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Maintaining Sustainable Accounting Systems in Small Business

Luísa Cagica Carvalho and Elisa Truant

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Maintaining Sustainable Accounting Systems in Small Business

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Small and medium enterprises (SMEs) have a prominent role in both the European and the Italian economies, but their approach towards corporate social responsibility (CSR) and sustainability is still underdeveloped. The reasons are mainly related to perceived low economic returns, lack of enforced compliance of the legislation, limited financial and practical support. In overcoming these problems, the role of small and medium practices (SMPs) can be determinant due to the relationship between SMEs and their (not only accounting) consultants. This chapter focuses on SMPs' role in promoting SMEs' initiatives and also considers the academic debate about their sustainability reporting. The investigation of this stream of research and the results of a web survey (involving SMPs in the Northeast of Italy) emphasize how SMPs can support SMEs' sustainable practices and reporting.

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Urban public transport seeks the mobility of citizens within the municipal area, and it is a service whose importance is on the increase as a consequence of the ever more dynamic changes in life and work. This chapter analyzes companies that provided services for Italian cities in 2010, estimating the environmental efficiency for the service, using DEA (data envelopment analysis) technique. In the Italian context, both large enterprises and SMEs operate, and this study compares whether the differences in efficiency levels can be explained in terms of the type of company.

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The analysis and the consideration of the sustainability development throughout the SMEs has been less considered by the academic literature than the one developed by large firms so far, although small and medium enterprises represent the majority of the local businesses in many geographical areas of the world. Since small and medium entrepreneurs usually do not know how to tackle the challenges concerning internationalization and sustainability, a managerial model for underling which kind of relationships and interactions must be built is the real aim of the present chapter. In order to do that the chapter is focused of a limited area, the Piedmont Region (Italy), to deep analyse the relationship SMEs can create and improve with the local institutions, associations, and business partners.

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Energy management has emerged as a comprehensive framework for implementing sustainable accounting initiatives. This chapter elaborates and explains the energy management and auditing practices in the context of Indian micro, small, and medium enterprises (MSMEs). MSMEs form a neglected but a large part of the Indian economy. The chapter delves upon the importance of implementing energy management in MSMEs. Moreover, MSMEs are generally inefficient in their energy usage due to lack of technological upgradation. Therefore, energy management initiatives are of greater relevance for this sector. Energy management requires the coordination among a network of organizations including the focal organization, the government bodies, NGOs, and trained energy consultants. For energy management

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Chapter 2
Environmental Efficiency Analysis of Bus Transport in Italy:
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ABSTRACT

Urban public transport seeks the mobility of citizens within the municipal area, and it is a service whose importance is on the increase as a consequence of the ever more dynamic changes in life and work. This chapter analyzes companies that provided services for Italian cities in 2010, estimating the environmental efficiency for the service, using DEA (data envelopment analysis) technique. In the Italian context, both large enterprises and SMEs operate, and this study compares whether the differences in efficiency levels can be explained in terms of the type of company.

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INTRODUCTION

Urban transport provides residents with mobility in municipal areas and this increasingly important service is a consequence of far reaching changes in lifestyles and work patterns. As residential areas spread into the outskirts, businesses re-locate into industrial estates and university faculties create out-of-town campuses, there is greater need for access which public transport must provide.

There has often been a lot of focus on the economic outcomes of transport issues, but less consideration given to social and environmental aspects, like transport emissions.

Public transport is a means for people to move around a town efficiently with the least impact on the environment and help reduce, for instance, CO2 emissions.

During the last few decades, sustainability - and in particular the environmental issue - has become a variable that needs to be analysed and measured (Carpenter, 1993).

This chapter addresses two related themes concerning "good" and "green" urban transport with particular reference to the provision of urban bus services in Italy.

The first theme examines the way public urban transport providers can measure efficiency: in particular, the chapter considers the theoretical and practical issues that an urban transport provider could encounter when benchmarking the situation.

The results of empirical studies concerning the efficiency of public services indicate that private sector participation in public services has generally improved the efficiency of those services (as suggested by property rights and public choice theory). However, the effects are largely dependent on other governance arrangements (e.g. contracts) and the particular industry context (e.g. level of competition).

In Italy, externalisation of public services favoured different forms of governance: private corporations, outsourcing, public-private partnerships and privatisation (Doherty & Horne, 2002; Torres & Pina, 2002; Crediop, 2004; Reichard, 2008; Keune et al., 2008). The urban bus services sector was also subject to externalisation and today the sector is characterised by the presence of large companies (mostly public-private partnerships) and small-medium enterprises (SMEs), ie private companies.

The second theme considers the differences in behaviour of small-medium and large companies and how these differences can be a means of explaining the disparity in attitude by transport providers to the potential benefits of benchmarking.

This is important because understanding what is best quality performance and attempting to move towards an industry best is one of the most secure ways of ensuring the provision of quality services in a sustainability stable environment.

There is a plethora of management models and ideas which can be used in a business context to improve business performance. Benchmarking has been a key tool in the business improvement armoury for many years.

Benchmarking is a way of measuring how good the business is at what it does, making a quantitative statement as to whether its performance is as good as other businesses and using this information to improve its business process. Benchmarking, then, is a tool for finding an industry's best practices, leading to improvement in performance. Benchmarking can be applied widely and can cover all aspects of measurable activity: it could cover both inputs (internal efficiency) and outputs (revenue and passenger responses) in an urban bus context.

After having carried out some benchmarking, the organisation will have acquired an in-depth knowledge of itself. The benchmarking measurement process provides a baseline data set for improvement and for target setting which the whole organisation can understand. Areas for potential improvement are identified and target values (perhaps with intermediate milestones) can be set.

Benchmarking is a key step in a continuous improvement process although it will not add value in itself – it is the catalyst to change. Value is only added through achieving real improvements.

CHARACTERISTICS OF URBAN TRANSPORT IN ITALY

Legislation concerning public transport in Italy is the 1997 Law No. 59 and, in particular, the Decree No. 422 of the same year which triggered real reform in the sector in the late 90s. This law's main aim was to regionalise the sector so that regions and other local authorities (provinces, boroughs, rural communities, etc) would be assigned planning and delivering roles concerning public transport at regional and local levels. These are transportation services for both people and goods via land, water and air that are not part of the national network and that run continuously or periodically with set routes, times, frequencies and prices. These services are available to the public on a regional or inter-regional scale. So, the regions and other local authorities were assigned powers to legislate in order to carry out the principles established in the framework of the law. They could then give local authorities duties that did not require regional approval.

