |
| **20** | 0.910 | 0.883 | 0.000 | 0.909 | 0.848 |
| **50** | 0.921 | 0.880 | 0.001 | 0.918 | 0.837 |
| **7** | 0.911 | 0.871 | 0.001 | 0.908 | 0.827 |
| **8** | 0.905 | 0.870 | 0.001 | 0.903 | 0.828 |
| **42** | 0.880 | 0.864 | 0.000 | 0.879 | 0.834 |
| **51** | 0.890 | 0.857 | 0.001 | 0.888 | 0.820 |
| **21** | 0.880 | 0.856 | 0.001 | 0.878 | 0.823 |
| **27** | 0.890 | 0.855 | 0.001 | 0.889 | 0.790 |
| **26** | 0.887 | 0.844 | 0.002 | 0.884 | 0.782 |
| **11** | 0.862 | 0.822 | 0.002 | 0.859 | 0.762 |
| **48** | 0.851 | 0.822 | 0.001 | 0.850 | 0.791 |
| **52** | 0.840 | 0.819 | 0.001 | 0.839 | 0.783 |
| **12** | 0.830 | 0.813 | 0.000 | 0.828 | 0.791 |
| **35** | 0.830 | 0.808 | 0.000 | 0.829 | 0.778 |
| **33** | 0.778 | 0.748 | 0.001 | 0.777 | 0.705 |
| **46** | 0.764 | 0.729 | 0.002 | 0.762 | 0.669 |
| **19** | 0.710 | 0.691 | 0.001 | 0.709 | 0.662 |

## Appendix 3 Weights and peers, MBA

| *School* | *λ1* | *peer1* | *λ2* | *peer2* | *λ3* | *peer3* | *λ4* | *peer4* | *λ5* | *peer 5* | *v1* | *v2* | *v3* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 1.000 | 1 | | | | | | | | | 0.00196 | 0.14570 | 0.82466 |
| **3** | 1.000 | 3 | | | | | | | | | 0.00107 | 0.92674 | 0.00000 |
| **4** | 0.518 | 3 | 0.046 | 14 | 0.436 | 18 | | | | | 0.00089 | 0.98037 | 0.00000 |
| **6** | 0.177 | 3 | 0.246 | 14 | 0.577 | 18 | | | | | 0.00093 | 1.01718 | 0.00000 |
| **7** | 0.954 | 3 | 0.029 | 14 | 0.018 | 18 | | | | | 0.00088 | 0.97042 | 0.00000 |
| **8** | 0.291 | 1 | 0.028 | 3 | 0.267 | 18 | 0.208 | 22 | 0.207 | 23 | 0.00216 | 0.49124 | 0.47370 |
| **9** | 1.000 | 9 | 0.000 | 23 | | | | | | | 0.00303 | 0.00000 | 0.78284 |
| **10** | 0.187 | 1 | 0.813 | 29 | | | | | | | 0.00750 | 0.00000 | 0.00000 |
| **11** | 0.229 | 3 | 0.457 | 14 | 0.313 | 18 | | | | | 0.00100 | 1.09888 | 0.00000 |
| **13** | 0.271 | 3 | 0.483 | 14 | 0.247 | 18 | | | | | 0.00098 | 1.07018 | 0.00000 |
| **14** | 1.000 | 14 | | | | | | | | | 0.00494 | 0.64892 | 0.00000 |
| **16** | 0.160 | 14 | 0.454 | 23 | 0.386 | 34 | | | | | 0.00936 | 0.23063 | 0.00000 |
| **17** | 0.387 | 14 | 0.613 | 18 | | | | | | | 0.00000 | 1.26582 | 0.00000 |
| **18** | 1.000 | 18 | | | | | | | | | 0.00017 | 1.02384 | 0.00000 |
| **19** | 0.413 | 3 | 0.335 | 14 | 0.252 | 23 | | | | | 0.00541 | 0.54591 | 0.00000 |
| **20** | 0.094 | 14 | 0.278 | 18 | 0.208 | 23 | 0.420 | 29 | | | 0.00436 | 0.57882 | 0.00000 |
| **21** | 0.227 | 14 | 0.247 | 18 | 0.010 | 23 | 0.517 | 29 | | | 0.00421 | 0.55823 | 0.00000 |
| **22** | 1.000 | 22 | | | | | | | | | 0.00000 | 0.00000 | 1.14286 |
| **23** | 1.000 | 23 | | | | | | | | | 0.00168 | 0.00000 | 0.99123 |
| **26** | 1.000 | 23 | | | | | | | | | 0.00168 | 0.00000 | 0.99123 |
| **29** | 0.000 | 23 | 1.000 | 29 | | | | | | | 0.00677 | 0.00000 | 0.03785 |
| **33** | 0.389 | 3 | 0.564 | 14 | 0.006 | 22 | 0.041 | 23 | | | 0.00152 | 0.82093 | 0.37561 |
| **34** | 1.000 | 34 | | | | | | | | | 0.00000 | 1.17026 | 0.49062 |
| **46** | 1.000 | 46 | | | | | | | | | 0.01123 | 0.00000 | 0.00000 |
| **48** | 0.236 | 14 | 0.665 | 18 | 0.099 | 46 | | | | | 0.00000 | 1.12360 | 0.00000 |
| | | | | | | | | | | ***Sum:*** | 0.07173 | 14.6676 | 6.11060 |

