The efficiency of public road transport in Tunisia: Validation by the DEA method

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Abstract: This article investigates the efficiency of Tunisian public road transport. The efficiency study related to this transport type requires the treatment of the various previous empirical studies that studied this efficiency and to collect a database from ten regional public transport companies during a period of study from 1995 to 2014 on annual frequencies. The nonparametric DEA method will be used to identify the different stochastic boundaries.

Key words: Road Public Transport, Efficiency, Data Envelopment Analysis.

Introduction

In the management of public road transport, the term efficiency refers to the comparison between the observed values of inputs such as fuel, tires, social charges on the one hand and outputs or outputs such as: quality of service, with the optimal values of the inputs, and semi-finished and finished goods entering the production process on the other hand (Karlaftis and Tsamboulas (2012)). Indeed, economic efficiency therefore requires producers of a good or service to make the best use of their available resources. To properly define the concept of economic efficiency, it is necessary to distinguish between technical efficiency and resource allocation efficiency mobilized in public road transport. Technical efficiency reflects the extent to which carriers achieve the maximum with inputs provided. While the allocation efficiency reflects the minimum level of inputs used to produce a certain level of production comparable to the general case.

The problem of evaluating the efficiency of public transport has passed a lot of ink. In fact, the literature on the evaluation of efficiency or, more generally, the efficiency of public transport is very broad. The analyzes focused on both the development of public transport efficiency assessment methods and the use of efficiency results to make different policy recommendations (Karlaftis and Tsamboulas (2012)). These efficiency assessment studies have been very popular in the public transport literature, largely because of interest in reforming public transport operations and for assessing the effects of changes on efficiency. To study the efficiency of public road transport in Tunisia using the nonparametric DEA method, a sample of twelve regional public road transport companies was referred to during an annual study period from 1995 to 2014. This database was collected from the Directorate of Land Transport (Ministry of Transport in Tunisia).

This article is organized around two parts. In the first, we synthesize the main empirical studies that have studied the efficiency of public road transport and in the second part; we verify this efficiency for the case of Tunisian road companies using the non-parametric technique of DEA.

I-Literature Review

Agarwal and al. (2011) measured the technical efficiency of 35 Indian transport operators using the DEA method. They obtained an average efficiency score equal to 83.26% and they noted that these operators will reduce their used amount of inputs.

Barnum and al. (2011) identified the individual technical efficiencies of urban transport. These authors have distributed efficiencies from the aggregated DEA score. They estimated the impact of efficient transits on the overall efficiency of common transport and proposed a resource reallocation method to improve these efficiencies.

Kumar (2011) evaluated the pure technical efficiency from the 31 Indian public transport operators between the years 2006-2007. This author found that these transport operators can reduce entries by at least 22.8% while adopting best practices. He asserted that managerial inefficiency is the main source of technical inefficiency. This inefficiency can be explained by poor financial and business strategies or by wasting business service operations.

Yu and Fan (2009), based on a study of 23 public transport companies in Taiwan, modeled efficiency of production (PE), efficiency service (SE) and operational efficiency (EO). The model used by these authors also aims to address the situation or the common inputs needed to redistribute the activities and / or processes that run the transit companies. To empirically validate this model, Yu and Fan (2009) used a nonparametric method called DEA.

The assessment of the determination of inefficiency is ignored despite, the existence of several previous empirical work on the efficiency of public road transport. The majority of studies focus on the choice of methods for practical assessments and on the approximations of the technical efficiencies of this transport. The results from these studies have shown that the technical inefficiency involved, the exogenous factors, the organization of the market, the regulation of the system and the characteristics of nature and network have crucial effects on the inefficiency while referring at work De Borger and al. (2002). Most of this research is aimed at studying the determinants of inefficiency. This research has shown that inefficiency is always associated with exogenous factors that escape corporate control. The results of this research show that decision makers are more important than transport operators in this inefficiency. The purpose of the study of the efficiency of public transport is to provide an interpretation and recommendations to improve the efficiency of these operators. In this context, Cowie (2002) stated that improving the efficiency of these operators can be achieved from a number of sources, namely: changing work processes, improving operations, and investment trends, as well as, the choice of techniques for the most robust estimates to identify levels of efficiency. But it is more interesting to understand the factors and sources of inefficiencies that help improve efficiency.