The state would maintain the following powers for:

- All those covering national public transport, for example:
  - Air transport, except exclusively regional connections and helicopter services.
  - Sea transport, except coastal navigation which is mostly done regionally.
  - International car transport, except cross border and inter-regional routes that connect more than two regions.
  - International railway services as well as medium-long, higher standard national railway services.
  - Sea connections between railway terminals.
  - Transport of dangerous, harmful and polluting goods.
- Some public transport services of regional and local interest, for example:
  - Agreements, conventions and international treaties concerning cross border services for transporting people and goods.
  - Safety measures.
  - Introduction of guide lines and framework principles in order to reduce pollution caused by the public transport system.

It is also important to mention the role carried out nationally by the *Transport Regulations Authority* which came into existence under Art. 37 of the Decree No. 201 in 2011 and which, together with certain amendments, became law under Law No. 214 of the same year. It operates within the public services regulations authority under the 1995 Law No. 481. This Authority is responsible for regulating the transport sector, access to relative infrastructure and accessory services. Its mandate includes defining the quality levels of both national and local transport services and minimum rights that users can exert over transport companies. According to Art. 14 (2) of Legislative Decree No. 422/1997, when undertaking their urban planning duties, the regions are responsible for the following: a) defining the routes when planning local transport and in particular local ways b) draw up regional transport plans and updates considering local authorities' planning and in particular local ways made available by the provinces and/or metropolitan areas. This is in connection with local planning and economic development plans and aims to guarantee a transport network that encourages integration between the different forms of transport and favours those with less environmental footprint.

The term "minimum services" indicates services which are qualitatively and quantitatively sufficient to satisfy people's demands for transport and costs are included in the regions' budget. In fact, under Art. 14 (3) of Legislative Decree No. 422/1997, the regions must approve three-year local public transport programmes with the aim of determining: a) the network and organisation of services; b) integration of different means of transport with prices; c) resources to assign to management and investments; d) ways of establishing prices; e) ways of implementing and revising public service contracts; f) system of monitoring the services; g) criteria for the reduction of congestion and pollution.

Additionally, Art. 16 (1 and 2) of Legislative Decree No. 422/1997 highlights important criteria for defining the "minimum services". For example: a) integration of transport networks; b) school and work commuter needs; c) use of services in order to access administrative, health and cultural facilities; d) need to reduce congestion and pollution; e) use of different means of transport most able to satisfy travellers' needs, with particular attention to those with reduced mobility; f) choice of solutions designed to guarantee sufficient transport services at as low a price as possible, including different means of transport; g) consideration of the impact of outside forces like traffic congestion and pollution, when determining the costs of road transport.

In order to appoint regional and local transport service providers, discourage monopolies and introduce rules of competitiveness, national and European laws (Legislative Decree No. 422 of 1997, Law No. 102 of 2002, Law No. 99 of 2009 and European Regulations No. 1370 of 2007) name three different application procedures: a) open tender; b) in house c) direct contracts within set thresholds.

Lastly, management of local and regional public transport by appointed transport operators – regardless of contract type – can only be regulated via service contracts that do not exceed nine years. These contracts must define: a) validity period; b) characteristics of the services offered and schedules; c) minimum standards of quality of service regarding age, maintenance, comfort and cleanliness of vehicles, regularity of services; d) price structure used; e) total sum local authority might have to pay the transport company for services rendered under contract and payment conditions, including possible adjustments following changes in fare structure; f) procedures for modifying contract following its conclusion; g) guarantees that transport company must give; h) fines following breach of contract; i) redefining commitment, with reference to staff and capital invested by the public transport company following drop in demand during the contract period; l) obligation of issuing recognised transport sector contracts for staff as required by the largest national trade unions and employers' associations.

The *National Report of Infrastructure and Transport* was set up by the Ministry of Infrastructure and Transport for bus transport services (which is of major interest in this paper). Its latest issue reports that there are 997 local public road transport companies in Italy operating regionally (in 2014) and 248 of these only transport passengers in and around the city (24.9%), 535 only out of town (53.7%) and 214 (21.5%) both (See Table 1).

Companies in the sector are extremely diverse in terms of size (number of employees). In fact, there are 592 operators (59.4%) in the 1-10 employees range (with 332 or 56.1% in south Italy and the islands), 179 with more than 50 employees (17.9%) and 126 (12.6%) large firms (over 100 employees) are mostly in north Italy. This distribution of companies over the country shows subtle differences. 29.5% (294) are

Table 1. Local public transport (bus sector): Companies shown by geographical area and type of services offered – Year 2014

Geographic Areas	Total Number of Companies	Only City Service	Only Out of Town Service	Mixed Service
North Italy	**294**	42	180	72
Central Italy	**163**	101	14	48
South Italy and islands	**540**	105	341	94
Total	**997**	**248**	**535**	**214**

Source: National Report of Infrastructure and Transport – Years 2014-2015, pag. 151

based in north Italy, 16.3% (163) in the centre and the remaining 54.2% (540) in the south and on the islands. 44.3% of the companies (239) with no more than 5 employees are in south Italy and the islands and just 9.1% (49) with over 100 (Table 2). Even observing the geographic distribution of the companies and number of means of transport used, a different structure can be seen. In fact, 243 companies of a total of 427 (56.9%) with a maximum of 5 buses operate in the south and on the islands, while 45.7% of firms with over 100 buses (53 out of 116) operate in the north (Table 3).