**Appendix 4 Efficiency analysis results, MBA**

| *School* | *F (VRS)_MBA* | *Bias-corrected F (VRS)_MBA* | *Var_MBA* | *Upper bound (97.5%)_MBA* | *Lower bound (2.5%)_MBA* |
|---|---|---|---|---|---|
| **23** | 1.000 | 0.981 | 0.000 | 0.999 | 0.928 |
| **26** | 1.000 | 0.981 | 0.000 | 0.999 | 0.928 |
| **9** | 1.000 | 0.980 | 0.000 | 0.999 | 0.951 |
| **3** | 1.000 | 0.974 | 0.000 | 0.999 | 0.944 |
| **7** | 0.991 | 0.974 | 0.000 | 0.990 | 0.943 |
| **29** | 1.000 | 0.974 | 0.000 | 0.999 | 0.944 |
| **21** | 0.985 | 0.971 | 0.000 | 0.984 | 0.954 |
| **4** | 0.980 | 0.970 | 0.000 | 0.980 | 0.954 |
| **18** | 1.000 | 0.969 | 0.001 | 0.999 | 0.927 |
| **1** | 1.000 | 0.966 | 0.001 | 0.999 | 0.918 |
| **14** | 1.000 | 0.963 | 0.001 | 0.999 | 0.890 |
| **22** | 1.000 | 0.962 | 0.001 | 0.999 | 0.890 |
| **34** | 1.000 | 0.962 | 0.001 | 0.999 | 0.889 |
| **46** | 1.000 | 0.962 | 0.001 | 0.999 | 0.890 |
| **6** | 0.968 | 0.957 | 0.000 | 0.967 | 0.942 |
| **48** | 0.973 | 0.955 | 0.000 | 0.972 | 0.929 |
| **20** | 0.955 | 0.941 | 0.000 | 0.954 | 0.923 |
| **13** | 0.951 | 0.940 | 0.000 | 0.950 | 0.922 |
| **16** | 0.939 | 0.922 | 0.000 | 0.938 | 0.894 |
| **11** | 0.922 | 0.912 | 0.000 | 0.921 | 0.896 |
| **33** | 0.922 | 0.906 | 0.000 | 0.921 | 0.879 |
| **8** | 0.917 | 0.903 | 0.000 | 0.916 | 0.888 |
| **10** | 0.909 | 0.896 | 0.000 | 0.908 | 0.874 |
| **19** | 0.897 | 0.882 | 0.000 | 0.896 | 0.862 |
| **17** | 0.868 | 0.857 | 0.000 | 0.868 | 0.841 |

