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Empirical Analysis of the Effects of Ownership Model (Public vs. Private) on the Efficiency of Urban Rail Firms

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Abstract: The discussion over public vs. private management in the operation of public transport has been on the research agenda for the past decade. Several studies have analyzed the benefits of private management; however, no study has analyzed the effects of the management model while controlling for other external factors such as economic crises and political factors. This study intends to focus on the impact of the ownership model (public vs. private) of urban rail firms on their efficiency, while expanding the existing literature by controlling for economic and political factors. The methodology consisted of the calculation of DEA scores and subsequent use of regression analysis to identify the main determinants. We used a data set of four Portuguese rail firms during the period 2009–2018 along with five distinct efficiency scores. The results show that privately managed firms tend to be more efficient, but with distinct behavior depending on the economic cycle. In periods of growing GDP, private firms lose their potential superiority over public firms. The results also show that election years and unemployment rate also play a role in understanding the efficiency scores of these firms.

Keywords: data envelopment analysis; efficiency; private sector involvement; urban transport; rail transit



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1. Introduction

The involvement of the private sector in utilities in general and in transportation in particular is not recent; the expansion of such involvement is reported to have occurred in the 1980s and 1990s, driven by an agenda of devolution of public services to the private sector and a recentering of the role of government in planning, regulation and financing [1]. In Europe, the procurement directives introduced in 1993 and subsequent rulings by the European Court of Justice pressed public authorities to put services out to tender, while directives on the liberalization of electricity, gas and other network services have forced the breakup of integrated public sector energy companies [2].

Two major motivations underpin the use of Public Private Partnerships (PPP) and concessions (e.g., [3,4]): (i) overcoming public budget constraints by using private sector funding, even if at a higher interest rate; and (ii) improving service at a reduced cost to end users by utilizing private sector management, knowhow, expertise, and competition to would boost efficiency and encourage innovation. Some authors also argue that private ownership is associated with more efficient debt structures, which results in higher operational efficiency (see [5]).

However, ref. [2] claims that there is a clear trend of municipalities shifting from privatization to ‘remunicipalization’. In several countries in Europe, including Germany, France and the UK, among others, there are various cases of services being brought back under public control in sectors such as water, energy, public transport and waste

management. In many cases, the ending of contract maturity is an important enabling factor, but bases for such decisions regarding the nonrenewal of contracts and changes in the model include cost reduction, higher service effectiveness, better control, private failure and greater flexibility to adjust the service to meet public objectives.

Within the context set above, this paper aims at contributing to the discussion by comparing the economic efficiency of privately and publicly managed urban rail transportation firms in Portugal. This comparison was done through econometric models with a dummy variable identifying the groups of publicly (0) and privately (1) managed firms. The economic efficiency was obtained for a yearly base with a DEA model developed from the financial reporting data of the firms. Several studies have focused on the comparison of public vs. private efficiency, and will be discussed in the literature review; a significant share of these studies concluded by finding potential higher efficiency of privately managed companies, although in many cases this was at the cost of quality of service. This paper provides a new perspective by considering the effects of external events.

Urban transport systems are under significant pressure to be able to tackle increasing demand as a shift from private cars to public systems emerges as a political driver [6], and are also required to perform more efficiently in order to decrease the overall cost of service and the need for funding, whether direct or through taxes [7].

The influence of the type of management on economic efficiency was assessed through regression analysis by controlling for the potential effects of the following exogenous factors: (i) the financial crisis between 2008 and 2010; (ii) the period of the Portuguese bailout program (troika) between 2011 and 2014; (iii) GDP growth; and (iv) the unemployment rate. Additionally, the creation of a regulator for the transportation sector in 2014 and the political cycles identified by the election years were considered. A one-year lead and lag of the election year was also considered. The rationale for including these control variables was to assess the effects of political, economic and institutional factors, all of which can play an important role in efficiency, as discussed by [8,9].

This paper is organized as follows: after this introduction, Section 2 will present the literature review and the derived research questions; Section 3 will discuss the methodology and data used; Section 4 will present the results and the corresponding discussion; finally, Section 5 will present the main conclusions and policy implications.

2. Literature Review and Research Questions

Many authors have addressed the problem of measuring rail efficiency, although from different perspectives, such as assuming a specific definition or measurement of efficiency (e.g., purely cost, financial, economic, environmental, operational, etc.), or looking at different determinants.

Focusing on the most recent contributions, for example, [10] has focused on efficiency from a cost perspective. The authors performed a two-stage DEA model in twenty international urban rail systems (2009–2011). The main purpose was to identify which systems performed more efficiently. They concluded that, for example, Hong Kong exhibited higher levels of efficiency, while Sydney had a higher technical efficiency than allocative and cost efficiency. Other authors have focused on efficiency from an environmental perspective. That is the case, for example, in [11], which analyzed the environmental efficiency of the Hong Kong system, performing a historical analysis of efficiency levels.