Table 4 highlights certain ratios between characteristics of local bus companies (total employees and total buses used) and the resident population in each of the three geographic areas. In particular, it

Table 2. Geographic areas of local public transport companies (bus services) by number of employees – Year 2014

Geographic Area	Total Number of Companies	Number of Employees (Classes)					
		1-5	6-10	11-20	21-50	51-100	Over 100
North Italy	**294**	124	51	21	21	20	57
Central Italy	**163**	59	26	24	25	9	20
South Italy and the islands	**540**	239	93	81	54	24	49
Total	**997**	**422**	**170**	**126**	**100**	**53**	**126**

Source: National Report of Infrastructure and Transport – Years 2014-2015, pag. 153

Table 3. Geographic areas of local public transport companies (bus services) by number of buses used – Year 2014

Geographic Area	Total Number of Companies	Number of Buses Used (Classes)					
		1-5	6-10	11-20	21-50	51-100	Oltre 100
North Italy	**294**	119	55	23	26	18	53
Central Italy	**163**	65	27	24	23	3	21
South Italy and the islands	**540**	243	112	72	57	14	42
Total	**997**	**427**	**194**	**119**	**106**	**35**	**116**

Source: National Report of Infrastructure and Transport – Year 2014-2015, pag. 154

Table 4. Geographic distribution of employees and buses used – local public transport companies (bus companies) – City and out of town services – Year 2014

Geographic Area	Total Employees	Buses Used	Pesident Population	Employees/Residents (x1,000)	Buses/Residents (x1,000)
North Italy	32,990	20,021	27,785,211	1.19	7.21
Central Italy	19,864	10,713	12,070,842	1.65	8.88
South Italy and the islands	31,626	15,210	20,926,615	1.51	7.27
	84,480	**45,944**	**60,782,668**	**1.39**	**7.56**

Source: National Report of Infrastructure and Transport – Years 2014-2015, pag. 156

comes to light that the ratio between employees per 1,000 residents and that between buses and every 1,000 residents have a higher value compared to the national average in central Italy (respectively, 1.65 v 1.39 and 8.88 v 7.56) while the minimums were recorded in north Italy.

Lastly, Table 5 shows some data concerning overall supply and demand of local public transport (buses).

FOCUS OF THE MAIN CHAPTER

The main objective of this chapter is to analyse efficiency in Italy's public urban transportation sector. In fact, CO2 emissions were also taken into account with the aim of highlighting the environmental impact.

We focused on CO2 emissions due to their major contribution to global climate change and consequential growing concerns.

Our analysis covers 156 Italian companies that provided urban bus services, in 2010.

As we saw earlier, both large and small-medium sized enterprises (SMEs) now operate this service following the outsourcing process of the sector.

The main methodology used to analyse this efficiency is Data Envelopment Analysis (DEA). DEA is a non-parametric technique that has enjoyed great popularity in measuring performance for benchmarking purposes by defining efficiency scores for each company.

We set the following objectives:

1. To estimate efficiency scores for public urban transportation service, using (among others) those resources to reduce e.g. Co2 emissions.
2. And to contrast whether differences in efficiency levels can be explained in terms of enterprise type (large companies versus smes). When analysing the resources used and outputs obtained, any excesses of input used or increases in output necessary to improve the performance come to light.

Therefore, this study attempts to contribute to the literature by presenting a non-radial and input-oriented DEA framework based on the slacks-based measure (SBM) to assess environmental efficiency in Italy's transportation sector.

Table 5. Some indicators of supply and demand of local public transport (bus companies) – Year 2014

Demand	
	2014
Total number of passengers (millions)	**3,746.0**
City service	2,822.9
Out of town service	923.1
Total passengers-km (billion)	**29.118**
City service	11.207
Out of town service	17.911
Supply	
	2014
City service	
Buses used	18,606
Bus-km (millions)	698.95
Places available (millions)	1.60
Places-km available (milioni)	62,810.24
Out of town service	
Buses used	27,338
Bus-km (millions)	1,047.69
Places available (millions)	1.84
Places-km available (millions)	70,884.89
Total	
Buses used	45,944
Bus-km (millions)	1,746.64
Places available (millions)	3.44
Places-km available (millions)	133,695.13

Source: Own data taken from National Report of Infrastructure and Transport – Years 2014-2015, pag. 156-158

CORPORATE EFFICIENCY STUDIES IN THE URBAN TRANSPORT SECTOR

Several studies have analysed urban transport service efficiency, with the use of non-parametric techniques. Here is a quick look at some of them.

Karlaftis et al. (2004) presented a review of papers analysing the performance of transport systems. Daraio et al. (2016) offered a critical discussion of the existing empirical studies, relating them to the main methodological approaches used. The comprehensive classification of selected relevant dimensions of the empirical literature, namely inputs, outputs, kinds of data analysed, methods adopted and policy relevant questions addressed, and the systematic investigation of their interrelationships are summarised.

Tomazinis (1977) analysed parameters in order to measure public transport systems and defined some simple concepts for evaluating them, like efficiency, productivity and service quality. Fielding et al. (1985 a,b) published many parameters that could be used to assess performance, and put them into three categories: efficiency, effectiveness and overall performance (which included the first two).

Viton (1997) studied the efficiency of the US bus system, applying DEA to 217 public and private companies and using these parameters: vehicles/distance in miles and passengers transported (outputs) and average speed, average age of fleet, miles travelled, fuel used, personnel employed in the transport service, maintenance personnel, administrative personnel, capital and costs (inputs).

Using a DEA model, Chu et al. (1992) and Viton (1998) created a unique measure of performance, determining that the US bus system saw an improvement in productivity between 1988 and 1992. They also noted that efficiency and effectiveness are generally negatively correlated.

Nolan (1996) analysed technical efficiency of 29 average sized US bus systems with a DEA model. They used bus numbers, total employee numbers and fuel consumed as input and vehicles per mile as output.

Levaggi (1994) used a DEA model to 55 urban transport companies in Italy. They selected the number of kilometres travelled, average speed, capital represented by proxy, vehicle numbers, and a capacity coefficient defined by the ratio between passengers by kilometre and available seats per kilometre and population densities as output. They used employee costs, fuel used, miles travelled, population density and vehicle numbers as input. They discovered that firms operated with excess capital, excess bus capacity and that salaries represented a high percentage of total costs.

Karlaftis and McCarthy (1997) found that systems that scored well on one aspect of performance (e.g. efficiency, effectiveness or overall performance) generally did well on the others although this contradicts Chu et al. (1992).

Karlaftis (2004) used a DEA model on 259 US systems and defined three different models matched to specific parameters. The models had different outputs: vehicles/distance in miles; passengers per mile or passengers transported; or both, together. They used total employee numbers, fuel used and vehicle numbers as inputs. They determined that efficiency was positively related to effectiveness and that the importance of economies of scale depended on the output selected.

Husain et al. (2000) also applied a DEA to evaluate Malaysian public transportation service efficiency, with 46 service units. They used employee numbers and total labour costs as inputs. They selected total services and companies' gross revenues as outputs. They determined that more efficient companies had higher revenues.

