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PUBLIC BUS PASSENGER TRANSPORTATION COMPANY EFFICIENCY ASSESSMENT USING DATA ENVELOPMENT ANALYSIS

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Resumo

As medidas de avaliação de desempenho desenvolvidas e aplicadas nas empresas permitem, entre outras, que estas possam avaliar-se e buscar planos de melhoria. Uma das formas de busca de aperfeiçoamento é através do uso de benchmarking, no qual as empresas se empenham em um sistema de aprendizado, comparando organizações, setores ou unidades. Uma das ferramentas para aplicação do benchmarking é o uso de Análise de Envoltória de Dados (DEA) que, dentre várias unidades produtivas, identifica as eficientes e ineficientes. Com foco nas empresas de transporte coletivo por ônibus da cidade de São Paulo, e com a utilização de dados de 2011, buscou-se verificar a existência de relação entre empresas eficientes operacionalmente x eficientes financeiramente. Os resultados preliminares não permitiram corroborar a hipótese de uma relação com significância estatística entre eficiência operacional e eficiência financeira.

Palavras-chave: Avaliação de Desempenho, Eficiência Técnica, Programação Linear, Análise Envoltória de Dados, Transporte Público por Ônibus.

Abstract

The performance appraisal measures developed and applied at companies allow them to carry out self-assessments and to seek improvement plans, among others. One of the ways of seeking refinement is through the use of benchmarking, in which companies become involved in a learning system, comparing organizations or even sectors. One of the tools for applying benchmarking is the use of Data Envelopment Analysis (DEA) which among several productive units, identifies those that are identifies those, among several productive units, that are efficient and inefficient. An attempt was made to ascertain whether there is a relation between operationally efficient x financially efficient companies. The preliminary results did not allow the corroboration of the hypothesis of a relation with statistical significance between operational efficiency and financial efficiency.

Keywords: Performance Assessment, Technical Efficiency, Linear Programming, Data Envelopment Analysis, Public Transportation by Bus.

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1 Introduction

According to the Brazilian Institute of Geography and Statistics (IBGE), the population of the city of São Paulo surpassed 11 million inhabitants in 2010. If we take into account the 38 municipalities that compose the metropolitan region of São Paulo, we will arrive at approximately 17 million people. According to data from the Municipal Department of Transportation of São Paulo, 55% of motorized trips in this region take place by public transportation, totaling six million passengers transported per business day.

To meet the passenger demand in the city, São Paulo Transporte S/A manages the concession of lines to various bus companies, all of private enterprise. Today, the system is operated by 13 consortiums, formed by 28 companies and cooperatives, responsible for the operation of 15 thousand vehicles on almost 1,500 lines.

To link São Paulo to the city's other regions, the metropolitan bus system, under the responsibility of EMTU, also subordinated to the state government, offers an extensive network of lines operated by privately held companies, an intercity corridor on a separate lane with diesel bus and trolleybus trunk lines, besides a special highway service, which covers the Guarulhos International Airport.

All the bus lines are operated by concessionaires, under the supervision of SPTrans. The latter issues operation service orders for each line, including definition of routes, hours of operation and necessary fleet. Ticket payments can be made by users in cash or by means of a card called "Bilhete Único" (like Unified Ticket). The abovementioned managing body also coordinates the implementation and/or use of the bus corridors and bus terminals of the municipality.

The current model of municipal public transportation in São Paulo splits the city up into nine different areas, whereas plots were established for eight of them (1 - Northwest, 2 - North, 3 - Northeast, 4 - East, 5 - Southeast, 6 - South, 7 - Southwest and 8 - West) for the distribution of the companies and cooperatives that render the transportation services by bus, microbus, van and trolleybus.

Area 9 is that of the central region of the city, which does not have specific plots, so that there is no company or cooperative operating specifically within these limits. The lines that operate exclusively within the limits of area 9 come under the responsibility of companies from areas 1 to 8, usually that are located closest to the point considered the starting point of the line (a rule that has several exceptions).

The Municipal Transportation System comprises an integrated network, created by the Municipal Department of Transportation in 2003, together with SPTrans. This network allows faster travel and rationalization in the use of the means of transportation in the city.

