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Technical and Scale Efficiency of Tunisia's Regional Public Transport: A DEA Study

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Abstract:
This study examines the technical and scale efficiency of twelve regional public transport companies in Tunisia over an eight-year period (2008–2015) using Data Envelopment Analysis (DEA). The analysis considers three input variables (number of employees, fleet size, and fuel consumption) and one output variable (offered seat-kilometers, PKO). Efficiency is evaluated under both constant returns to scale (CRS) and variable returns to scale (VRS) assumptions. The results reveal significant variations in efficiency across companies and over time. Under CRS, average efficiency scores range from 0.26 to 0.91, while under VRS, they range from 0.4 to 0.96, highlighting the presence of pure technical inefficiencies and scale inefficiencies. The study finds that certain companies could achieve substantial productivity gains by aligning with the efficient frontier, and that inefficiencies persist regardless of company size. These findings provide valuable insights for policymakers and transport planners aiming to improve the operational performance of regional urban transport systems in Tunisia.

Keywords: Data Envelopment Analysis (DEA), Technical Efficiency, Scale Efficiency, Public Transport, Regional Transport Companies, Tunisia

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Introduction

The spatial distribution of human activities inevitably generates a need for the movement of people and goods and determines the configuration of transport modes as well as the required infrastructure capacities. Transport is generally divided into several modes (walking, private vehicles, public transport, rail transport, maritime transport, air transport, etc.), each of which has its own logic of demand and supply. In fact, the transport of both passengers and goods constitutes an essential service without which cities could not function or engage in exchanges. The development of transport, particularly the emergence of mechanized transport, which resulted in increased speeds and reduced costs, has significantly contributed to these transformations.

Transport is in fact one of the key sectors of economic activity; as such, it represents a share of production and is also an indispensable means for the realization of production. This explains the existence of a reciprocal interaction between transport and economic activities. Therefore, transport does not merely play the role of ensuring societal mobility and providing accessibility for residents to commercial centers, industrial areas, and leisure facilities; it also acts as a determining factor at the heart of citizens' daily lives, business competitiveness, and economic growth.

Research in this field is not recent. Indeed, for a long time, researchers have addressed transport-related issues by drawing on several economic concepts, such as pricing (Mousseau, V., Roy, B., & Sommerlatt, I., 2000; Finez, J., 2014; Anderson, S. P., & Renault, R., 2005), competitiveness (Decoster, F., & Versini, F., 2009; Bernadet, M., & Sinsou, J. P., 2010; Meunier, C., & Zeroual, T., 2006; Filser, M., 2018; Kahn, R., & Brenac, T., 2018).

The use of these concepts has increasingly attracted the attention of researchers and planners seeking to better understand the specific characteristics of the transport sector and subsequently analyze its performance.

1. Tunisian Public Urban Collective Transport Sector

The Tunisian transport service is provided at nearly 70% by the public sector under the supervision of the Ministry of Transport. The latter is the competent authority whose main mission is to plan and ensure the proper functioning of a national transport system, making it a factor of sustainable development. The transport sector is composed of three sub-sectors: land transport, maritime freight transport, and air transport. In this study, we focus on road-based land transport.

2. Sector Overview

Transport companies differ according to the type of service provided (intra- and/or interurban). The size of the areas they cover leads to different distances traveled, while transport demand is measured through the number of passengers and can also be reflected by the intensity of socio-economic activities, which varies from one region to another. Transport services can be divided into urban or regional transport and interurban transport. Urban or regional transport is provided by the Tunis Transport Company and twelve other regional transport companies. These companies are non-administrative entities and enjoy financial autonomy. In addition to urban transport services, they also provide interurban transport to delegations within the various governorates.
On the other hand, interurban transport—namely services operating on routes that extend beyond urban transport boundaries—is provided by the Société Nationale de Transport Interurbain (SNTRI). The classified road network is distributed as follows:

- **National Roads:** 3,938 km
- **Regional Roads:** 5,117 km
- **Local Roads:** 2,453 km
- **Roads under classification:** 1,242 km

The State is therefore regularly required to address several key questions:

- What is the current state of the urban public transport system?
- Which public transport companies are identified as inefficient?
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3. Analysis of Efficiency Scores of Regional Transport Companies in Tunisia

3.1 Literature Review

In general, researchers do not find significant differences in efficiency between public and private companies, even though the approaches may differ and despite variations in the inputs and outputs used. The literature review presented below shows that there are substantial differences among econometric estimates. This diversity is mainly due to different methodological choices by authors and the variety of samples considered.