Pina and Torres (2001) compared the efficiency of public and private sectors in the provision of urban transportation services of Catalonia (Spain). The results conclude that exogenous factors are not relevant and that private management of urban transport service is not more efficient than public management.

As inputs they choose: gas/distance in kilometres; cost/km or cost/passenger; and subsidy/passenger. As output they selected: bus number per kilometre per employee (bus-km/employee) a variable that provides information on urban transport performance in respect to regarding total employees; number of buses per kilometre per year – a variable that shows average productivity and the bus use level; number of buses per kilometre per resident, representing public transport supply in each city; and as indicators of quality: accident rate and frequency and agility of service provided.

Garcia Sanchez (2009) undertook a comparative efficiency analysis of public bus transport in Spain using Data Envelopment Analysis. Efficiency levels are negative in relation to population density and peak-to-base ratio. Nevertheless, efficiency levels are not related to the form of public versus private ownership.

Roy and Yvrande-Billon (2007) investigated the impact of ownership structures and contractual choices on technical efficiency in the French urban public transport sector. They found that the technical efficiency of urban public transport operators depends on the ownership regime and type of contract governing their transactions.

De Gruyter et al. (2016) assessed the sustainability of urban public transport systems in cities by adopting a quantitative measurement framework containing 15 public transport sustainability indicators. It compares aggregate sustainability performance of urban public transport in international regions of cities, and then examines the relative sustainability of selected cities in the Asia and Middle East region.

Ying et al. (2014) improved a DEA model to evaluate eco-efficiency analysis using environmental pollution as an undesirable output in 30 Chinese provincial capital cities.

RESEARCH DESIGN

This section outlines the research design to assess urban transport efficiency. The research method is described first, followed by an overview of selected public transport variables (input and output) and the description of the sample identified to evaluate the level of efficiency.

Research Method

The study relies on efficiency measurement via Data Envelopment Analysis a non-parametric technique introduced by Charnes et al. (1978). The Constant Returns to Scale (CCR) DEA developed by Charnes, Cooper and Rhodes (1978) is grounded on Farrell's work (1957), *"The measurement of productive efficiency"* and the main advantages are the ability to accommodate multiple inputs and outputs, the no a priori weights assumption and the requirement of small numbers of observations (Sexton, 1986). The DEA has acquired huge popularity in measuring performances because of it providing a synthetic set of performance for similar units denominated Decision Making Units (DMUs). DMUs are defined as entities (firms) responsible for turning inputs into outputs and presenting its managers and decision- maker setting the goals and choosing how to achieve them.

The basic model was enhanced by Banker, Charnes and Cooper (1984) in order to account for the evaluation of Variable Returns to Scale and become the BCC model (VRS). The VRS model searches for pure technical efficiency (also called managerial efficiency) and includes the so-called convexity constraints by changing the specification of the problem and providing the measure of Managerial Efficiency θ VRS adding $e\lambda = 1$ to the programme (θ is a scalar and λ is a vector of constants). From its inception, the DEA has treated each DMU as a "black box" by only considering the inputs consumed and the final outputs produced by this "black box" (Färe & Grosskopf, 2000). However, the efficiency measure is associated to the use of a minimum number of inputs in order to produce a certain number of outputs or the maximum production of outputs using a certain number of inputs (Fethi & Pasiouras, 2010) from which the orientation issues descend.

As is widely known, there are two types of DEA models; the radial (CCR) and the non-radial.

Due to the neglect of slacks, by radial model, when reporting the efficiency score, it is important to remember how relevant slacks are when evaluating managerial efficiency. Therefore, the DEA frameworks of this study are based on the Slack-Based Model (SBM) a non-radial model developed by Tone (2001). The model deals with input excess and output shortfall of each DMU, called Slacks and projecting each DMU to the furthest point on the efficient frontier by minimising the objective function and finding the maximum slacks.

The following figure presents the SBM linear models. In the case of the SBM model the variables s^+ and s^- are the measurement of the distance of inputs $X\lambda$ and outputs $Y\lambda$ of a virtual unit from those of the unit that was evaluated.

Giving the purpose of the analysis, it is important to choose an appropriate model orientation (Charnes et al., 1978; Banker et al., 1984; Coelli, 1996; Coelli et al., 2005;). The SBM considers the input-oriented model efficiency under assumption of the constant and variable returns to scale in order to further account for the scale efficiency. The input orientation is, fundamentally, addressed by the question: "How much can input quantities be proportionally reduced without changing the output quantities produced?"

The input orientation is chosen because of its increasing efficiency by potential reduction in the level of inputs relative to the given level of outputs considered and because it satisfies the Pareto-Koopmans sense of technical efficiency quantified by non-radial DEA models and the assumption of the variable returns to scale as per (Tone, 2001).

The following table shows the linear formulation of the CRS SBM Model.

The variables s^+ and s^- measure the distance of inputs $X\lambda$ and outputs $Y\lambda$ of a virtual unit from those of the unit evaluated (X_o). The measurements of the average distance of inputs and outputs from the efficiency threshold is provided by the numerator and the denominator of the model. For the Variable Returns to Scale, the $e^T\lambda = 1$ condition needs to be added to the formula. Under the DEA framework an efficient DMU scores $\theta = 1$ (100% efficient), while the DMUs scoring less than 1 are inefficient. The SBM CRS efficiency rate is always lower or equal to that of the input-oriented VRS model.

Table 6. Linear formulation CRS SMB Model

SBM Model (Constant Return to Scale) *Input oriented*

$$\rho = \min_{\lambda, s^-, s^+} \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{s_i^-}{x_{io}}}{1 + \frac{1}{s}\sum_{r=1}^{s} \frac{s_r^+}{y_{ro}}}$$

$$\begin{aligned} s.t.\quad & \boldsymbol{x}_o - \boldsymbol{s}^- = \boldsymbol{X\lambda} \\ & \boldsymbol{y}_o + \boldsymbol{s}^+ = \boldsymbol{Y\lambda} \\ & \boldsymbol{\lambda} \geq 0, \boldsymbol{s}^- \geq 0, \boldsymbol{s}^+ \geq 0 \end{aligned}$$

Source: own elaboration

In order to account for scale dimension, the measure of the Scale Efficiency is evaluated by the ratio of SBM-CRS efficiency scores to SBM-VRS efficiency scores. The lower the scale efficiency, the higher the impact of scale size (Thanassoulis, 2001).