DEA is a widely used method of assessing efficiency (Barros and al (2010)). This method is strongly adopted to analyze the efficiency of the agricultural and manufactured industries and in the direction of companies or public companies. Absolute and relative scales can be considered in this evaluation. Alexandersson and Pyddoke (2010) discussed the efficiency of public service in Sweden from competitive offers and the dominant tools for providing this service. These offers initially reduced the costs of transport contracts and increased calls for additional offers. In addition, Nilsson (2011) noted that public transport providers have missed very important results in contract design. Thus, the decision-makers are not aware of the different specifications of the contracts submitted and the control mechanisms are often lacking. For example, new types of contracts could be introduced without a plan on how these should be evaluated.

Palander (2016) evaluated the environmental impacts of larger and heavier vehicles on emission efficiency in the Finnish border industry using synchronized methods of calculation. Sanches-Pereira and Gomez (2015) studied the development of the Swedish biofuel system and discussed their impacts on the achievement of 10% renewable fuels in 2020. They identified development models to establish a fleet of vehicles fossil fuel-independent by 2030

(Sanches-Pereiraet Gomez, (2015)) Cong and al. (2017) examined the entire biogas chain (biomass supply, biogas production and distribution and fuel substitution) of the environment and economic prospects in Denmark.

II-Empirical validation

We will empirically verify the efficiency of road transport companies in Tunisia. For this, we will use a sample of twelve companies serving the Tunisian cities which are: Beja, Bizerte, Gabes, Gafsa, Jendouba, Kairouan, Kasserine, Kef, Medenine, Nabeul, Sfax and Sousse during a period of study going from 1995 until to 2014 on annual frequencies[1]. The analysis of economies of scale and density in the public road transport sector requires the implementation of a road infrastructure and the use of factors of production. The optimal allocation of resources is based on the use of labor and rolling stock factors, which are the decisive determinants of the total productivity of these factors. The combination of these two factors of production represents a technology allowing achieving a certain level of output. The latter represents the public road transport service in our research. The individual-time data basis for the explanatory and endogenous variables includes network size (TR), number of stations (NS), fleet of vehicles (PV), number of employees (NE) and production (Y) see the article by Mezghani and Boujelbene (2016).

We approximate the network size variable (TR) by the cumulative length of the lines reserved by the twelve regional public road transport companies in Tunisia. Also, we use the variable number of stations (NS). Station refers to the stop of vehicles to pick up or drop off passengers, either a pickup on demand in the field of transport. In addition, we consider the vehicle fleet variable (PV) as the number of vehicles acquired on the creation or extension of public road services for urban and interurban transport or the renewal of the fleet used by these services to know: Auto-bus, Auto-cars, articulated Auto-buses, articulated cars, Auto-cars comfort and minibus. We calculate the number of employees based on the total number of employees composed of administrative, operational and technical staff. Finally, we estimate the production of public road transport services in regional societies as endogenous variable noted (Y). The production variable is calculated based on the vehicles / kilometers offered. This production reflects both the average effective capacity used to service and the distance traveled by all vehicles simultaneously.