**Appendix 5 Weights and peers, EMBA**

| School | λ1 | peer1 | λ2 | peer2 | λ3 | peer3 | λ4 | peer4 | v1 | v2 |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0.867 | 9 | 0.133 | 25 | | | | | 0.00000 | 1.16049 |
| **3** | 0.731 | 9 | 0.269 | 27 | | | | | 0.00504 | 0.00000 |
| **7** | 1.000 | 7 | | | | | | | 0.00458 | 0.00000 |
| **8** | 0.132 | 9 | 0.868 | 37 | | | | | 0.00019 | 1.19910 |
| **9** | 1.000 | 9 | | | | | | | 0.00406 | 0.00000 |
| **10** | 0.867 | 9 | 0.133 | 27 | | | | | 0.00486 | 0.00000 |
| **11** | 0.325 | 9 | 0.670 | 25 | 0.005 | 37 | | | 0.00000 | 1.21053 |
| **12** | 0.352 | 9 | 0.540 | 27 | 0.108 | 37 | | | 0.00521 | 0.28203 |
| **13** | 0.411 | 7 | 0.010 | 9 | 0.086 | 25 | 0.492 | 27 | 0.00685 | 0.08305 |
| **14** | 1.000 | 14 | | | | | | | 0.00000 | 1.25862 |
| **15** | 0.365 | 9 | 0.254 | 25 | 0.381 | 37 | | | 0.00000 | 1.37500 |
| **17** | 0.113 | 9 | 0.055 | 25 | 0.832 | 37 | | | 0.00000 | 1.43243 |
| **18** | 0.365 | 9 | 0.254 | 25 | 0.381 | 37 | | | 0.00000 | 1.37500 |
| **19** | 0.135 | 7 | 0.309 | 9 | 0.288 | 25 | 0.268 | 27 | 0.00635 | 0.07701 |
| **21** | 0.318 | 9 | 0.273 | 25 | 0.409 | 37 | | | 0.00000 | 1.36111 |
| **24** | 0.408 | 9 | 0.237 | 25 | 0.355 | 37 | | | 0.00000 | 1.06977 |
| **25** | 1.000 | 25 | | | | | | | 0.00000 | 1.14815 |
| **27** | 1.000 | 27 | | | | | | | 0.00585 | 0.00000 |
| **28** | 0.222 | 9 | 0.778 | 37 | | | | | 0.00021 | 1.28849 |
| **29** | 0.112 | 7 | 0.551 | 9 | 0.337 | 27 | | | 0.00519 | 0.00000 |
| **31** | 0.010 | 7 | 0.650 | 9 | 0.078 | 25 | 0.262 | 27 | 0.00537 | 0.06515 |
| **32** | 0.047 | 7 | 0.225 | 9 | 0.397 | 25 | 0.331 | 27 | 0.00696 | 0.08441 |
| **34** | 0.002 | 9 | 0.399 | 25 | 0.599 | 37 | | | 0.00000 | 1.31579 |
| **37** | 1.000 | 37 | | | | | | | 0.00658 | 0.00000 |
| **38** | 0.237 | 9 | 0.105 | 25 | 0.658 | 37 | | | 0.00000 | 1.04878 |
| **39** | 1.000 | 37 | | | | | | | 0.00000 | 1.15556 |
| **36** | 1.000 | 37 | | | | | | | 0.00000 | 1.00000 |
| **35** | 0.176 | 9 | 0.310 | 25 | 0.515 | 37 | | | 0.00000 | 1.43750 |
| | | | | | | | | ***Sum:*** | 0.06730 | 20.4279 |

**Appendix 6 Efficiency analysis results, EMBA**

| *School* | *F (VRS)_EMBA* | *Bias-corrected F (VRS)_EMBA* | *Var_EMBA* | *Upper bound (97.5%)_EMBA* | *Lower bound (2.5%)_EMBA* |
|---|---|---|---|---|---|
| **36** | 1.000 | 0.971 | 0.000 | 0.998 | 0.930 |
| **24** | 0.970 | 0.945 | 0.000 | 0.968 | 0.907 |
| **5** | 0.970 | 0.935 | 0.001 | 0.967 | 0.889 |
| **9** | 1.000 | 0.895 | 0.004 | 0.996 | 0.813 |
| **27** | 1.000 | 0.889 | 0.005 | 0.994 | 0.797 |
| **2** | 1.000 | 0.885 | 0.006 | 0.994 | 0.785 |
| **25** | 1.000 | 0.881 | 0.008 | 0.995 | 0.772 |
| **7** | 1.000 | 0.879 | 0.008 | 0.996 | 0.770 |
| **14** | 1.000 | 0.879 | 0.008 | 0.994 | 0.771 |
| **11** | 0.909 | 0.855 | 0.002 | 0.904 | 0.789 |
| **1** | 0.889 | 0.837 | 0.002 | 0.885 | 0.787 |
| **29** | 0.885 | 0.834 | 0.002 | 0.880 | 0.771 |
| **3** | 0.877 | 0.833 | 0.002 | 0.874 | 0.769 |
| **6** | 0.865 | 0.820 | 0.002 | 0.863 | 0.759 |
| **10** | 0.871 | 0.815 | 0.003 | 0.867 | 0.748 |
| **19** | 0.826 | 0.788 | 0.001 | 0.821 | 0.745 |
| **32** | 0.833 | 0.788 | 0.001 | 0.828 | 0.750 |
| **8** | 0.814 | 0.785 | 0.001 | 0.812 | 0.751 |
| **31** | 0.823 | 0.772 | 0.002 | 0.819 | 0.718 |
| **12** | 0.793 | 0.744 | 0.002 | 0.789 | 0.702 |
| **34** | 0.801 | 0.736 | 0.005 | 0.797 | 0.657 |
| **21** | 0.765 | 0.734 | 0.001 | 0.761 | 0.701 |
| **15** | 0.756 | 0.722 | 0.001 | 0.754 | 0.689 |
| **18** | 0.756 | 0.722 | 0.001 | 0.754 | 0.689 |
| **13** | 0.752 | 0.718 | 0.001 | 0.749 | 0.676 |
| **28** | 0.758 | 0.712 | 0.002 | 0.754 | 0.673 |
| **35** | 0.727 | 0.701 | 0.001 | 0.723 | 0.666 |
| **17** | 0.704 | 0.670 | 0.002 | 0.701 | 0.624 |