After having chosen the proper model and orientation, another relevant aspect refers to the variables selection. The variable must respect an initial condition regarding the number of inputs and outputs in relation to the number of DMUs. In this context, Golany and Roll (1989) postulate the "rule of thumb" for which the minimal number of DMUs for the selected model should be at least double the considered inputs number, while Bowlin (1998) mentioned the necessity of having a number of DMUs at least three times the sum of inputs and output. Ozbek et al. (2009) refer to this issue by considering the minimal number of DMUs (n) as: $n > 2ms$, where m is the number of inputs and s is the number of outputs.

Inputs and Outputs

Efficiency is the ratio of output (services or products) to input (resources) for a given production unit under given conditions. Outputs should be the key business drivers critical to business success and inputs should be the resources that lead to the key business drivers. The definitions of the set of inputs and outputs are of paramount importance in evaluating efficiency, yet the literature on efficiency analysis in urban public transport is relatively homogeneous regarding the definition of inputs and outputs. This study uses six inputs and three outputs.

Turning our attention first to input variables, these normally fall in two main categories: "physical" production factors with their own measurement units (number of employees, number of vehicles, etc.) on one side, and costs in monetary units on the other, that are further split into capital expenses and operating expenses. The average number of employees (workforce average), number of vehicles in the fleet (vehicles operated) and CO2 emissions in the first category are largely the most considered variables as they represent the main inputs in the production process. As regards the costs in monetary units we analogously find that the prices of labour (personnel costs), capital (investments) and the operational costs are the far more utilised.

On the output side, we put variables related to the effectiveness of the production process, such as number of passengers (passengers transported) and the financial counterpart of the second one, as it considers the service revenues (sales revenues) and production value.

Data Sample

The data on urban transportation was provided by the Italian Local Public Transport Association (ASSTRA) which welcomes companies both owned by local and private entities.

Urban and extra-urban transport companies, bus services, trams, metro, cableway installations, some railway stations and shipping companies adhere to ASSTRA.

The database produced by ASSTRA cover over 100 cities for 156 urban transportation companies and include a range of indicators spanning public transport supply and demand, user and operational costs, system productivity, and environmental impacts. The database is available for 2010 only. 31 small-medium companies and 125 large companies are included in the database. There are 114 public owned companies and 42 private.

Table 7 presents the definitions, units of measurement, and descriptive statistics (mean, standard deviation (SD), minimum (Min) and maximum (Max)) of the input and output variables.

Figure 1. Schematic diagram of inputs and outputs
Source: own elaboration

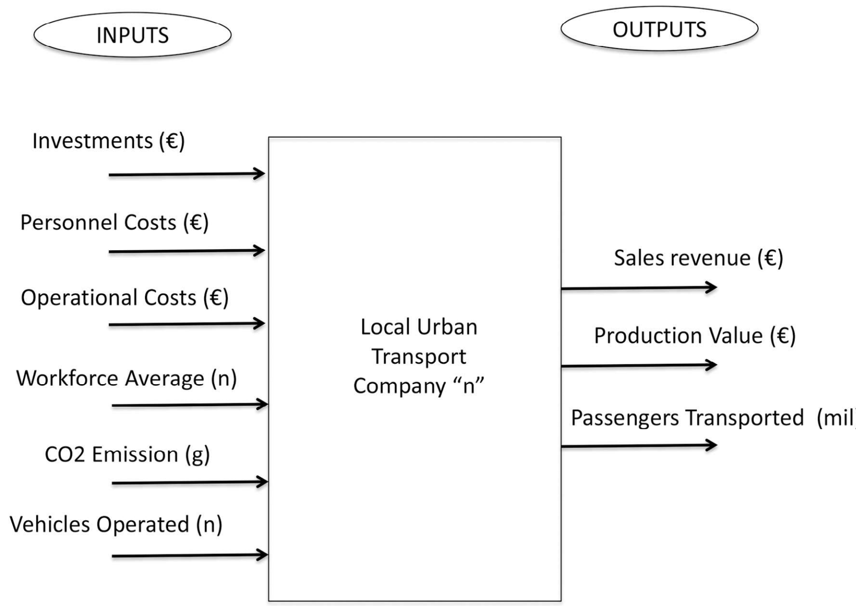


Table 7. Descriptive statistics

	Variables	Units	Min	Max	Mean	SD
Investments	Input	Euro	8.797	871.967.907	24.127.863	84.173.895
Personnel Costs	Input	Euro	63.218	566.150.343	24.953.493	55.042.888
Operational Costs	Input	Euro	361.837	1.356.703.558	52.216.798	126.663.469
Workforce Average	Input	Unit	2	12.693	575	1.231
CO2 Emission	Input	Gram	98,28	110.208	7.922	13.543
Vehicles Operated	Input	Unit	1	2.808	264	410
Sales Revenue	Input	Euro	144.759	853.704.878	33.603.361	83.618.396
Production Value	Input	Euro	278.490	1.049.186.481	49.873.208	106.595.673
Passengers Transported	Input	Million	0,02	670,27	26,86	69,29

Source: own elaboration

FINDINGS

Steps of the SBM DEA model were firstly *taken* with the assumption of constant returns to scale and then with variable returns to scale.

The data analysis showed that there were some significant differences between the urban transportation companies. After the efficiency performance analysis in SBM_CRS model, the final data showed that 30/156 (19.2%) urban transportation companies were technically efficient, with an efficiency score of 1.0, and seven of those were SMEs. The average technical efficiency score across all 156 urban transportation companies was 0.4586 and over 26% of the sample reached higher efficiency than the average i.e. the average efficiency score for SMEs is 0.4536 while it is 0.4598 for large companies (Table 8). Figure 2 shows the technical efficiency scores of the urban transportation companies, which are rank-ordered based on declining efficiency scores. The lowest scoring urban transportation companies had an efficiency score of 0.0857.

In the SBM_VRS model, the final data showed that 44/156 (28.2%) urban transportation companies were managerially efficient, with an efficiency score of 1.0, 10 of which were SMEs. The average managerial efficiency score across all the 156 urban transportation companies was 0.5628 and over 37% of the sample reached a higher efficiency than the average i.e. the average efficiency score for SMEs was 0.5812 while it was 0.5584 for large companies (Table 9). Figure 3 shows the managerial efficiency scores of the urban transportation companies, which are rank-ordered based on declining efficiency scores. The lowest scoring urban transportation companies had an efficiency score of 0.2028.