Chart 1:
Companies that form the consortiums

Area	Consortium	Companies
Area 1	Consórcio Bandeirante de Transporte	Viação Gato Preto Ltda. / Viação Santa Brígida Ltda.
	Consórcio Transcooper Fenix	Fênix – Cooperativa de Trabalhadores no Transporte Coletivo da Grande São Paulo
		Transcooper – Cooperativa de Trabalhadores dos Profissionais no Transporte de Passageiros em Geral da Região Sudeste
Area	Consórcio Sambaíba	Sambaíba Transportes Urbanos Ltda.

2	Consórcio Transcooper Fênix	Fênix – Cooperativa de Trabalhadores no Transporte Coletivo da Grande São Paulo Transcooper – Cooperativa de Trabalhadores dos Profissionais no Transporte de Passageiros em Geral da Região Sudeste
Area 3	Consórcio Plus	Expandir Empreendimentos e Participações Ltda. VIP Transportes Urbanos Ltda.
	Consórcio Aliança Paulistana	Associação Paulistana dos Condutores de Transporte Complementar da Zona Leste Coopernova Aliança – Cooperativa de Transporte Alternativo Nova Aliança
Area 4	Consórcio Leste 4	Ambiental Transportes Urbanos S/A (formerly Himalaia) Empresa de Transportes Coletivos Novo Horizonte S/A
	Consórcio Transcooper Fênix	Transcooper – Cooperativa de Trabalhadores dos Profissionais no Transporte de Passageiros em Geral da Região Sudeste
Area 5	Via Sul Transporte Ltda.	Via Sul Transportes Urbanos Ltda.
	Consórcio Aliança Cooperpeople	Coopertranse – Coop. Dos Trab. Espec. em Transp. de Pass. em Geral no ESP Coopernova Aliança – Cooperativa de Transporte Alternativo Nova Aliança
Area 6	Consórcio Unisul	TUPI Transportes Urbanos Piratininga Ltda. / Viação Cidade Dutra Ltda MobiBrasil Transporte Urbano Ltda. (formerly Metropolitana) VIP Transportes Urbano Ltda.
	Consórcio Authopam	Cooperativa dos Trabalhadores Autônomos Transporte de São Paulo – Cooper Pam Consórcio dos Trabalhadores em Transporte Coletivo de Passageiros e de Cargas do Estado de São Paulo – Cooper Líder
Area 7	Consórcio 7	Transkuba Transportes Gerais Ltda. / Viação Campo Belo Ltda. Viação Gatusa Transportes Urbanos Ltda. / VIP Transportes Urbanos Ltda.
	Consórcio Authopam	Cooperativa dos Trab. Autônomos em Transp. De São Paulo Cooper Pam
Area 8	Consórcio Sudoeste de Transporte	Viação Gato Preto Ltda. / OAK TREE Transportes Urbanos Ltda. Transppass Transporte de Passageiros Ltda.
	Consórcio Unicoopers Cooperalfa	Cooperalfa – Cooperativa de Trabalho dos Condutores Autônomos Unicoopers – Coop. Unificada de Transp. Coletivo Urbano de Passageiros

Source: SPTrans

All the companies listed above received codes according Area and their position.

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2 Referencial Teórico

2.1 The importance of measuring performance

The survival of companies in the market is determined, among other factors, by a relation between the organization's objectives and the operation of its activities. According to Smith (2005), performance management is the key to the attainment of best managerial practices to achieve the goals and objectives of any institution.

This performance management affords, among others, optimization in the use of resources and/or in production, seeking alignment between resources, people, production and

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efficiency across the company (strategic, tactical and operational levels) so as to maximize income.

According to Hronec (1994), performance measures represent the vital signs of a company. The author sees performance measurement as a means of quantifying the activities within a process or, moreover, of verifying whether its outputs achieve the specific goal, and this process should not present interruptions, i.e., it should be seamless for information feedback, while the company will consequently be able to generate new goals and adapt its strategies.

Besides monitoring the system through the implementation of indicators, the models should also allow constant improvement in the appraised performance, which could be achieved through a comparison of the evaluated units, through benchmarking process.