The application of DEA (Data Envelopment Analysis) to evaluate efficiency in the transport sector, as used here, has become common in transport literature. The approach adopted is non-parametric, as it does not impose any restriction on the functional form relating inputs and outputs (cost or production function). It is based on a data envelopment method called DEA, developed by Charnes, Cooper, and Rhodes (1978) from the pioneering work of Farrell (1957).

Levaggi (1994) applied the DEA method to measure the efficiency of 55 urban transport companies in Italy. Efficiency was measured using three inputs: the number of vehicles, employee costs, and energy consumption, with the output being the total distance traveled.

Nolan (1996) measured the efficiency of 29 medium-sized urban transport companies in the United States. The output used was vehicle kilometers, while the inputs were the number of buses, total number of employees, and energy consumed.

Viton (1997) conducted a study on the efficiency of public and private collective transport systems in the United States, covering 217 public and private companies. Viton used vehicles/distance and passengers transported as outputs, with inputs including average speed, average fleet age, fuel consumption, number of employees, and total transport hours.

Cowie and Asenova (1999) also employed the DEA method to measure the efficiency of the British bus industry. They used passenger-kilometers as the output and capital and labor factors as inputs.

Husain et al. (2000) used two inputs and two outputs to evaluate the performance of 46 small transport companies in Malaysia. Inputs included the number of employees and total wage costs, while outputs were total service provided and gross revenue.

Pina and Torres (2001) studied the performance of public and private transport services in Spain using the DEA approach. Outputs included the number of buses per kilometer per employee (bus km/employee), and input indicators reflected both fuel consumption per kilometer and cost per kilometer.

Karlaftis (2004) applied DEA to measure the efficiency of 256 public transport systems in the United States during 1990–1994. Karlaftis used two outputs: kilometers traveled and the number of passengers, and three inputs: number of vehicles, fuel consumption, and total number of employees. Hirschhausen and Cullmann (2010) studied the efficiency of public and private collective transport systems in Germany (between 127 and 179 firms) over a 15-year period from 1990 to 2004. They used three inputs: two related to labor ("full-time and part-time employees") and one capital variable ("number of vehicles in use"). Two outputs were selected: "Seats per km" and "Vehicle km".

3.2 Justification for Choosing the Sequential DEA Method

The chosen method is non-parametric because it does not require any restriction on the form or function relating inputs and outputs (cost or production function). It is based on a Data Envelopment Analysis (DEA) method developed by Charnes, Cooper, and Rhodes (1978) from the pioneering work of Farrell (1957).

- *Sequential DEA*

The fixed-reference period calculates the Malmquist indices year by year, using the same reference period, usually the first year. This method has the advantage of maintaining circularity, meaning that the indices of two consecutive years can be multiplied to obtain the total growth over these two periods. However, the results depend on the reference period and do not solve infeasibility problems.

Sequential DEA reconstructs the reference period year by year using the new information obtained. It compares current production with all past production. Consequently, a decrease in productivity is attributed to a reduction in efficiency rather than to a decline in the industry’s production function (negative technological change), which aligns better with economic theory. This method is independent of the reference period and addresses some infeasibility issues.

3.3 Study Model Presentation

DEA provides a statistical analysis without a prior specification of the functional form of the frontier. It is therefore important to recall that this technique is a mathematical programming method used to evaluate the efficient

frontier of firms. The program improves the relationship between inputs and outputs to make it easier to identify the most efficient firms in terms of production.
When simultaneously solving N linear programs (12 firms in this study), the method evaluates firms for which this combination is considered original.