[1] The statistical data relating to the management of these twelve companies were collected from data from the Directorate of Land Transport (Ministry of Transport-Tunisia) (1995-2014)

We rely on the work of Mezghani and Boujelbene (2016) in the nonlinear modeling of the output of the twelve public road transport companies during the period 1995-2014 on annual frequencies. The nonlinear model is specified under the following equation:

$$Y_{it} = A_i (TR)_{it}^{\alpha_i} (NS)_{it}^{\beta_i} (PV)_{it}^{\theta_i} (NE)_{it}^{\lambda_i} e^{\varepsilon_{it}} \qquad \forall \text{ t} = 1995 \rightarrow 2014 \text{ et i} = 1,.......,12$$

We use the log-log specification on the right and on the left to linearize this equation above:

$$Log(Y_{it}) = Log(A_i) + \alpha_i Log(TR)_{it} + \beta_i Log(NS)_{it} + \theta_i Log(PV)_{it} + \lambda_i Log(NE)_{it} + \varepsilon_{it}$$

We will refer to the deterministic nonparametric technique based on linear programming without any constraints on the structure of the production function. This technique, known as Data Envelopment Analysis (DEA), creates for a wrapping data observed for a linear piece boundary. Also, we use certain assumptions to verify the convexity and freedom of disposition of products and factors. Indeed, we represent, graphically, the dependency between the variables from the figures below and we will set the variable production of public road transport services in the ordinate axis. Also, we measure the correlation between the variables and this output from scatter cloud scatter. For this, we will present the point clouds from the figures below:

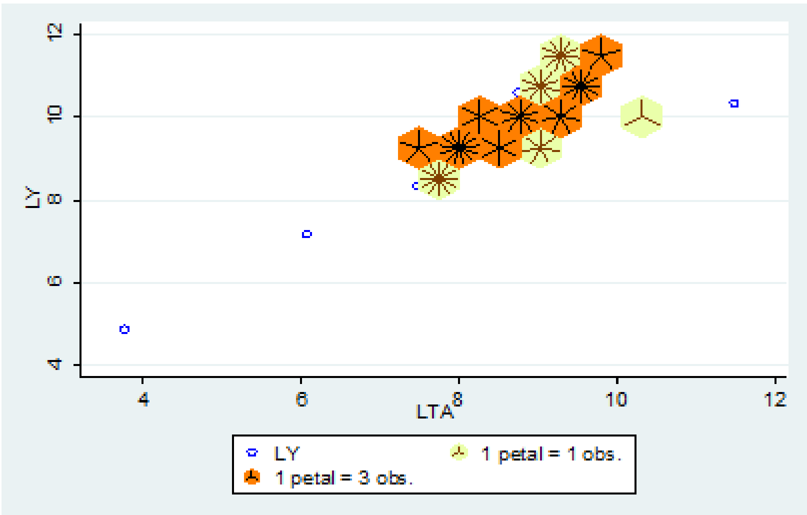

Figure 1: Dependency between the production variable and the network size variable

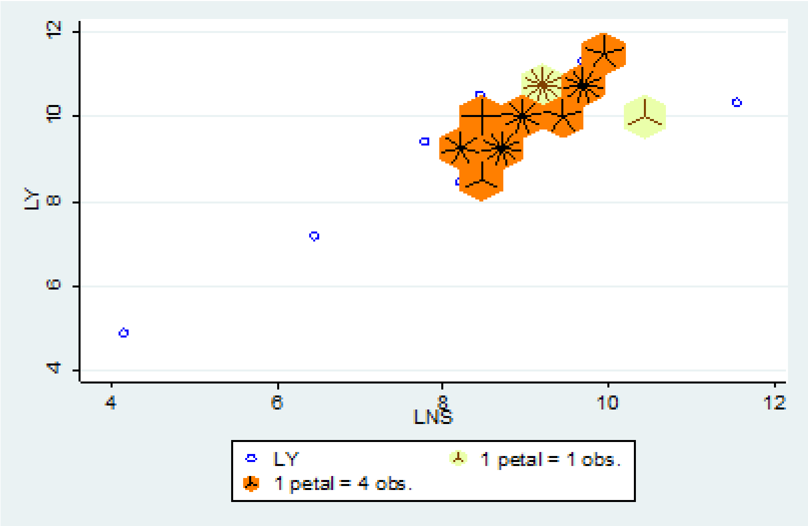

Figure 2: Dependency between the production variable and the variable number of stations