The application of benchmarking consists of a comparison of two or more productive units geared towards an investigation of the best processes at companies that lead to a better performance. Through a proactive procedure, it is possible to ascertain how another DMU performs a specific task with the intention of improving the performance of the same task. Min and Min (1997) cites benchmarking as a continuous process for quality improvement, evaluating its internal strengths and weaknesses and the advantages of the best competitors.

Drew (1997) mentions that benchmarking has become one of the tools used most often for strategic management, owing to the possibility of obtaining learning in a more agile manner. The author also argues that benchmarking interacts with the success of processes, in the development of new products and organizational changes at companies, warning that benchmarking, on its own, does not lead to a competitive advantage as it is geared towards the development and implementation of procedures that are imitators or offer little innovation.

Drew (1997) also declares that benchmarking has been accepted by many organizations as an important organizational learning tool, but draws attention to the limitations of its use. The author asserts that the benefits of its use translate into transmission and absorption of knowledge far beyond the limits of the organization, and that this knowledge can lead companies to reflect on the knowledge acquired.

2.2 Operational and Financial Performance Appraisal Measures

As the need to implement a performance appraisal measurement system must be aligned with the company's objectives, many indicators were created as tools that help the organization to achieve its goals.

Having identified the objectives of the appraisal measurement in the organization, it is important to define the model of indicators that will be responsible for measuring performance, in view of the vast range of existing appraisal measures.

As mentioned by Rafaeli & Müller (2007), many proposals have been developed and implemented to measure the performance of processes, areas or companies, including TQM - Total Quality Management. Other tools such as TOC - Theory of Constraints; IC – Intellectual Capital and the Quantum and Rummler and Brache models were also developed.

Endeavoring to identify the metrics used for financial performance, scholars share the consensus that there are an infinite number of models and indexes. The use of just one of the countless metrics as a single financial performance appraisal measure might not appear reasonable, as each one of them indicates varied benefits and caters to different interests. The various financial performance constructs can offer advantages and disadvantages, depending on the point of view of each stakeholder, and they should be chosen carefully so as not to generate disinformation or biases.

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Peterson and Peterson (1996) mentions that the traditional measures of financial performance are all based on accounting data. The major advantage in the use of these measurements is the availability of information, which is all found in the financial statements, besides their easy calculation and interpretation.

The Boston Consulting Group/FGV (1999) mentions that companies have discovered that financial performance measures differing from traditional measures are better at translating performance and assist in the management of companies when making decisions that create shareholder value.

Young & O'Byrne (2001) classify the performance appraisal measures in five categories:

• Residual income measures: consider the cost of capital (own and third party). This measure is characterized as not incorporating the appreciation generated by the market on future growth opportunities. E.g.: CVA (Cash Value Added), Economic Profit, EVA® (Economic Value Added);

• Residual income components: meaning the elements of income that do not include the costs of capital. These components are widely used at the lower levels of the company's organizational structure. E.g.: EBIT (Earnings before Interest and Taxes); EBITDA (Earnings before Interest, Taxes, Depreciation and Amortization), which is the EBIT plus depreciation and amortization; NOPAT (Net Operating Profit after Taxes) and RONA (Return on Net Assets);

• Market-based measures: meaning some measures derived from the capitals market. E.g.: TSR (Total Shareholder Return) and MVA® (Market Value Added). Market-based measures are only possible for public organizations with shares traded in the market;

• Cash flow measures: these are structured to circumvent the influence of the accrual basis used in accounting. E.g.: Cash Flow from Operations; Free Cash Flow for shareholders and CFROI (Cash Flow Return on Investment);

• Traditional income measures: these include the measures that executives and external analysts have focused on for decades. E.g.: Net Income and Earnings per Share.

Finally, Traditional Income measures have the advantage of being available in the financial reports. However, they do not consider the cost of equity and there is the possibility of their manipulation, thus entirely distorting the value created.