In practice, the highest-performing firms in our sample form the efficiency frontier, which serves as a benchmark for calculating the efficiency of other firms. Inefficiency is measured as the distance from this efficient frontier. Since the top-performing firms establish the efficient frontier, their score equals 1, while others receive a score between 0 and 1.

Thus, the technical efficiency scores estimated by the DEA method are **relative efficiency measures**. This method can be applied in two slightly different orientations: input-oriented or output-oriented. The input-oriented approach minimizes input use for a given level of output, while the output-oriented approach maximizes outputs for a given level of input. Both approaches yield very similar scores and comparable firm rankings.

The input-oriented approach is particularly relevant because it measures a firm's ability to use the minimum inputs to improve efficiency, as inputs are the variables most controllable by decision-makers. By choosing this method, we can collect data year by year or analyze the temporal evolution of a given firm.

❖ *Year-by-Year Models*

Annual analysis determines the relative efficiency of each port entity compared to others during the study year. This can be achieved by solving the following two linear programs:

- **Input-Oriented CCR Dual Model**

$$\begin{cases} Min_{\theta,\lambda,ON,IM,IL}\ Z_0 = \theta - \varepsilon\left(s_1 1'OS + m_1 1'IM\right) \\ -Y_{r0} + \sum_{j=1}^{12} \lambda_j Y_{rj} - OS_r = 0 \\ \theta X_{i0} - \sum_{j=1}^{12} \lambda_j X_{ij} - IM_i = 0 \\ \lambda \geq 0, OS \geq 0, IM \geq 0, \varepsilon \geq 0 \end{cases}$$

- **Input-Oriented BCC Dual Model**

$$\begin{cases} Min_{\theta,\lambda,ON,IM,IL}\ Z_0 = \theta - \varepsilon\left(s_1 1'OS + m_1 1'IM\right) \\ -Y_{r0} + \sum_{j=1}^{12} \lambda_j Y_{rj} - OS_r = 0 \\ \theta X_{i0} - \sum_{j=1}^{12} \lambda_j X_{ij} - IM_i = 0 \\ N'1\lambda = 1 \\ \lambda \geq 0, OS \geq 0, IM \geq 0, \varepsilon \geq 0 \end{cases}$$

Q : the efficiency score of the Decision,

Y_{r0} : the observed quantity of output r of the DMU whose efficiency is being measured, with r=1,2,

X_{i0} : the observed quantity of input iii of the DMU whose efficiency is being measured, with i=1,2,…,

Y_{rj} : the observed quantity of output rrr of DMU jjj, with j=1,2,…

X_{ij} : the observed quantity of input iii of DMU_j,

l_j : the weight coefficients assigned to DMU jjj,

OS_r : the output slack variable for output r,

IS_i : the input slack variable for input i.

4. Data and Variables Presentation

4.1 Sample Description

In Tunisia, the State entrusts land transport companies with the mission of providing regular public collective transport. Public transport companies provide nearly 95% of regular public transport in the capital and 100% in the rest of the country. They can be grouped into two subsets: Four public establishments with an industrial and commercial nature (SNT, SMLT, SNCFT, SNTRI), and Twelve Regional Transport Companies (SRTG).

The latter are commercial companies in form, but their capital is predominantly held by the State and local public authorities. The relationships of these public companies with the State are governed by public enterprise law. Transport services are divided into urban or regional transport and interurban transport. Urban or regional transport is provided by the Société des Transports de Tunis (STT) and the twelve other regional transport companies. The sample analyzed in this study consists only of the twelve regional transport companies.