While analysing the scale of efficiency, it emerges that the average score across all the 156 urban transportation companies was 0.8415 and over 70% of the sample reached a higher level than the average i.e. the scale of efficiency score for SMEs was 0.7993 while it was 0.8520 for large companies (Table 10). Figure 4 shows the scale of efficiency scores of the urban transportation companies, which are rank-ordered based on declining scores. The lowest scoring urban transportation companies had a scale of efficiency score of 0.1231.

Figure 2. DEA SBM-CRS Technical Efficiency Score of the 156 urban transportation companies, rank-ordered in terms of declining scores. Large companies in blue, SMEs in red
Source: own elaboration

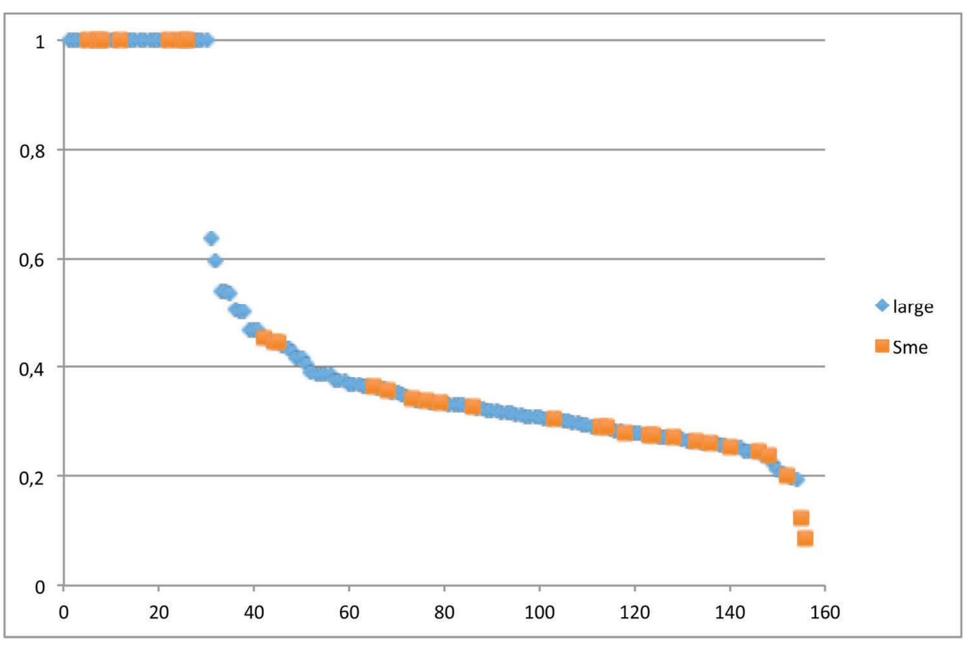


Table 8. DEA SBM-CRS technical efficiency score

	All	SMEs	Large
Mean	0.4586	0.4536	0.4598
Std. Dev.	0.2764	0.3098	0.2688
Min	0.0857	0.0857	0.1933
Max	1	1	1

Source: own elaboration

Figure 3.DEA SBM-VRS Managerial Efficiency score of the 156 urban transportation companies, rank-ordered in terms of declining score. Large companies in blue, SMEs in red
Source: own elaboration

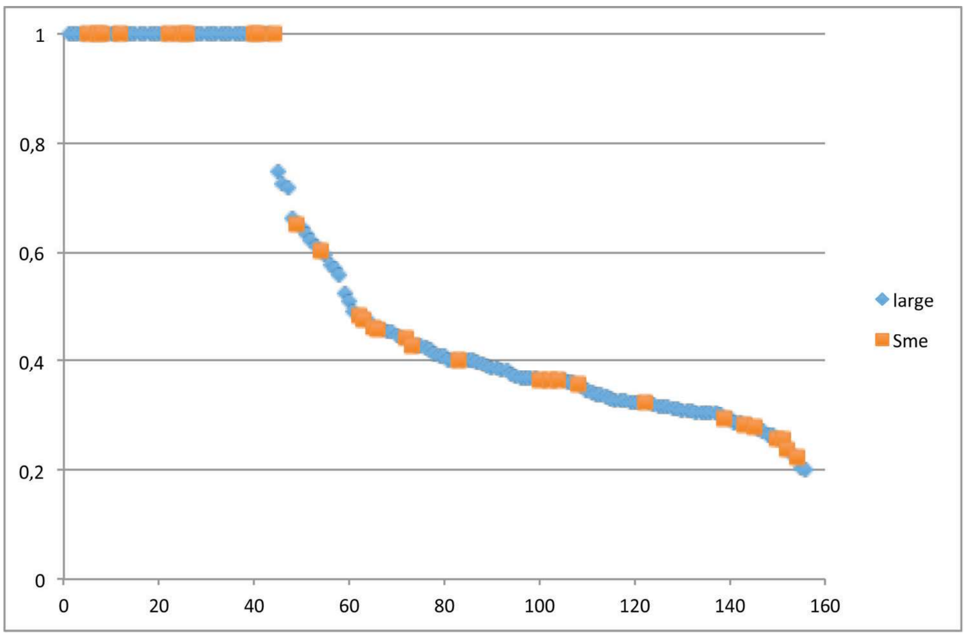


Table 9. DEA SBM-VRS managerial efficiency score

	All	SMEs	Large
Mean	0.5629	0.5812	0.5584
Std. Dev.	0.2916	0.3086	0.2883
Min	0.2028	0.2219	0.2028
Max	1	1	1

Source: own elaboration

Figure 4. DEA Scala Efficiency score of the 156 urban transportation companies, rank-ordered in terms of declining score. Large companies in blue, SMEs in red
Source: own elaboration