In Measuring Organizational Performance - Metrics for Entrepreneurship and Strategic Management Research, Carton and Hofer (2006), after a survey of the literature on firm performance, conclude that there is no common point of the variables that should be considered when measuring the company. In all, the authors examined five approaches to the economic and financial performance of a company: accounting, the Balanced Scorecard, strategic management, entrepreneurism and microeconomics, whose main characteristics are listed below:

From the perspective of the use of accounting to measure organization performance, there is the advantage of the standardization of the financial statements and of the rigor in record keeping, minimizing bias formation (Carton & Hofer, 2006). Besides this advantage, accounting can also inform the company's value creation.

Finally, the microeconomic perspective where two approaches are covered: Economic Value and the Neoclassical Theory of Production.

In the Economic Value perspective, Barney (2001) mentions that the value created is precisely the value consumed in the use of assets. Contradicting the idea that the company does not present profits, the concept becomes different, since nominal profit differs from economic profit. Economic profit is nominal profit minus the average cost of capital. And average cost of capital is based on future returns adjusted by the risk of operations, while

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economic profit is equal to the value creation necessary to cater to the interest of investors. Thus, if this value creation is not sufficient to fulfill the minimum required return, the company will have difficulty staying afloat, since there would be a flight of resource providers. On the other hand, if the company generates more value than expected by the market, these manage to attract more resources to meet a higher demand resulting in competitive advantage.

The perspective based on the neoclassical theory of production explains that, at a company, there is an inflow of resources and raw materials (inputs) of all kinds to produce an outflow of products and/or services (outputs). This relation between inputs and outputs can be described through a production function such as, for example, in the case of a product P produced for n inputs X, the function would be as follows:

$$P = f(X_1, X_2, X_3, \dots, X_n).$$

Koopmans (1951) mentions in his study that a company is efficient if it manages to increase the production of a product without, however, decreasing the production of another. Efficiency can also be understood as profit maximization or cost minimization. Watson & Holman (1979) state that a firm's productivity is the ratio between the goods and services produced and its resources used, as follows:

$$Productivity = \frac{Goods\ and\ Services\ Produced}{Resources\ Used}$$

This microeconomic perspective appears to be the most suitable for addressing a performance measure to gauge the efficiency of transportation companies, which can be applied using the Data Envelopment Analysis approach.

2.3 Data Envelopment Analysis

DEA, or Data Envelopment Analysis, can be more easily understood if we clarify some of its concepts and composition, pertaining to the model, such as:

• DMU – Decision Making Unit (DMU) – It is important for these units to have the same resources (inputs) and to obtain the same products (outputs).

• Inputs – meaning the resources (inputs) consumed by the DMUs for desired production; the fewer the resources used, the better for the DMU.

• Outputs – meaning the products (results) generated by the DMUs; the more there is produced, the better for the DMUs.

• Production Plan: meaning the ratio between the units of inputs used and the outputs produced by each one of the DMUs;

• Efficiency Score – meaning an efficiency ranking generated for each DMU, through linear programming. The indicator ranges from 0 to 1, whereas an efficiency score equal to 1, shows the efficient unit(s) in relation to the others.

The DEA approach allows users to allocate various inputs and products to calculate the efficiency of the DMUs. Once the efficient and inefficient companies have been identified, an efficiency border can be built with the efficient units, which will serve as benchmarking for the inefficient units.

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Since it is possible to find different sizes of DMUs within a DEA approach, there are two DEA models that concern about their sizes. The CCR model (Charnes, Cooper & Rhodes, 1978), also known as CRS - Constant Returns to Scale,) allows constant returns to scale and understands that there is a proportionality between the input and output variables.

The BCC, or VRS - Variable Returns to Scale (Banker, Charnes & Cooper, 1984) model, assumes that there is no proportionality between the input and output variables, but instead convexity between them.

Due to the input and production variables, the DEA models can present two orientations: input orientation, which will identify as efficient DMUs those that minimize the use of resources, (ii) and the output orientation, which will measure the efficiency of the DMUs by the efficiency of their production without however, altering their expenditures.

For a performance measurement model for transportation companies, the DEA model to be recommended is the BCC (or VRS), since the units under evaluation present significant differences in scale. An input-oriented model should also be adopted since they are variables closer to being controlled than the output variables.