companies	**Description**
SRTBizert	Société Régionale de Transport de Bizerte
SRTNabeul	Société Régionale de Transport de Nabeul
SRTSahel	Société de Transport du Sahel
SRTBéj	Société Régionale de Transport de Béja
SRTKef	Société Régionale de Transport du Kef ;
SRT Jendouba	Société Régionale de Transport de Jendouba
SRT Kairouan	Société Régionale de Transport de Kairouan
SRTSfax	Société Régionale de Transport de Sfax
SRTGabès	Société Régionale de Transport de Gabès
SRTGafsa	Société Régionale de Transport de Gafsa
SRTKasserine	Société Régionale de Transport de Kasserine
SRTMédenine	Société Régionale de Transport de Médenine

The final sample thus consists of the twelve regional transport companies over an 8-year period from 2008 to 2015. The maximum sample size is 96 observations (12 × 8).

4.2 Choice of Inputs and Outputs

➢ *Input Variables*

The inputs used in this study are those most commonly employed in the literature: **labor, capital, and energy**.

❖ **Labor Variable**

This variable is recorded in **full-time equivalent** (FTE). It includes the staff of the main operator, temporary personnel, and subcontracted staff.

❖ **Capital Variable**

Due to the **lack of sufficient financial data** to construct time series of capital expenditures, we use the **number of vehicles in the fleet available to the operator**. Capital is measured in **vehicle-years**.

❖ **Fuel Consumption**

Fuel consumption is measured in volume (**thousands of liters**) as well as fuel expenditures for each regional transport company.

➢ *Output Variable*

In studies on production frontiers in the urban transport sector, researchers note that a common characteristic of empirical work in this field is the **diversity of data used to measure outputs and inputs**. This diversity suggests that there are no universally accepted input or output variables for this sector. For this reason, we chose **not to use a traffic-related variable** (such as the number of trips, journeys, or passenger-kilometers) as the output, and instead retained a **supply-side variable**, namely the **number of offered seat-kilometers (SKO)**.

5. Year-by-Year Analysis: Results and Interpretations

The efficiency score of each company in the study sample is calculated by the objective function of the DEA model used. The results presented in the table below identify relatively efficient firms (score = 1) and relatively inefficient firms (score < 1) during the period 2008–2015 under both CRS and VRS assumptions. The analysis suggests performing DEA under both CRS and VRS assumptions using the same dataset to derive scale efficiency measures. If a company shows differences in efficiency scores under the two DEA types, this indicates that the company is not operating at an optimal scale.

➢ **Technical Efficiency under Constant Returns to Scale (CRS)**

FIRMES	2008	2009	2010	2011	2012	2013	2014	2015
SFAX	0.442	0,425	0,414	0,399	0,390	0,388	0,372	0,361
SOUSSE	0.540	0,516	0,498	0,474	0,457	0,445	0,440	0,438
NABEUL	0.303	0,291	0,278	0,271	0,264	0,261	0,261	0,260
Medenine	0.755	0,788	0,764	0,733	0,716	0,714	0,708	0,690
Kef	0.726	0,697	0,677	0,657	0,643	0,632	0,639	0,636
kassrine	0.192	0,492	0,562	0,592	0,595	0,600	0,606	0,596
kairouen	1.000	0,975	0,981	0,968	0,943	0,93	0,912	0,892
Jandouba	0.732	0,711	0,683	0,659	0,640	0,627	0,615	0,596
gafssa	0.550	0,54	0,522	0,501	0,495	0,495	0,494	0,494
gabes	0.641	0,635	0,633	0,590	0,570	0,553	0,540	0,528
bizerte	0.556	0,519	0,484	0,472	0,465	0,461	0,456	0,443
Beja	1.000	1	0,958	0,936	0,910	0,891	0,873	0,851
Moyenne	**0.620**	**0.633**	**0.621**	**0.604**	**0.590**	**0.583**	**0.576**	**0.565**

Table 1: Identification of Efficiency Scores under Constant Returns to Scale

Focusing on the constant returns to scale (CRS) results in the table, the following interpretations can be made: In 2008, Kairouan and Beja were the two companies identified as efficient, while the other companies had efficiency scores ranging from 0.192 (Kasserine) to 0.755 (Medenine). Kasserine was the most inefficient company; its score indicates that it could produce the same level of output using only 19% of its resources (or by reducing its inputs by 81%). In 2009, with the exception of Beja, which maintained its efficiency level, all other companies were declared inefficient, with efficiency scores ranging from 0.291 (Nabeul) to 0.975 (Kairouan).