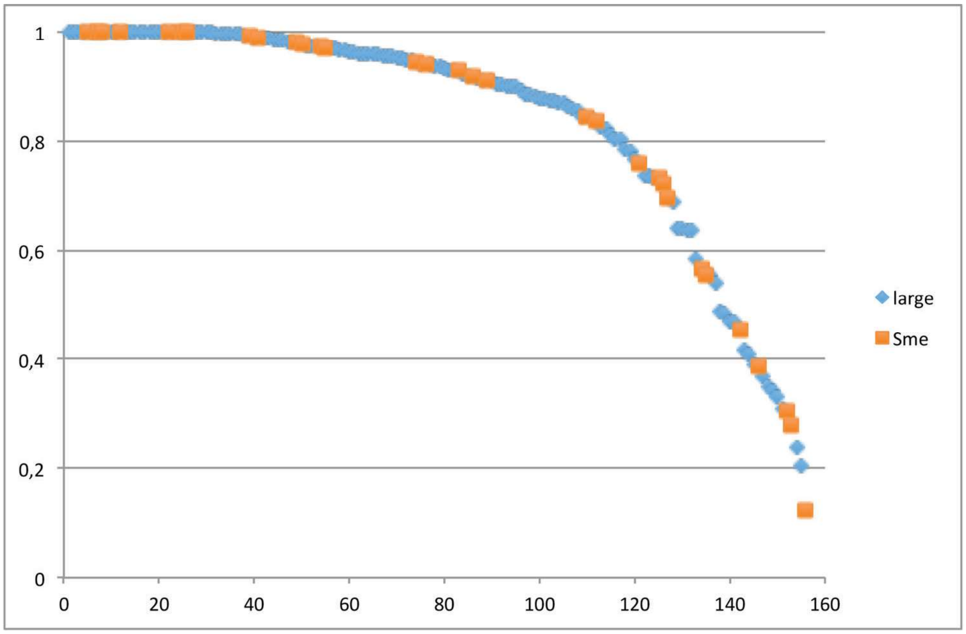


Table 10. DEA Scala Efficiency Score

	All	SMEs	Large
Mean	0.8415	0.7993	0.8520
Std. Dev.	0.2124	0.2560	0.1999
Min	0.1231	0.1231	0.2033
Max	1	1	1

Source: own elaboration

DISCUSSION

The previous Tables report the findings from CRS and VRS analysis of the urban transportation companies. Technical efficiency can be examined by breaking it down into pure technical efficiency and scale efficiency. The average index of pure technical efficiency was at 45.86% and of scale efficiency at 84.15%. However, the means show that most of the technical inefficiency is in the form of scale inefficiency.

Some limitations in the results of the analysis and discussion emerged, such as the number of selected variables and some uncontrolled external circumstances, even though the DEA method is an efficient system in the urban transportation sector. In order to go beyond these limitations and for a more in-depth analysis of the phenomenon, would be appropriate use a greater number of selected variables as well as the introduction of variables that took into account the different conditions of service delivery e.g. the number of hours of service, seating capacity, measured in total seats, the average number of stops per route, the frequency of the service, measured by means of the ratio Hours of service/Average time for route (Garcıa Sanchez, 2009).

It would also be a good idea to include some uncontrollable variables in the analysis that could influence the management of the urban transportation companies, e.g population density, numbers of private vehicles in circulation, the coefficient of intensity in rush hours.

However, the approach used to analyse the efficiency of the urban transportation sector is a valid tool and the results obtained provided useful indications as to the performance and management implications. The authors also calculated the potential for improvement for each inefficient unit in order to provide useful managerial tools.

This is presented as the percentage of change in each input or output variable necessary for the unit to become 100% efficient. It can have a positive or negative value, indicating whether the inputs or outputs are too large or too small to reach the optimal level. The potential improvement is calculated on the actual and target scores (the value of input or output that should be achievable by the sample and which would ensure a 100% efficiency) determined for each sample.

The analysis of slacks for large companies reveals a surplus of resources due to technical inefficiency of around 19 million for investments, 20 million for personnel costs, 3.8 million for operational costs and 1% for CO2 emissions and vehicles used. Production value should also be increased by at least 1%.

The analysis of slacks for SMEs reveals a surplus of resources due to technical inefficiency of around 11 million for investments, 8 million for personnel costs and 1% for CO2 emission and vehicles used. Sales revenues should also be increased by at least 1%.

The analysis of slacks for large companies reveals a surplus of resources due to managerial inefficiency of around 11 million for investments, 13 million for personnel costs, 300 units for workforce average, 1 million operational costs and 150 vehicles used. The number of passengers transported should also be increased by at least 2%.

The analysis of slacks for SMEs reveals a surplus of resources due to managerial inefficiency of around 11 million for investments, 7 million for personnel costs and 1% for CO2 emissions, 200 units for workforce average, and 180 vehicles used. The number of passengers transported should also be increased by at least 1%.