One of the recommendations in the use of this approach (DEA) is the definition of how many input and output variables should be used. Depending on the sample size, a large quantity of inputs and outputs may result in a border with 100% of efficient DMUs. One of the empirical recommendations is that the quantity of DMUs should be double or triple the quantity of variables. Gonzáles Araya (2003) recently suggested that this number is even higher (4 to 5 times) when, besides the efficiency border, it needs to analyze the benchmarks of the analyzed units.

There is also the possibility of combining the different forces of each one of these approaches in a hybrid method (Tofallis, 2001), where, as a first priority, the border units are identified by the DEA, defined on a surface. This allows a greater advantage in relating multiple results or outputs with multiple inputs to be estimated.

While there is a consensus about the best input variables to be used, there is a constant discussion about the output variables that should be used. One group defends the use of supply-oriented pure measures, such as kilometers per vehicle or kilometers per seat, while another group defends demand-oriented measures, i.e., passengers and passengers per kilometer. Those who defend the use of supply-oriented measures argue that demand is not a controlled variable of management. Those who defend demand measures argue that what ultimately counts is the vehicle body since otherwise the companies that drive their buses empty through less congested areas would be the most efficient.

3 Methodological proposal of preliminary analysis and the database

To evaluate the operational efficiency of bus companies from the city of São Paulo, six variables were selected that indicate the classical relations between production, capital and labor, all from the year 2011. The quantities of lines that each company operates, the average operating fleet, numbers of departures, and the average administrative expense per vehicle were selected as input variables. The variables that represent total passengers and total kilometers driven over the year were used as output variables. Out of all the chosen variables, the only one that could be used both as an input and as an output is the total kilometers driven. If used as an input, it would end up indicating that the shorter the routes for a particular quantity of passengers, the better for the operating company. However, the public transportation managing body of the city manages not only the interest of companies, but particularly of the population in general, and it understands that the longer the distance driven, the better the service delivered to the population in general.

Chart 2:
Inputs and Outputs used to measure operational efficiency

Operational Efficiency	Input	Output
	Quantity of line Fleet Departures Expenses per vehicle	Passengers carried Kilometers driven

Source: The author

In the evaluation of the financial efficiency of these companies, seven variables were selected that form economic and financial efficiency metrics. The total assets of the company, shareholders' equity and the average administrative expense per vehicle were used as input variables. As outputs, the variables represented total net revenue, net income for the current year, current ratio and return on assets. In transportation, and quite possibly in other industries, one of the recurring concerns is the payment capacity of suppliers, especially during recessions or in times of crisis. This capacity provides the company with the assurance that there is no interruption in the supply of inputs, and for this reason the liquidity indicator was added to the model. Return on Assets is also an important indicator, as it represents the return on its operational activity, of crucial importance to the shareholders.

Chart 3:
Inputs and Outputs used to measure financial efficiency

Financial Efficiency	Input	Output
	Total Assets Shareholders' Equity Expenses per vehicle	Net Revenue Net Income Current Ratio Return on Assets

Source: The author

It should be observed that a certain degree of homogeneity is required among DMUs for their definition. In this analysis, it was confirmed that all the companies operate only with passenger transportation, are circumstantiated in the same city, have the same variables and follow the determinations of the same managing body. Accordingly, none of them had to be excluded due to lack of homogeneity.

The model of choice was the input-oriented DEA BCC, since there are significant differences in scale between DMUs, and the objective is to verify whether the production obtained justifies the quantity of resources allocated. The same output-oriented model was also applied. The results of the DEA model were obtained using the DEA-Solver software, available at *www.saitech-inc.com*. Judging by the variation existing in the size and in the characteristics of the companies, the hypothesis of constant returns to scale would be inappropriate, which justifies the choice of a model of variable returns (DEA BCC model).

In the outlier detection analysis of this study, two DMUs were found to be present with a high current ratio (CR-42.54): PA32 and PA3252. In verifying the first type of ratio cited by Bogetoft (2011), the veracity of the data was confirmed. No technological innovation or new management practiced was verified either, indicating that there may have been some excess inflow of cash on the last days of the fiscal year, reflecting a value that is not normal with the sample, which caused its removal.