**Appendix 7 Weights and peers, Master in management**

| *School* | *λ1* | *peer1* | *λ2* | *peer2* | *λ3* | *peer3* | *λ4* | *peer4* | *v1* | *v2* | *v3* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.948 | 4 | 0.052 | 20 | | | | | 0.00000 | 1.02276 | 0.02610 |
| 3 | 1.000 | 3 | | | | | | | 0.01269 | 0.00000 | 0.00000 |
| 4 | 1.000 | 4 | | | | | | | 0.00140 | 0.93315 | 0.00000 |
| 11 | 0.813 | 4 | 0.018 | 18 | 0.139 | 37 | 0.030 | 44 | 0.00193 | 0.96301 | 0.02851 |
| 12 | 0.259 | 3 | 0.741 | 4 | | | | | 0.00225 | 1.02736 | 0.00000 |
| 13 | 0.295 | 4 | 0.199 | 16 | 0.472 | 20 | 0.033 | 37 | 0.00000 | 1.17336 | 0.02928 |
| 14 | 0.710 | 4 | 0.290 | 20 | | | | | 0.00000 | 1.03609 | 0.02644 |
| 15 | 0.799 | 3 | 0.201 | 43 | | | | | 0.00935 | 0.30221 | 0.00000 |
| 16 | 1.000 | 16 | | | | | | | 0.00000 | 1.06383 | 0.00000 |
| 17 | 0.033 | 4 | 0.967 | 37 | | | | | 0.00110 | 0.96691 | 0.00000 |
| 18 | 1.000 | 18 | | | | | | | 0.01281 | 0.00000 | 0.00000 |
| 20 | 1.000 | 20 | | | | | | | 0.00000 | 1.03093 | 0.00000 |
| 22 | 0.661 | 4 | 0.274 | 16 | 0.036 | 37 | 0.029 | 44 | 0.00000 | 1.10527 | 0.02922 |
| 23 | 1.000 | 37 | | | | | | | 0.00000 | 1.03093 | 0.00000 |
| 24 | 0.292 | 3 | 0.708 | 43 | | | | | 0.01264 | 0.40864 | 0.00000 |
| 25 | 0.306 | 4 | 0.694 | 37 | | | | | 0.00120 | 1.05984 | 0.00000 |
| 26 | 0.497 | 4 | 0.499 | 37 | 0.004 | 44 | | | 0.00000 | 1.15201 | 0.03048 |
| 27 | 0.978 | 37 | 0.022 | 44 | | | | | 0.00000 | 1.09357 | 0.03076 |
| 33 | 0.002 | 4 | 0.525 | 16 | 0.385 | 20 | 0.087 | 37 | 0.00081 | 1.30211 | 0.00000 |
| 34 | 0.978 | 37 | 0.022 | 44 | | | | | 0.00000 | 1.24757 | 0.03509 |
| 37 | 1.000 | 37 | | | | | | | 0.00000 | 1.02041 | 0.00000 |
| 44 | 1.000 | 44 | | | | | | | 0.00000 | 0.00000 | 0.10753 |
| 46 | 0.545 | 16 | 0.364 | 20 | 0.091 | 37 | | | 0.00000 | 1.21951 | 0.00000 |
| 47 | 0.511 | 16 | 0.404 | 20 | 0.085 | 37 | | | 0.00000 | 1.11111 | 0.00000 |
| 48 | 0.511 | 16 | 0.404 | 20 | 0.085 | 37 | | | 0.00000 | 1.19048 | 0.00000 |
| 50 | 0.980 | 37 | 0.020 | 44 | | | | | 0.00000 | 1.13206 | 0.03184 |
| 52 | 0.027 | 4 | 0.973 | 37 | | | | | 0.00127 | 1.11667 | 0.00000 |
| 42 | 0.120 | 4 | 0.352 | 16 | 0.469 | 20 | 0.059 | 37 | 0.00000 | 1.11926 | 0.02793 |
| 43 | 0.000 | 44 | 1.000 | 43 | | | | | 0.01176 | 0.00000 | 0.03633 |
| 36 | 1.000 | 37 | | | | | | | 0.00000 | 1.08696 | 0.00000 |
| 35 | 1.000 | 35 | | | | | | | 0.00000 | 0.91512 | 0.30990 |
| | | | | | | | | ***Sum:*** | 0.06921 | 27.8311 | 0.74941 |