➢ **Technical Efficiency under Variable Returns to Scale (VRS)**

companies	2008	2009	2010	2011	2012	2013	2014	2015
SFAX	1.000	0,996	0,988	0,963	0,943	0,932	0,913	0,897
SOUSSE	1.000	1	0,992	0,969	0,956	0,949	0,945	0,944
NABEUL	0.509	0,478	0,472	0,464	0,452	0,452	0,454	0,455
Medenine	1.000	0,957	0,938	0,917	0,905	0,912	0,910	0,901
Kef	0.752	0,71	0,688	0,667	0,654	0,646	0,654	0,653
kassrine	0.199	0,502	0,576	0,604	0,609	0,617	0,624	0,618

kairouen	1.000	0,976	0,981	0,976	0,960	0,953	0,940	0,927
Jandouba	0.758	0,72	0,693	0,669	0,650	0,639	0,628	0,611
gafssa	0.729	0,677	0,660	0,640	0,631	0,629	0,625	0,621
gabes	0.872	0,798	0,797	0,768	0,755	0,744	0,735	0,728
bizerte	0.799	0,734	0,714	0,702	0,697	0,693	0,687	0,678
Beja	1.000	1	0,962	0,945	0,920	0,907	0,889	0,868
Moyenne	**0.801**	**0.796**	**0.788**	**0.774**	**0.761**	**0.756**	**0.751**	**0,742**

Table 2: Identification of Technical Efficiency Scores under Variable Returns to Scale (VRS)

Efficiency under the VRS regime identifies pure technical efficiency by removing the effect of scale. Indeed, efficiency measured under VRS is generally higher than technical efficiency measured under CRS.
Scale inefficiency is then calculated as the difference between CRS technical inefficiency and VRS technical inefficiency. We observe that under the assumption of variable returns to scale, the number of firms declared efficient is higher compared to the constant returns to scale technology.

For example, comparing the efficiency scores of Sfax in 2008 under VRS and CRS assumptions shows that its technical efficiency under CRS was 0.442, while under VRS it was equal to 1.By comparing the pure technical efficiency scores obtained under the VRS assumption with the efficiency scores under CRS, one can derive the scale efficiency scores for each firm.

- **Annual Average Technical Efficiency Results**

année	EFF TECHNIQUE	EFF PURE	EFF ECH
2008	*0.620*	*0.801*	*0.785*
2009	*0.633*	*0.796*	*0,802*
2010	*0.621*	*0.788*	*0,794*
2011	*0.604*	*0.774*	*0,786*
2012	*0.590*	*0.761*	*0,781*
2013	*0.583*	*0.756*	*0,777*
2014	*0.576*	*0.751*	*0,773*
2015	*0.565*	*0,742*	*0,768*

Table 3: Annual Average Technical Efficiency and Its Different

Components

This table shows that the annual average scores for the three types of efficiency are almost identical. The annual average total technical efficiency varies between 0.60 and 0.78. The best performance in the urban public transport sector was achieved in 2009, with an average score of 0.633, while the lowest performance occurred in 2015, with an average score of 0.565.
This indicates that in 2015, the regional urban transport companies were characterized by a high overuse of production factors and a low level of productivity.