Thus, having observed all the stages for assembly of the model, the input-oriented DEA BCC model was run with operational data, obtaining an efficiency score ranking the companies from most efficient to least efficient. The input-oriented DEA BCC with financial data was run concomitantly, also obtaining an efficiency score ranking the companies.

With the obtainment of the two scores, operational and financial, Pearson's Correlation was applied to show the level of adhesion between companies with operational efficiency and with financial efficiency. A Scatter Diagram was also generated with the purpose of verifying the behavior between operational and financial results.

After this first round, some tests were carried out to verify the behavior of the efficiencies with another model: the product-oriented BCC. Following the same stages for the input-oriented BCC, the testers thus found two scores ranking the companies, to which Pearson's Correlation and Scatter Diagram were applied.

The sample consists of public bus transportation companies from the city of São Paulo. Initially, 39 DMUs were detected, but after some had been eliminated, 27 remained for analysis. The elimination occurred as they did not all have the necessary information to apply the model. Units PA21, PA22, PA31, CA41, PA52, CA64, CA74, PA71, CA83 and PA11PA21 did not have financial statements for 2011, and were excluded from the sample. Units PA32 and PA32PA52 were excluded as they presented a high current ratio, which would compromise e the application of the DEA approach.

3 Results

3.1 - Operational Efficiency – Input-oriented DEA-BCC model

As presented previously, the variables representing average fleet, administrative expenses per vehicle and numbers of departures were used as inputs, while the variables of passengers carried and kilometers driven, all of 2011, were used as outputs.

Hence the following scores were obtained after applying the model with the help of the DEA-Solver program:

Table 1 – Ranking with scores of the DMUs in the input-oriented BCC model for operational efficiency:

Ranking	Company	Score
1	CA33CA64CA74	1
1	CA11	1
1	PA12PA22PA41	1
1	PA12	1
1	PA81	1
1	CA31	1
1	CA33	1
1	PA31	1
1	CA41	1
1	CA42	1
1	CA81	1
1	PA51	1
1	CA61	1
1	CA62	1

1	CA63	1
1	CA73	1
1	PA62	1
1	CA71	1
1	CA72	1
20	CA11CA83	0,985252
21	CA82	0,970035
22	PA82	0,952087
23	PA61	0,950174
24	CA12	0,942113
25	PA61PA71	0,914249
26	CA21	0,91095
27	CA51	0,882748

Source: The author

3.1 - Financial Efficiency – Input-oriented DEA-BCC models

The variables of 2011 that represent Total Assets, Shareholders' Equity, Expenses per Vehicle, Net Revenue, Net Income, Current Ratio and Return on Assets were used and presented the following statistical data:

The following score was obtained based on these variables as Table 2:

Table 2:
Ranking with scores of the DMUs in the input-oriented DEA-BCC model for financial efficiency:

Rating	Company	Score
1	CA33CA64CA74	1
1	PA12PA22PA41	1
1	PA82	1
1	PA12	1
1	CA21	1
1	CA31	1
1	CA33	1
1	PA31	1
1	CA41	1
1	PA81	1
1	CA81	1
1	PA51	1
1	CA73	1
1	CA72	1
1	PA62	1
16	CA11CA83	0.897268
16	CA11	0.897268
18	CA61	0.857669

19	PA61	0.837287
19	PA61PA71	0.837287
21	CA63	0.828381
22	CA62	0.703622
23	CA12	0.607994
24	CA82	0.361204
25	CA42	0.342614
26	CA71	0.304087
27	CA51	0.23675

Source: The author

4 Analysis and verification of the operational efficiency and financial efficiency scores

Once the results are obtained in the DEA-BCC models, with both orientations and for the operational and financial data, these will reveal whether financial efficiency explains operational efficiency. For this purpose, Pearson's Correlation was used to measure the degree of correlation between the two results: operational and financial. Thus we compared the scores obtained by the input-oriented DEA-BCC models, with the following result:

Chart 4:
Comparison between the scores generated by the input-oriented DEA-BCC models – Operational and Financial