**Appendix 8 Efficiency analysis results, Master in management (MiM)**

| *School* | *F (VRS)_MiM* | *Bias-corrected F (VRS)_MiM* | *Var_MiM* | *Upper bound (97.5%)_MiM* | *Lower bound (2.5%)_MiM* |
|---|---|---|---|---|---|
| **20** | 1.000 | 0.978 | 0.000 | 0.998 | 0.958 |
| **17** | 0.990 | 0.977 | 0.000 | 0.989 | 0.960 |
| **1** | 0.999 | 0.972 | 0.000 | 0.998 | 0.923 |
| **14** | 0.987 | 0.971 | 0.000 | 0.984 | 0.951 |
| **23** | 0.990 | 0.968 | 0.000 | 0.988 | 0.934 |
| **4** | 1.000 | 0.954 | 0.001 | 0.998 | 0.892 |
| **37** | 1.000 | 0.951 | 0.001 | 0.997 | 0.884 |
| **15** | 0.976 | 0.950 | 0.000 | 0.974 | 0.913 |
| **43** | 1.000 | 0.950 | 0.001 | 0.997 | 0.897 |
| **16** | 1.000 | 0.927 | 0.004 | 0.997 | 0.802 |
| **18** | 1.000 | 0.927 | 0.005 | 0.998 | 0.801 |
| **35** | 1.000 | 0.927 | 0.004 | 0.998 | 0.798 |
| **3** | 1.000 | 0.926 | 0.004 | 0.997 | 0.798 |
| **44** | 1.000 | 0.925 | 0.005 | 0.997 | 0.791 |
| **47** | 0.942 | 0.925 | 0.000 | 0.940 | 0.893 |
| **36** | 0.939 | 0.916 | 0.000 | 0.938 | 0.883 |
| **22** | 0.927 | 0.907 | 0.000 | 0.925 | 0.882 |
| **42** | 0.918 | 0.901 | 0.000 | 0.916 | 0.880 |
| **27** | 0.913 | 0.900 | 0.000 | 0.912 | 0.882 |
| **11** | 0.921 | 0.896 | 0.000 | 0.918 | 0.868 |
| **25** | 0.904 | 0.888 | 0.000 | 0.902 | 0.874 |
| **50** | 0.882 | 0.866 | 0.000 | 0.880 | 0.847 |
| **26** | 0.877 | 0.863 | 0.000 | 0.875 | 0.847 |
| **48** | 0.879 | 0.859 | 0.000 | 0.877 | 0.827 |
| **13** | 0.874 | 0.855 | 0.000 | 0.871 | 0.833 |
| **12** | 0.867 | 0.848 | 0.000 | 0.865 | 0.822 |
| **52** | 0.858 | 0.845 | 0.000 | 0.856 | 0.831 |
| **46** | 0.859 | 0.841 | 0.000 | 0.857 | 0.809 |
| **34** | 0.800 | 0.776 | 0.001 | 0.798 | 0.740 |
| **33** | 0.775 | 0.751 | 0.001 | 0.773 | 0.716 |
| **24** | 0.722 | 0.697 | 0.001 | 0.720 | 0.659 |