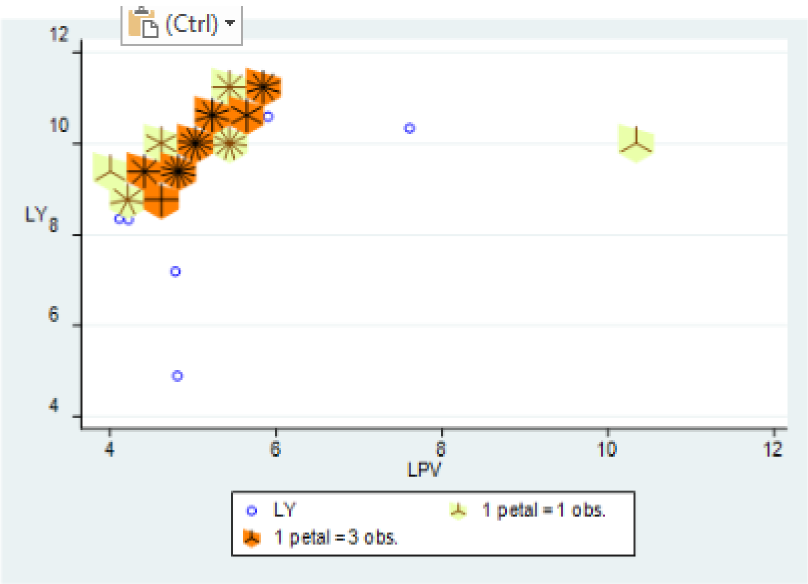

Figure 3: Dependence between the production variable and the vehicle fleet variable

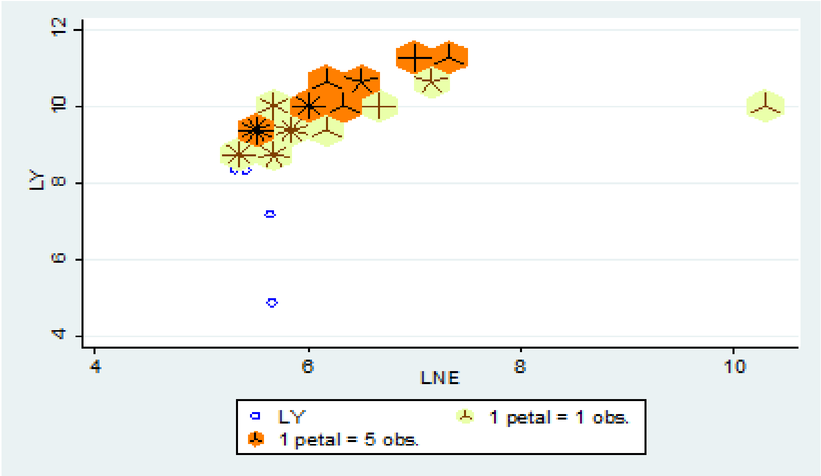

Figure 4: Dependency between the output variable and the variable number of employees

From these figures we can see that this is indeed a low correlation between the production of public road transport services and the fleet of vehicles (PV) because the clouds of points are concentrated towards the zero value. But there is a strong correlation between this production and the size of the network and the number of employees. Similarly, there is a strong positive correlation between the number of stations (NS) and logarithmic production. In this section the DEA method will be used to model the "multi-product-multi-factor" primal technology without going through the dual cost function that presupposes lack of technical inefficiency (Blancard and Boussemart (2006)). This method retains only the hypotheses of free dispositions of the inputs and outputs as well as the convexity for the production set as the case of transport. Also, this method does not impose any functional form of the cost and production functions. The table below indicates the efficiency frontier scores for the twelve regional public transport companies during a study period of the twenty years observed.