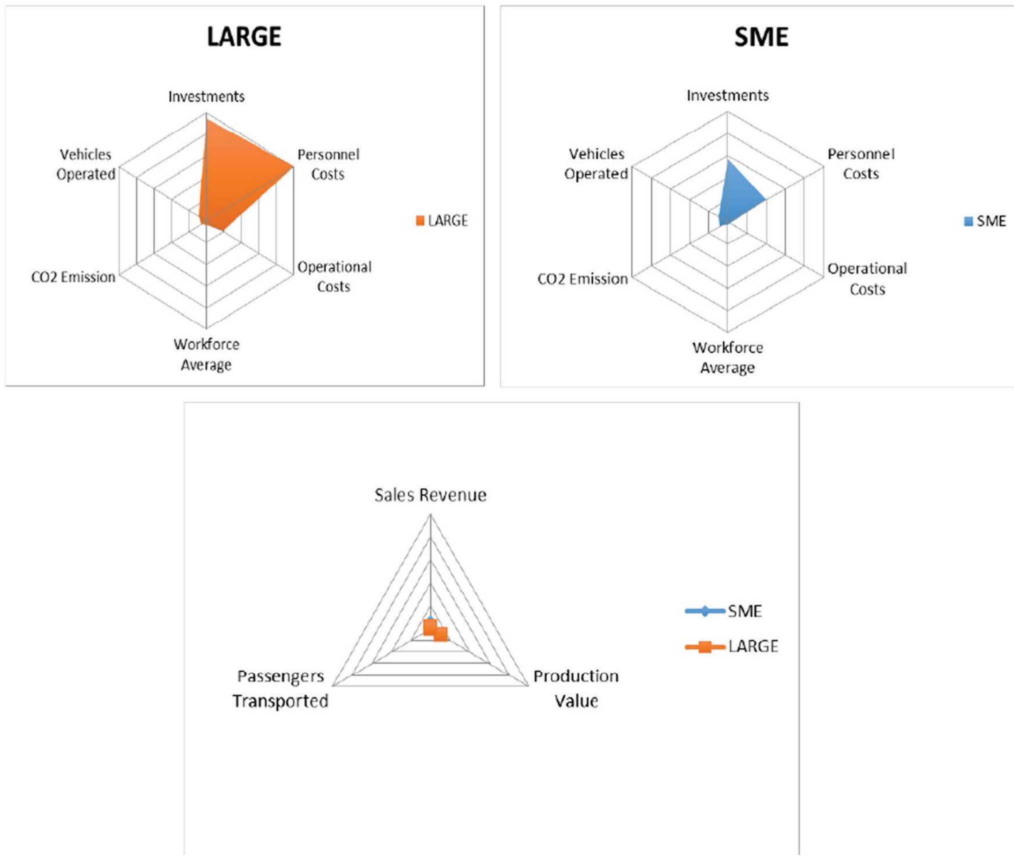
CONCLUSION

Growing interest in evaluating the efficiency of public services is especially important in the municipal area, because of its influence on residents' standards of living. Public bus transport is one of the councils' responsibilities and there is particular interest in introducing managerial improvements due to the characteristics surrounding its performance.

Regarding the results, analysis using the DEA technique reveals that:

- The average index of technical efficiency was 45.86%; managerial efficiency 56.29%, and scale efficiency 84.15%.
- 30 companies are technically efficient. In particular, seven smes – 22.58% - and twenty-three large companies – 18.4%.

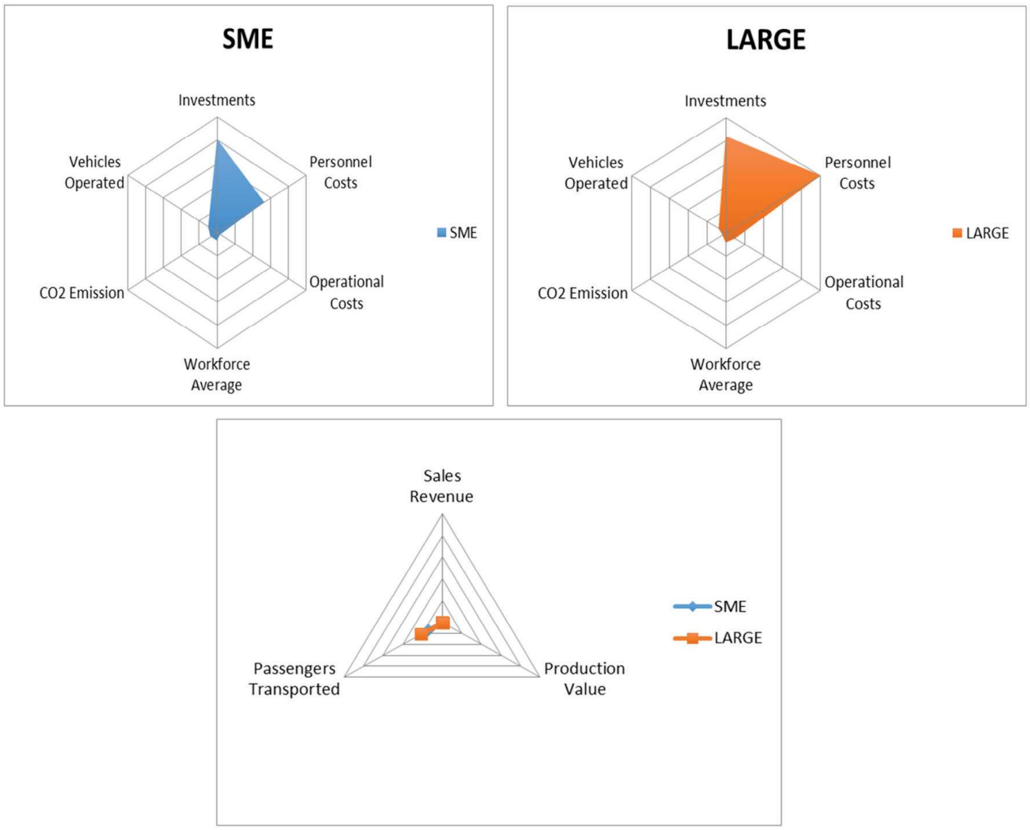
Figure 5. Slacks DEA SBM-CRS for inputs and outputs
Source: own elaboration



- 40 companies are managerially efficient. In particular, ten smes – 32.25% - and thirty-four large companies – 27.2%.
- The analysis of slacks reveals surplus resources for smes and large companies in order for them to improve technical and managerial efficiency, as well as a significant increase of sales revenues, production value and number of passengers transported.
- Regarding environmental impact, smes and large companies reached an acceptable level of co2 emissions.
- Efficiency performance of large companies is limited by ownership characteristics. Large companies are often public companies and limited by the "publicness effect" (Alfiero et al., 2017) that influences some managerial activity and attributes (for instance, the stock of investments, the number of employees, etc).

Our study also shows that the performance differentials between the various regulatory schemes are slight, although statistically significant. The efficiency scores of the operators, whether SMEs or large companies, are low. So, what our results demonstrate is about 81% of all operators operate far from their relative production frontier. Operators are under-producing or not meeting their goals.

Figure 6. Slacks DEA SBM-VRS for inputs and outputs
Source: own elaboration



In terms of policy implications, what our study therefore suggests is that, given the current objectives imposed on operators by local authorities, only marginal positive results on technical efficiency are to be expected from regulatory changes that would consist of improvement of management and high-powered incentives.

This does not mean that the regulatory framework has no effect on technical efficiency, but rather that the main cause of the financial crisis endured by the sector is not technical inefficiency. Performance encompasses dimensions other than technical efficiency like service quality or commercial efficiency which will have to be considered in order to complete our research agenda.

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KEY TERMS AND DEFINITIONS

Data Envelopment Analysis (DEA): A nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision-making units (or DMUs).

Scale Efficiency: Success of a branch at operating in optimum scale. Scale efficient branch works at the most productive scale size.

Slacks-Based Model: A non-radial DEA model that deals with both input excesses and output shortfalls simultaneously and measures efficiency between 0 and 1. SBM is not translation invariant and it identifies more sources of inefficiency.

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