Company	Operational Efficiency Score	Rating	Company	Financial Efficiency Score	Rating
CA11	1	1	CA11	0.897267702	16
CA12	0.942112547	24	CA12	0.607993957	23
PA12	1	1	PA12	1	1
CA21	0.910949746	26	CA21	1	1
CA31	1	1	CA31	1	1
CA33	1	1	CA33	1	1
PA31	1	1	PA31	1	1
CA41	1	1	CA41	1	1
CA42	1	1	CA42	0,342614481	25
CA51	0.882748117	27	CA51	0.236750433	27
PA51	1	1	PA51	1	1
CA61	1	1	CA61	0.857669312	18
CA62	1	1	CA62	0.703621501	22
CA63	1	1	CA63	0.82838093	21
PA61	0.95017413	23	PA61	0.837287119	19
PA62	1	1	PA62	1	1
CA71	1	1	CA71	0.304086754	26
CA72	1	1	CA72	1	1
CA73	1	1	CA73	1	1
CA81	1	1	CA81	1	1

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CA82	0.970034805	21	CA82	0.361204058	24
PA81	1	1	PA81	1	1
PA82	0.952086844	22	PA82	1	1
PA12PA22PA41	1	1	PA12PA22PA41	1	1
CA33CA64CA74	1	1	CA33CA64CA74	1	1
PA61PA71	0.914249356	25	PA61PA71	0.837287119	19
CA11CA83	0.985251767	20	CA11CA83	0.897267702	16

Source: The author

Correlation between the scores = 0.355211439

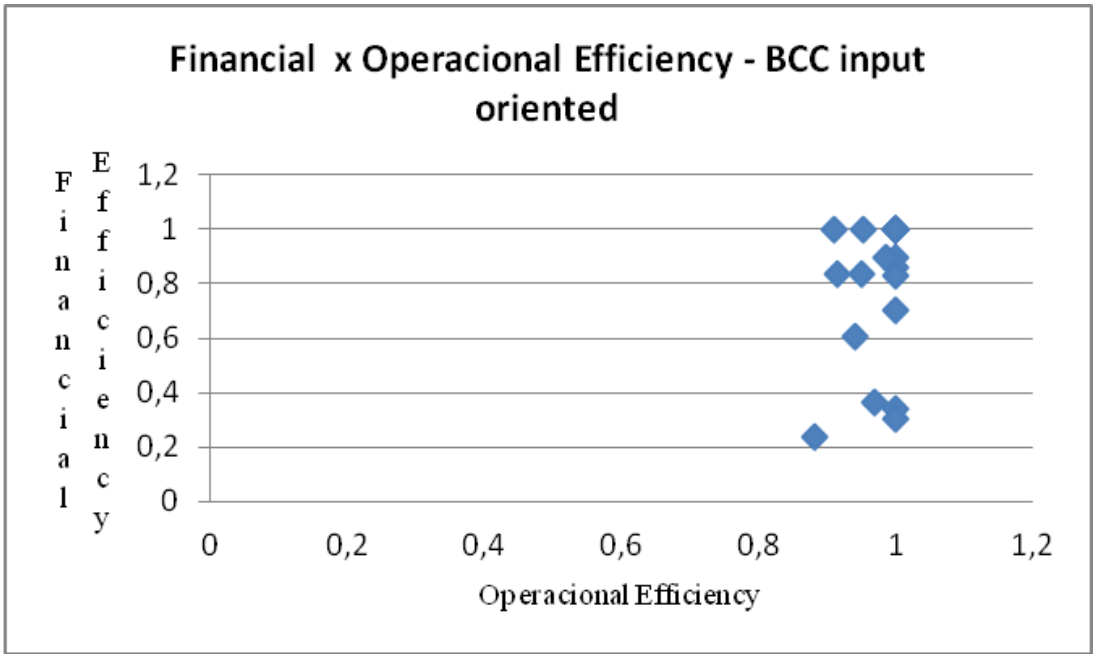

Figure 1 – Dispersion between the operational efficiency and financial efficiency results using the input-oriented DEA-BCC model.
Source: The author

The horizontal axis represents operational efficiency, and it can be seen that the companies analyzed by the DEA-BCC model are very close to the efficiency border. However, greater dispersion can be observed when compared with the y-axis, which represents financial efficiency. Therefore, we verified that operationally efficient companies can become financially inefficient as is the case of CA11, CA42, CA61, CA62, CA63, CA71 and PA12PA22PA41.