The literature also explores the contribution of distinct determinants towards understanding their effects on efficiency. As discussed next, these determinants can be related to organizational forms, urban context, etc.; [12], for instance focused on operational efficiency, but tried to understand the effects of urban organization on the performance of the systems.

An important subset of the literature has focused on the effects of governance and organization; [13] focused on understanding the effects of organizational patterns on urban rail efficiency, using case studies in China. The author concluded that systems operating under PPP regimes tend to exhibit higher levels of efficiency. A similar approach was developed in [14], supporting the same conclusion.

The discussion of the merits and pitfalls of private management of transportation companies has distant roots in economic and management theory ([15,16]). The underlying rationale of the discussion and research has been to identify the optimal ownership models or, in other words, the organizational and ownership models that allow the most efficient use of resources [17]. In fact, the search for the optimal configuration of systems in terms of ownership and regulation should be focused on achieving the most efficient solutions.

In the specific field of rail services and rail urban transit, the discussion in the literature started with the study of case in the UK. The UK had a leading role in fostering private sector participation in rail systems with the Railways Act of 1993 [18]. The first evidence, confirmed by [19], was that it was possible to achieve higher efficiency and lower government subsidies, all without decreasing the quality of service. In [20] it is claimed that British passenger rail privatization stimulated an increase in efficiency while decreasing government subsidies, although at the expense of some forms of the winner's curse syndrome.

However, the British case has been quite controversial, as discussed by [21–23] also claims that efficiency gains have been achieved at the expense of a lower quality-to-price ratio, and therefore the conclusions on the increase in social welfare are less clear.

Other regions have evidenced similar patterns in terms of increased efficiency, as discussed by [24]. These authors analysed the privatization of the Canadian National Railway and found a long-term increase in productivity and profitability, among other financial indicators.

Many authors have found evidence that increasing the role of the private sector can increase productivity and social welfare (e.g., [25–27]). The Japanese experience also seems to support the thesis of a superior performance of private management over purely public management, as extensively discussed by [28,29].

This discussion has mostly been centered on traditional forms of privatization, which have changed over the last 20 to 30 years with an increase in the use of PPPs and concessions. Although many scholars still use the term “privatization”, in many cases, the ownership model is in fact, a PPP or a concession (for more on the distinction between PPP and concession, see [30]).

However, the literature has provided only weak evidence on the influence of external economic factors on the efficiency of companies when taking into account their ownership model. Our study intends to analyse the Portuguese case and assess the effects of private sector involvement in terms of increasing efficiency. Is private management a driver of efficiency for urban transit? How are private and public companies affected by external factors? Are there statistically significant differences? These are our main research questions.

Regarding methodologies, that the large majority of studies have used DEA methods ([14,31,32]), although a few exceptions can be found, e.g., [33], which used an entropy-TOPSIS method. Our methodology will also be a DEA model, as presented and discussed in the next section.

3. Research Methods and Data

Our case study was a set of four urban rail firms operating in Portugal, in the cities of Lisbon and Porto. Portugal has four urban rail companies, three of which are privately managed under concession regimes (Metro do Porto, Metro Transportes do Sul and Fertagus) and one of which is an SOE (State Owned Enterprise), Metro de Lisboa. Metro de Lisboa was originally created in 1959, and since then has been the metro service provider in Lisbon. In 1999 the government awarded a concession for the first privately operated commuter rail. Fertagus won the concession and, since then, has been operating commuter rail services to the city center from the south bank of Lisbon. In 2002 a second urban rail concession was awarded in the south bank region to Metro Transportes do Sul. In the city of Porto, Metro do Porto was created in 1993 with the responsibility for building and operating the system (2003 was the first year of operation). Therefore, there was no privatization in Portugal;

the ownership of the four firms has not changed in their entire operation life, which is consistent with the aims of this research. The information needed in order to evaluate economic efficiency was retrieved from the annual reports from 2009 to 2018 of the four major urban rail firms in Portugal. The results of the three privately managed firms were aggregated to obtain the average efficiency instead of the individual efficiency of each firm. In addition to the type of contract, statistical data were obtained for the unemployment rate (*unra*) and gross domestic product growth (*gdp*). The other potential explanatory variables considered were as follows: (i) election years (*elye*); (ii) financial crisis (*ficr*) period; and (iii) troika (*troi*) supervision period. For the election years, a lead (*elyelead*) and lag (*elyelag*) of one year were also considered. Portugal was severely affected by the 2008 economic crisis until 2010, resulting in the request for an international bailout programme from the European Commission, the European Central Bank and the International Monetary Fund between 2011 and 2014.