Table 1: Estimation of Efficiency Scores

Group	Model 1[2]	Model 2[3]	Model 3[4]
Beja	0.14952004	0.16030214	0.1229748
Bizerte	0.24682881	0.27215705	0.0892451
Gabes	0.18375039	0.21863253	0.21863253
Gafsa	0.40714578	0.50994948	0.50994948
Jendouba	0.18287237	0.253783	0.17300256
Kairouan	0.11761969	0.12404482	0.0977524
Kasserine	0.14284827	0.20444706	0.1528206
Kef	0.40013103	0.50104776	0.2280864
Medenine	0.0913636	0.14259814	0.11698087
Nabeul	0.33302198	0.3280313	0.24840745
Sfax	0.17208471	0.22915617	0.20062044
Sousse	0.09832305	0.20182302	0.0989373

The table and figures above represent the average efficiency scores for the twelve Tunisian regional transport companies. We notice that Medenine, Sousse and Beja are more efficient. On the other hand, Kef, Gafsa and Nabeul are less efficient. We can represent these scores in the following figures:

[2] The normal stochastic frontier (model 1)
[3] The differential stochastic frontier (model 2)
[4] Extraction between the normal stochastic frontier and the differential stochastic frontier (model 3)

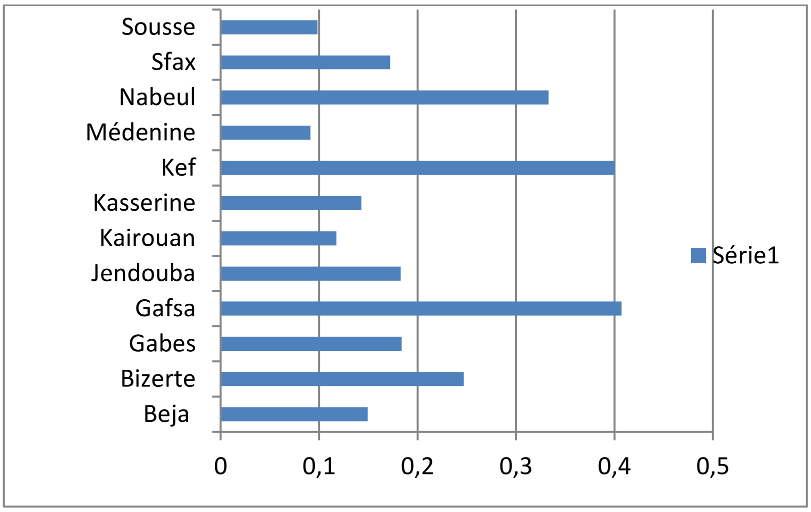

Figure 5: Representation of the efficiency scores of the normal stochastic frontier by public transport company (model 1)

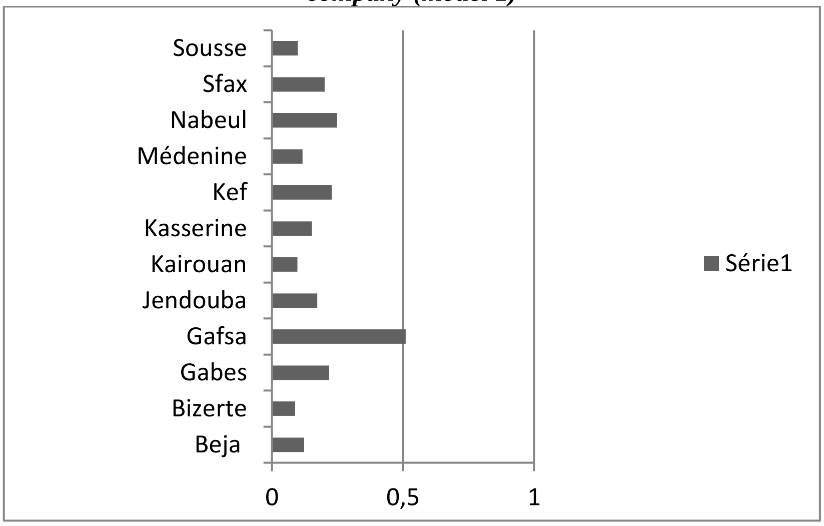

Figure 6: Representation of Differential Stochastic Boundary Efficiency Scores by Public Transport Company (Model 2)