- **Classification of Companies According to Efficiency Scores**

firmes	scores d'efficiences
SFAX	0,94
SOUSSE	0,96
Medenine	0,92
kairouen	0,92
Beja	0,95
moy grp1	0,938
Kef	0,66
Jandouba	0,65
gafssa	0,64
gabes	0,76
bizerte	0,7
moy grp2	0,682
NABEUL	0,46
kassrine	0,59
moy grp3	0,525

Table 4: Classification of Companies by Group

This table shows that the **annual average total technical efficiency** for **Group 1** is **93.8%**. This means that if the companies in this group were able to **align with the production frontier**, the potential productivity gains to be recovered would be approximately **7.2%**.

groupes	moyenne	Min	Max	Écart-type
groupe1	0,938	0,92	0,96	0,01788854
groupe2	0,682	0,64	0,76	0,0491935
groupe3	0,525	0,46	0,59	0,09192388

Conclusion

Our empirical study is based on a sample of twelve regional transport companies over an 8-year period from 2008 to 2015, with four variables: three inputs (number of employees, fleet size, and fuel consumption) and one output (number of offered seat-kilometers, PKO). All data used in this study were obtained from the Tunisian Ministry of Transport. The results of our estimations reveal the following main conclusions:

Focusing on constant returns to scale (CRS), the average efficiency scores during the study period ranged from 0.26 (Nabeul company) to 0.91 (Beja company). For all twelve companies, the average efficiency scores decreased from 0.620 in 2008 to 0.565 in 2015.

Focusing on variable returns to scale (VRS), the average efficiency scores during the study period ranged from 0.4 (Nabeul company) to 0.96 (Sousse company). However, for the entire sample, VRS efficiency scores declined from 0.81 in 2008 to 0.74 in 2015.

Efficiency measured under the VRS assumption is higher than technical efficiency measured under CRS. For example, the Sfax company in 2008 had an efficiency score of 0.442 under CRS, whereas under VRS it reached 1.

The results indicate that inefficiencies exist regardless of company size, both in terms of pure technical efficiency and scale efficiency.

References

H. L. Boschken (2002), « Behavior of urban public authorities operating in competitive markets»,*Administration and Society, vol*. 31, no. 6, pp. 726–758, 2000.

Fraquelli.G, Piacenza.M, and Abrate.G, (2004): «Regulating Public Transit Networks: How Do Urban-Intercity Diversification and Speed-up Measures Affect Firms' Cost Performance? », *Annals of Public and*

Cooperative Economics, Vol 75(2), pp. 193-225. http://www.hermesricerche.it/elements/wp02-1.pdf.

B. Thiry and H. Tulkens (1992),« Allowing for inefficiency in parametric estimation of production functionsfor urban transit firms»,*Journal of Productivity Analysis,*vol. 3, no. 1-2, pp. 45–65.

B. De Borger, K. Kerstens, and l. Costa (2002),« Public transit performance: what does one learn fromfrontierstudies»,*Transport Reviews,* vol. 22, no. 1, pp. 1–38.

Amaral, M., Saussier, S., &Yvrande-Billon, A. (2009).« Auction procedures and competition in public services: The case of urban public transport in France and London. », *Utilities policy,* 17(2), 166-175.

Agarwal S, Yadav S P, Singh S P (2011). «DEA based estimation of the technical efficiency of state transport undertakings in India. ».*Operational Research Society of India*, 47 (3): 216-230.

Abbes.S et Bulteau.J, (2003) : «Analyse des caractéristiques des réseaux de transport collectif urbain en France».*University of Calgary*,

Croissant, Y., Roy, W., & Canton, J. (2013).« Reducing urban public transport costs by tendering lots: a panel data estimation. », *Applied Economics*, 45(26), 3711-3722.

Hirschhausen.C.V, and Cullmann.A.A, (2010): «A Nonparametric Efficiency Analysis of German Public Transport Companies», *Transportation Research Part E,* Vol 46(3): pp 436-445

J. Odeck and A. Alkadi (2001),« Evaluating efficiency in the Norwegian bus industry using dataenvelopment analysis»,*Transportation,* vol. 28, no. 3, pp. 211–232.

J. Preston, (2001)« Regulation policy in land passenger transportation in Europe»,in Proceedings of the 7thInternational Conference on Competition and Ownership of Land Transport, Molde, Norway, June 2001.