A four-step methodology was used in this research: (i) efficiency estimation; (ii) assessment of the uncontrolled effect of the type of management through regression analysis; (iii) assessment of the controlled effect of the type of management; and (iv) evaluation of potential interactions between the type of management and the continuous variables.

The first step consisted of estimating efficiency scores for each group of firms (publicly and privately managed), which was accomplished through data envelopment analysis (DEA). A yearly timescale was used, and a total of five financial efficiency scores were obtained. The scores are presented in Table 1.

Table 1. Variables in the DEA scores.

Scheme	Input	Output
ECON1	Operating costs (€)	Revenue (from tickets) (€)
	Assets (€)	
	Liabilities as percentage of asset (%)	
ECON2	Operating costs (€)	Revenue (from tickets) (€)
	Assets (€)	EBITDA as percentage of revenue (%)
ECON3	Operating costs (€)	Revenue (from tickets) (€)
	Assets (€)	
ECON4	Operating costs (€)	Revenue (from tickets) (€)
		EBITDA as percentage of revenue (%)
ECON5	Liabilities as percentage of asset (%)	Revenue (from tickets) (€)
		EBITDA as percentage of revenue (%)

The economic scores were analysed from 2009 to 2018, and the data of the three privately managed firms were aggregated as one firm. Five combinations of inputs (Operating costs, Assets, and Liabilities as percentage of assets) and outputs (Revenue and EBITDA (Earnings Before Interest, Taxes, Depreciations and Amortizations) as percentage of revenue) were considered, as shown in Table 1. As DEA is used to calculate performance indicators without the need to specify a production function, we used economic data representing different characteristics of the inputs and outputs used in the operation. As inputs in ECON1 we used investment (assets and liabilities as a percentage of assets) and operating costs, in ECON2 and ECON3 we used data related to assets and operation costs, in ECON4 we used only operating costs and in ECON5 we used liabilities (as a percentage of assets). As outputs we always used revenue, and in three cases also used EBITDA as a percentage of revenue. This means that for the ECON1 efficiency score we took into consideration the entire characteristics of the companies, in ECON2 and ECON3 we looked at the efficiency in the utilization of the assets and of the production, in ECON4 we looked at the efficiency of the production and in ECON5 we looked at the efficiency of the liabilities as a percentage of assets.

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sis (DEA). A yearly timescale was used and a total of five economic efficiency scores were obtained.

The model chosen was the CCR [34] model oriented for inputs as shown by Equation (1). This model is also known as constant returns to scale, since it considers that any variation in the inputs generates a proportional variation in the outputs. With orientation for inputs, efficiency is achieved with the minimization of the inputs to obtain a specific level of outputs (Equations (2) and (3)). The model proposed by [34] is as follows:

$$\max h_0 = \frac{\sum_{r \in R} u_r Y_{r0}}{\sum_{i \in I} v_i X_{i0}} \quad (1)$$

subject to the following:

$$\frac{\sum_{r \in R} u_r Y_{rj}}{\sum_{i \in I} v_i X_{ij}} \leq 1, \forall j \in J \quad (2)$$

$$u_r, v_i \geq 0, \forall r \in R, i \in I \quad (3)$$

where J is the set of DMUs ($j = 1, \dots, |J|$), I is the set of inputs ($i = 1, \dots, |I|$), R is the set of outputs ($r = 1, \dots, |R|$), X_{ij} is input i of DMU j , Y_{rj} is output r of DMU j , v_i is the weight of input i , and u_r is the weight of output r .

The linear programming formulation of the model can be written as follows in Equation (4):

$$\max h'_0 = \sum_{r \in R} u_r Y_{r0} \quad (4)$$

subject to the following:

$$\sum_{r \in R} u_r Y_{rj} - \sum_{i \in I} v_i X_{ij} \leq 0, \forall j \in J \quad (5)$$

$$\sum_{i \in I} v_i X_{i0} = 1 \quad (6)$$

$$u_r, v_i \geq 0, \forall r \in R, i \in I \quad (7)$$

while the formulation of the dual programme is stated as follows:

$$\min z_0$$

subject to the following:

$$\sum_{j \in J} Y_{rj} \lambda_j \geq Y_{r0}, \forall r \in R \quad (8)$$

$$\sum_{j \in J} X_{ij} \lambda_j \geq z_0 X_{i0}, \forall i \in I \quad (9)$$

$$\lambda_j \geq 0, z_0 \text{ unconstrained} \quad (10)$$

The uncontrolled assessment of the effect type of management was done, testing whether there was a statistically significant difference between the means of the efficiency of the privately and publicly management firms. Parametric (t -test) and non-parametric (Mann–Whitney U) tests were used depending on the normality of the efficiency scores distribution in each group. The Shapiro–Wilk test was chosen to assess the normality of the data distribution. Complementary uncontrolled analysis of the dataset was done using the same approach with the remaining categorical variables (financial crisis, troika, election years and regulator), however, only the main relevant results are reported here. Regarding the continuous predictors (unemployment rate and GDP growth), the correlation with the efficiency scores globally and for each group were evaluated. Parametric (Pearson) and non-parametric (Kendall's tau and Spearman rho) correlations were used depending on whether the variables evidenced normal or non-normal distribution, respectively. Although not reported here, visual assessment of the data was also carried out with boxplots and scatterplots.

Ordinary least squares (OLS) multiple linear regression was used to evaluate the influence of the contract type on efficiency scores while controlling for the effect of all

other significant predictors. The baseline for the controlled evaluation of the effect of the contract type on the economic efficiency of the road concessions was the following econometric model:

$$Y_i = \beta_0 + \beta_1 \text{troi} + \beta_2 \text{ficr} + \beta_3 \text{gdp} + \beta_4 \text{unra} + \beta_5 \text{elye} + \beta_6 \text{mana} + \beta_7 \text{regu} + \mu_i \quad (11)$$

where

ficr is a variable designed to evaluate the effect of the 2008 financial crisis; it assumes the value 1 between 2008 and 2010 and 0 otherwise.

troi is a dummy variable; the years 2011–2014, period of the International Monetary Fund /European Central Bank/European Union (IMF/ECB/UE) bailout programme, are 1 and zero otherwise.

gdp is GDP growth as a percentage; the objective is to evaluate the effect of economic growth in efficiency.

unra is the unemployment rate as a percentage; employment rate is known to be a relevant proxy for transport demand, and may therefore have the ability to influence efficiency. The analysis also included the log transformation.

elye is a dummy variable that has the value of 1 in years with a national Parliament election (elections for the central government) and 0 otherwise. This variable aims at identifying whether an election and/or a potential policy change had any impact on efficiency. In order to consider lagged impacts, we have also used a lead or a lag of one year in relation to the election year.

mana is a dummy variable that considers the nature of ownership. It assumes the value 0 for the publicly managed urban rail firms and 1 for the group of three privately managed urban rail firms. This approach allows us to assess the specific impact of the type of management on the firms' efficiency overall, but not that of each individual privately managed firm.

regu is a dummy variable representing the creation of the public transport regulator in 2014. It takes the value 0 before 2014 and 1 thereafter, controlling for any effect of this change in the sector on the firm's efficiency.

There is some debate regarding the most adequate modelling approach for the second stage of DEA. In our research, we opted to follow the recommendation of [35], which is to use OLS regression, as the data is not censored, but rather bounded. The DEA results are bounded between 0 and 1, thus the values cannot be above 1 or below 0. Alternative approaches, such as the TOBIT regression, are adequate for situations where the data is censored, which would imply that the DEA results could be higher than 1 or lower than 0 while simply being unmeasurable, which is not the case. Furthermore, the work of [35] reveals that while the two modelling approaches provide different regression coefficients, the statistical significance and sign of the coefficients seem to be consistent, which are the most important aspects on our research.

The selection of the variables to include in the regression models was done using a best subsets approach and using the Akaike information criterion or the adjusted R^2 as the criterion for entry or removal of the predictors in the process of selecting the best subsets. Multicollinearity and heteroscedasticity were assessed through the volume of inflation factor (VIF) and the Breusch–Pagan test, respectively. The normality of the residuals (Shapiro–Wilk test), specification (Linktest), functional form (Ramsey test) and outliers (Cook's distance) were also assessed.

The relation between predictors was evaluated by building a generalized linear model (GLM) with an interaction term. This was done only for the OLS models determined in the previous step with the highest fit (based on the R-squared), with all variables statistically significant and with at least one continuous variable.

4. Results and Discussion

Table A1 (in Appendix A) presents the scores obtained, along with the exogenous variables considered. It is possible to observe that higher efficiency scores seem to exist for most DMUs on the privately managed firms.

Except for the privately managed firms of ECON5, the distributions are normal based on the Shapiro–Wilk test results (not presented). Coincidentally, ECON5 was the only economic efficiency score evidencing a noncontrolled statistically significant difference between privately and publicly managed companies. The statistical significance is confirmed by both the *t*-test results (Table 2) and the Mann–Whitney U test (not presented here), for a significance level of 0.05.

Table 2. Results of the non-controlled effect of the type of management.