It was also observed that companies which are not operationally efficient achieved financial efficiency, as is the case of the companies CA21 and PA82. It can be deduced that it is possible for an operationally efficient company to be financially inefficient rather than an operational inefficient company be financially efficiently, showing that operational efficiency explains financial efficiency more than the opposite.

Once the pairs of information (operational score x financial score) referring to each company have been plotted, a point cloud is obtained that is defined by x and y coordinates. This cloud, in turn, should define an axis or direction that would characterize a pattern of

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relationship between x and y. The regression will be linear if a trend or axis is observed in the Cartesian point-cloud.

In the Scatter Diagrams on Figure 1, note that there is no explanatory relation between the variables. The diagrams do not indicate that the y-values vary in relation to that of x, i.e., operational efficiency does not explain financial efficiency. The ratio is not representative (0.35), within a scale of -1 to +1.

5 Final considerations

The DEA models proposed for comparative performance appraisal provide, with the available variables, a distinct view between operationally efficient and financially efficient companies. The results of the application undoubtedly allow us to conclude that financial efficiency and operational efficiency are not incompatible. The good use of resources in the operational process and good financial results were found in many bus companies. However, it was also confirmed that some operationally efficient companies did not present good financial results, providing an opportunity for further research with the intention of identifying possible agency problems. Results were also obtained with operationally inefficient, yet financially efficient companies, suggesting that one type of efficiency does not determine the other.

In this study, it is apparent that public bus passenger transportation companies in the city of São Paulo operate relatively very close to the efficiency border, without major distortions. Much of this operational homogeneity can perhaps be explained by the regulatory actions of the managing body of the city, as well as the vast experience of many of its owners, traditional players of the transportation industry.

We must bear in mind that the bus operating companies from the city of São Paulo were selected through a bidding process for the concession or permission of their public transportation services and, when they do not prove efficient, have high efficiency scores, i.e., close to the efficient border. Bidding processes force operating companies to adopt cost reduction and service quality improvement strategies, including efficiency measures for performance appraisal, with the transfer of these gains to society. Therefore, it is suggested that the management bodies use efficiency evaluations as instruments for monitoring and encouraging operator performance, using the DEA for this purpose.

One of the potentials of the Data Envelopment Analysis is to indicate, to the companies that have proven inefficient, which efficient firms should serve as a reference. The consistency of this technique can be seen in this study as it indicated small companies (in Total Assets or fleet) as a reference for other even larger companies.

In adopting two different types of efficiency (operational and financial, it can be observed that there is a moderate correlation between these efficiencies. In other words, many companies considered efficient in the operational scope were also efficient in the financial scope. Owing to the considerable variation existing in the size and in the characteristics of the companies, the hypothesis of constant returns to scale would be inappropriate, which justifies the option for the models of variable returns.

For future studies within the public transportation system, there is a range of possibilities that could be listed as follows:

- From the strategic viewpoint, there is the possibility of the company, or of the managing body, to analyze the bus lines considering each one of them as a DMU, with inputs consumed and outputs generated between them, which would allow the identification of efficient and inefficient lines. The company would be able to seek new strategies and innovation to improve inefficient lines while the transportation

managing body would be able to seek compensation mechanisms for the companies operating these lines.

- In the managerial aspect, the application of the DEA approach can distinguish between efficient and inefficient managements. Hence the change of command in companies would be a cutoff point for the model to be applied before and after the managerial change, identifying pre- and post-change efficiencies.
- Other variables of interest to the population, such as level of satisfaction, complaints, waiting time, comfort and cleanliness could be used to compose the efficiency of that company, and would be able to encourage the managing body to propose performance-based flexible remuneration.
- Finally, using a more advanced approach in DEA, it is possible to identify technological and/or innovation impacts on the efficiencies of companies. A case open to study is the kind of impact on the efficiency of companies with the implementation of electronic fare collection cards (Unified Ticket). Or alternatively, how efficient companies have become with the implementation of AVLs (Automatic Vehicle Location), a system that helps bus transportation logistics with information such as geographical location of the vehicle in operation, average speed in each segment and at any time, and others.

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