VARIABLES		Levene's Test		t-Test		
		F	Sig.	t	df	Sig. (2-tailed)
ECON1	Equal variances assumed	15.365	0.001	−1.672	18	0.112
	Equal variances not assumed			−1.672	11.384	0.122
ECON2	Equal variances assumed	1.696	0.209	−1.915	18	0.072
	Equal variances not assumed			−1.915	15.458	0.074
ECON3	Equal variances assumed	2.541	0.128	−1.817	18	0.086
	Equal variances not assumed			−1.817	14.827	0.090
ECON4	Equal variances assumed	0.900	0.355	−1.725	18	0.102
	Equal variances not assumed			−1.725	17.061	0.103
ECON5	Equal variances assumed	0.224	0.642	2.117	18	0.048
	Equal variances not assumed			2.117	17.716	0.049

Concerning the remaining categorical variables, troika, election years and the introduction of the regulator have a statistically significant effect on most efficiency scores. The financial crisis is only statistically significant on ECON4 and ECON5.

Except for ECON5, there is a statistically significant correlation with GDP growth. In contrast, the unemployment rate only has a statistically significant correlation with ECON1. Regardless of the statistical significance, the sign of the correlations is consistent for all DMUs, with a positive correlation with GDP growth and a negative correlation with the unemployment rate. The former may be due to the relation between wealth and leisure, with an increase in wealth promoting more leisure activities that may require using more public transportation. The latter is probably related to the fact that with an increase in unemployed individuals, the demand for commuting between residence and work decreases. Furthermore, since unemployment tends to affect more low-skilled and low-wage jobs, it directly impacts those more prone to use public transportation over personal transportation. A similar pattern is observed when analysing the privately and publicly managed firms separately. Table 3 presents the correlations between efficiency scores and the continuous predictors.

Table 3. Correlations between efficiency scores and the continuous predictors.

Variable	Pearson		Kendall's tau		Spearman's rho	
	<i>gdpg</i>	<i>unra</i>	<i>gdpg</i>	<i>unra</i>	<i>gdpg</i>	<i>unra</i>
ECON1	0.604 *	−0.473 *	0.480 **	−0.480 **	0.632 **	−0.596 **
ECON2	0.654 **	−0.419	0.493 **	−0.385 *	0.708 **	−0.494 *
ECON3	0.652 **	−0.424	0.504 **	−0.396 *	0.714 **	−0.503 *
ECON4	0.613 **	−0.341	0.595 **	−0.292	0.773 **	−0.368
ECON5	0.302	−0.170	0.211	−0.125	0.340	−0.146

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

The comparison of means and correlation analysis reveals the following: (i) without controlling for other variables, the effect of the type of management is weak; (ii) ECON5 seems to be the less-explained factor based on the explanatory variables considered; and (iii) GDP growth has the strongest correlation with economic efficiency.

With the exceptions of *elye* and *mana*, all other variables have a VIF above 5, and *troi* is above 10, revealing strong multicollinearity between several of the categorical variables. There are no signs of heteroscedasticity (Breusch–Pagan test); however, for ECON2 and 5, the residual distributions are nonnormal (Shapiro–Wilk test), and an influential observation exists for ECON2 (Cook’s distance). However, the models built by combining subsets of the potential set of predictors to solve the multicollinearity issue do not suffer from these issues, with the exception of the influential observation in some of ECON2 models. Since robust standard errors were used in all models, the influence of the influential observation on the regression coefficient values is mitigated. There is also no evidence of specification problems (linktest).

From the total of ten regression models that were developed for each DMU, using the best subsets method to select which variables to include, the five with the highest adjusted R-squared in each DMU are presented in Table 4. The results reveal the existence of a statistically significant effect of management type on the economic efficiency of urban rail firms in all combinations of exogenous variables selected to control for. However, the effect of the management type on ECON5 is opposite to the effect on the other efficiency scores. The other influential variables in various models are GDP growth, the election year, the unemployment rate, the troika and the financial crisis.

Table 4. Result of the controlled effect of management type on urban rail firms’ economic efficiency.

VARIABLES	REGRESSION MODELS				
	1	2	3	4	5
ECON1					
<i>mana</i>	0.0821 ** (0.0350)	0.0821 ** (0.0353)	0.0821 ** (0.0353)	0.0821 ** (0.0353)	0.0821 ** (0.0360)
<i>gdp</i>	0.0228 ** (0.0082)	0.0254 *** (0.0073)	0.0254 *** (0.0073)	0.0187 ** (0.0082)	0.0291 *** (0.0075)
<i>unra</i>	−0.0104 * (0.0050)	−0.0185 * (0.0099)	−0.0185 * (0.0099)	−0.0124 ** (0.0053)	
<i>elylead</i>	0.0798 * (0.0412)	0.0949 ** (0.0392)	0.0949 ** (0.0392)	0.0621 (0.0407)	0.0730 * (0.0407)
<i>troi</i>		0.0620 (0.0690)	0.0620 (0.0690)		
<i>elye</i>				−0.0406 (0.0444)	
Constant	0.9266 *** (0.0791)	0.9923 *** (0.1116)	0.9923 *** (0.1116)	0.9681 *** (0.0825)	0.8042 *** (0.0299)
Observations	20	20	20	20	20
R-squared	0.6342	0.6528	0.6528	0.6510	0.5873
ECON2					
<i>mana</i>	0.1338 ** (0.0500)	0.1338 ** (0.0512)	0.1338 ** (0.0473)	0.1338 ** (0.0528)	0.1338 ** (0.0478)
<i>gdp</i>	0.0436 *** (0.0094)	0.0402 *** (0.0111)	0.0290 *** (0.0083)	0.0400 * (0.0196)	0.0378 *** (0.0068)
<i>unra</i>		−0.0056 (0.0073)	−0.0121* (0.0067)	−0.0059 (0.0134)	

Table 4. Cont.

VARIABLES	REGRESSION MODELS				
	1	2	3	4	5
<i>elye</i>			−0.1114 ** (0.0455)		−0.0904 ** (0.0405)
<i>ficr</i>				−0.0031 (0.1435)	
Constant	0.6327 *** (0.0414)	0.6995 *** (0.1024)	0.8126 *** (0.0987)	0.7033 *** (0.1702)	0.6613 *** (0.0437)
Observations	20	20	20	20	20
R-squared	0.5974	0.6040	0.6821	0.6040	0.6547
ECON3					
<i>mana</i>	0.1244 ** (0.0497)	0.1244 ** (0.0507)	0.1244 ** (0.0473)	0.1244 ** (0.0478)	0.1244 ** (0.0469)
<i>gdpg</i>	0.0423 *** (0.0094)	0.0386 *** (0.0112)	0.0279 *** (0.0086)	0.0367 *** (0.0069)	0.0255 ** (0.0096)
<i>unra</i>		−0.0059 (0.0076)	−0.0122 (0.0070)		
<i>elye</i>			−0.1068 ** (0.0470)	−0.0857 * (0.0412)	−0.1139 * (0.0570)
<i>troi</i>					−0.0805 (0.0651)
Constant	0.6330 *** (0.0416)	0.7038 *** (0.1064)	0.8122 *** (0.1029)	0.6602 *** (0.0439)	0.7039 *** (0.0654)
Observations	20	20	20	20	20
R-squared	0.5801	0.5878	0.6638	0.6345	0.6696
ECON4					
<i>mana</i>	0.1322 *** (0.0282)	0.1322 *** (0.0283)	0.1322 *** (0.0275)	0.1322 *** (0.0359)	0.1322 *** (0.0284)
<i>gdpg</i>			−0.0195 (0.0134)	0.0123 (0.0115)	
<i>elye</i>	−0.1107 *** (0.0353)	−0.1299 *** (0.0383)	−0.1421 *** (0.0451)	−0.1024 (0.0675)	−0.1049 ** (0.0352)
<i>ficr</i>	−0.3364 *** (0.0429)	−0.3231 *** (0.0459)	−0.3953 *** (0.0611)	−0.2745 *** (0.0639)	−0.2925 *** (0.0560)
<i>troi</i>	−0.1450 ** (0.0580)	−0.1654 ** (0.0609)	−0.3006 *** (0.0605)		−0.1165 ** (0.0520)
<i>elyelead</i>		−0.0385 (0.0397)	−0.0684 (0.0407)	0.0052 (0.0406)	
<i>elyelag</i>			0.0706 * (0.0341)	−0.0295 (0.0380)	
<i>unra</i>	−0.0166 * (0.0089)	−0.0123 (0.0095)		−0.0304 *** (0.0076)	−0.0154 (0.0095)
<i>regu</i>					0.0456 (0.0366)
Constant	0.9105 *** (0.0869)	0.8824 *** (0.0915)	0.8030 *** (0.0496)	1.0048 *** (0.1030)	0.8515 *** (0.1138)
Observations	20	20	20	20	20
R-squared	0.9099	0.9156	0.9264	0.8746	0.9147

Table 4. Cont.

VARIABLES	REGRESSION MODELS				
	1	2	3	4	5
ECON5					
<i>mana</i>	−0.2385 ** (0.0841)	−0.2385 ** (0.0838)	−0.2385 ** (0.0848)	−0.2385 ** (0.0848)	−0.2385 ** (0.0857)
<i>unra</i>	−0.0344 ** (0.0133)	−0.0391 ** (0.0157)	−0.0469 ** (0.0197)	−0.0312 (0.0214)	−0.0479 ** (0.0204)
<i>elye</i>	−0.1728 * (0.0844)	−0.2318 ** (0.0936)	−0.2096 ** (0.0733)	−0.2371 ** (0.0803)	−0.2503 ** (0.0915)
<i>ficr</i>	−0.3492 ** (0.1353)	−0.3150 ** (0.1270)	−0.3926 ** (0.1516)	−0.4661 ** (0.1839)	−0.3530 ** (0.1499)
<i>elyelag</i>		−0.1178 (0.1153)			−0.0997 (0.1175)
<i>gdpg</i>			−0.0218 (0.0216)	−0.0383 (0.0306)	−0.0164 (0.0219)
<i>troi</i>				−0.1878 (0.1771)	
Constant	1.2706 *** (0.1268)	1.3729 *** (0.1883)	1.4442 *** (0.2125)	1.3608 *** (0.2117)	1.4878 *** (0.2363)
Observations	20	20	20	20	20
R-squared	0.6284	0.6553	0.6471	0.6724	0.6653

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The results of the controlled and uncontrolled analysis are consistent, including the signal inversion on the management type dummy variable in the ECON5 regression model. Note that except for GDP growth and election year (not the lead or lag), all other variables have a negative effect on economic efficiency.

The interaction between the management type and the unemployment rate or the GDP growth was confirmed to be statistically significant for ECON1, 4 and 5 (Table 5). The most interesting results from are for ECON1 and 5. Regarding the former, the negative sign of the interaction between GDP growth and management type implies that the privately managed firms are less efficient under positive GDP growth conditions, losing their higher efficiency (coefficient of 0.069 for the management type dummy variable) with GDP growth of more than 1%. On the other hand, they become increasingly more efficient with negative GDP growth values. This may be related to the higher management flexibility of the privately managed firms, particularly regarding dealing with workers. Considering the financial crisis and troika supervision context of a significant portion of the time frame under analysis, this advantage may explain the higher efficiency of the privately managed firms. Compared with the model without interaction (Table 4), the model with interaction for ECON5 changes the signal of the management type dummy variable from negative to positive. Combining this with the regression coefficient of the interaction variable, it is possible to conclude that privately managed firms were more efficient when the unemployment rate was below 8%. Between 2009 and 2018, the unemployment rate was under that threshold (7%) only in the last year. Therefore, the publicly managed firm was more efficient based on the metrics underlying the ECON5 efficiency scores.

Table 5. Results of the controlled effect of the management type, considering interaction.

VARIABLES	REGRESSIONS MODELS				
	ECON1	ECON2	ECON3	ECON4	ECON5
<i>mana</i>	0.069 (0.092)	0.250 * (0.133)	0.130 ** (0.040)	0.316 *** (0.068)	0.527 ** (0.229)
<i>elyelead</i>	0.080 ** (0.022)				
<i>elye</i>		−0.111 ** (0.037)	−0.086 ** (0.034)	−0.111 ** (0.028)	−0.173 ** (0.065)
<i>troi</i>				−0.145 ** (0.048)	
<i>ficr</i>				−0.336 *** (0.031)	−0.349 ** (0.105)
<i>gdpg</i>	0.043 *** (0.005)	0.042 ** (0.011)	0.048 ** (0.011)		
<i>unra</i>	−0.011 ** (0.003)	−0.007 (0.008)		−0.009 (0.006)	−0.002 (0.013)
<i>mana</i> × <i>gdpg</i>	−0.041 ** (0.10)	−0.025 (0.014)	−0.022 (0.014)		
<i>mana</i> × <i>unra</i>	0.002 (0.007)	−0.009 (0.011)		−0.016 ** (0.005)	−0.065 ** (0.017)
Constant	0.933 *** (0.037)	0.755 *** (0.100)	0.657 *** (0.039)	0.819 *** (0.054)	0.888 *** (0.158)
Observations	20	20	20	20	20
R-squared	0.850	0.708	0.664	0.925	0.743

Robust standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Our results show that organizational models, in particular the type of management, seem to play a role in determining the level of efficiency of urban rail companies, as discussed by [13,14,17]. As shown, most of the indicators support the conclusion of a higher level of efficiency in privately managed firms, confirming the previous findings of [5,13,14]. In fact, as discussed in the literature, most studies (e.g., [25,27]) claim that the private sector is typically able to bring higher levels of productivity and social welfare. In four out of five scores, we found the same conclusion. It is important to mention that most studies do not use multiple efficiency scores [13]. Furthermore, our study also expands the existing body of knowledge by explicitly incorporating economic, political, and regulatory/legal variables in the external context that could potentially affect the level of efficiency. In fact, several of these variables were found to be statistically significant. Furthermore, the existence of statistically significant interaction between the type of management and external economic factors (GDP growth and unemployment rate) is a clear indication that the context in which firms operate impacts differently on the efficiency of privately and publicly managed firms.

5. Conclusions

The objective of this study was to analyse the effects of private sector involvement in the management of rail transport companies while controlling for external factors, such as economic and political factors, that may influence such efficiency levels.

Overall, on four out of five scores there was evidence that the private management model can be more efficient than public management. In the fifth score (ECON5), the results were the opposite, meaning that the public model was more efficient. This score used only the liabilities as an input, while scores one to four used a combination of Operational expenses (OPEX), Assets and liabilities. The evidence suggests that private management has a potential advantage in optimizing OPEX, however it is important to consider that the firms are distinct and there might be additional factors, as we will address in the discussion of study limitations.

The potential superiority of the private sector in terms of efficiency is eroded in periods of economic growth. The results show that privately managed firms are less efficient during positive GDP growths, losing their higher efficiency with GDP growth of more than 1%. These findings suggest that the private sector is more efficient in tackling economic crisis than the public sector, however when GDP and demand grow, such potential efficiency disappears. It is important to mention that the financial crisis and troika supervision context covered a significant share of the period of analysis, and this advantage may explain the higher efficiency of the privately managed firms. These findings are important in the context of the overall sustainability of the transportation sector, particularly economic sustainability. Policymakers should consider the effects of management models in the overall organization of the transportation system, searching for the models that deliver maximum efficiency in order to ensure long-term sustainability.

Some relevant limitations of the study must be noted: (i) there was only one publicly managed firm against three privately managed firms; (ii) each firm operates within a specific context that cannot accurately be accounted for; and (iii) the financial data of the privately managed firms were aggregated to estimate the overall efficiency of the group. These limitations complicate interpretation of the results and limit the overall conclusion. Linking the DEA models with the econometric models, there is a clear pattern that when measuring efficiency with the operational costs as an input, the privately managed firms were more efficient, independently of the other financial metrics used on inputs and outputs.

Future research should cover a larger period, particularly including more cycles of economic growth, in order to confirm the evidence of our findings. Ideally, it could also be relevant to include more firms and incorporate technical efficiency indicators able to assess production factors (such as labour, fleet, etc.), although OPEX indirectly captures some production factors. However, it should be noted that the inclusion of more firms is impossible in Portugal, and mixing with international firms adds more sources of variability. In fact, if the firms evaluated herein already operate under contexts that have differences, the contexts of firms operating in other countries will most probably be even more diversified.

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Appendix A

Table A1. Results of the non-controlled effect of the type of management.

Type of Company	Year	ECON1	ECON2	ECON3	ECON4	ECON14	ECON5
Public	2009	0.67682	0.40831	0.40831	0.27989	0.13335	0.42881
Public	2010	1	1	1	0.31354	1	0.21498
Public	2011	0.63039	0.40597	0.40597	0.34195	0.16800	0.52797
Public	2012	0.72113	0.56543	0.56543	0.56543	0.29387	0.86762
Public	2013	0.72094	0.51744	0.51744	0.51744	0.33246	1
Public	2014	0.79112	0.59195	0.59195	0.59195	0.22989	0.90998
Public	2015	0.83936	0.65675	0.65675	0.65675	0.14085	0.71742
Public	2016	0.97585	0.76467	0.76467	0.76467	0.15644	0.84411
Public	2017	0.98356	0.76243	0.76243	0.76243	0.16482	0.92519
Public	2018	1	0.77094	0.77094	0.77094	0.17116	1
Private	2009	0.84484	0.62145	0.62145	0.51866	0.18428	0.40616
Private	2010	0.92813	0.69163	0.69163	0.55727	0.20825	0.42432
Private	2011	0.97036	0.73276	0.73276	0.59419	0.22000	0.42865
Private	2012	0.94316	0.71152	0.71152	0.58787	0.21189	0.42031
Private	2013	0.83866	0.70183	0.70183	0.62507	0.20271	0.29975
Private	2014	0.87676	0.73012	0.73012	0.67423	0.20802	0.31900
Private	2015	0.88371	0.7727	0.7727	0.69715	0.22208	0.29177
Private	2016	0.92391	0.91195	0.81846	0.77671	0.91195	0.96838
Private	2017	0.95059	0.90757	0.90757	0.85600	0.78079	0.65705
Private	2018	1	1	1	1	1	0.83572

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