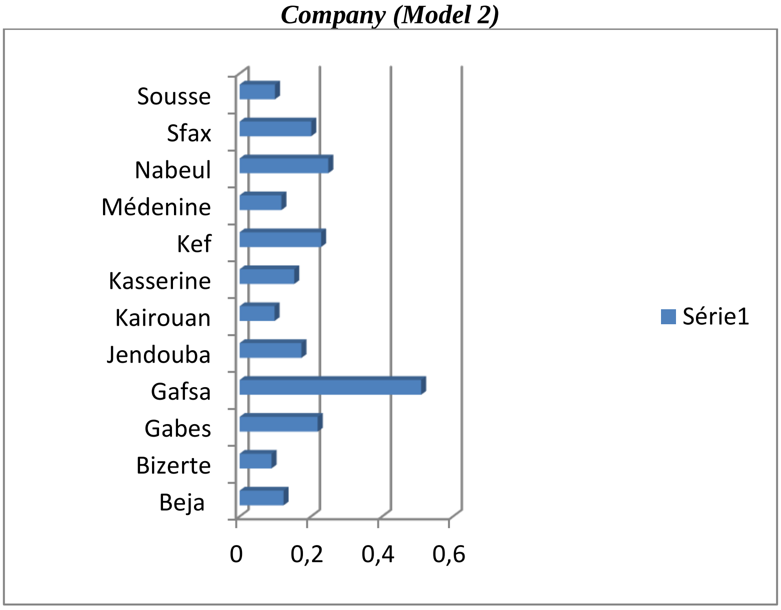

Figure 7: Representation of efficiency scores by public transport company: extraction between the normal stochastic frontier and the differential stochastic frontier (model3)

The first table and the figures mentioned above show the different efficiency scores achieved by public road transport companies in Tunisia during this observation period from 1995-2014. There is therefore a great heterogeneity for the different scores obtained. It can't be shown that these scores are functions of the financial and technical importance of the nature of the exploiting society. These figures show that technological inefficiency is illustrated for the Gafsa regional public road transport society. On the other hand, the regional road transport company of Bizerte is more efficient for the public transport services offered to its users. This assertion is logical because in this region of north-eastern Tunisia near the capital Tunis, this company has benefited greatly from state aid to invest in equipment, new equipment, internships for its staff in the size of its transport stations and networks, which has significantly improved its production for its users. While this is not the case in the South zone for the operating companies concerned, they suffer from a great deal of shortcomings in their exploited stock of equipment which remain obsolete and the small size of their operating networks badly served by dilapidated infrastructure. This negatively influences and impairs their efficiency and leads to an increase in their operating costs which have a negative impact on the pricing system when tariffs or transfer prices for public road transport services are not regulated.

Given the results obtained for the different scores of the 12 regional road transport companies, it can be said that the regional companies of the three governorates of Gafsa, Kef and Nabeul make full use of their production capacity, that is to say their operating equipment and their vehicle drivers. All the regional companies in the governorates of Bizerte, Jendouba and Sfax use their production capacity in terms of equipment and operating personnel, ie, there are production capacities that are not fully utilized the existence of operating equipment (vehicles and drivers of non-employee vehicles).

Lastly, companies in the governorates of Kairouan, Sousse and Medenine use their production capacity in terms of equipment and driver of vehicles only slightly. The last two regional categories of society mentioned previously know the law of non-proportional returns where the costs increase much more than the returns.

The heterogeneity in the management of these twelve public road transport companies in Tunisia with different efficiency scores negatively influences any efficient and fair pricing policy for the benefit of the users as well as for the benefit of the community who are always looking for the minimum cost in a better quality of service. The boundaries of these three models can be traced by the following curves which represent the trend of this boundary for these three different efficiency scores of the various regional public transport companies.

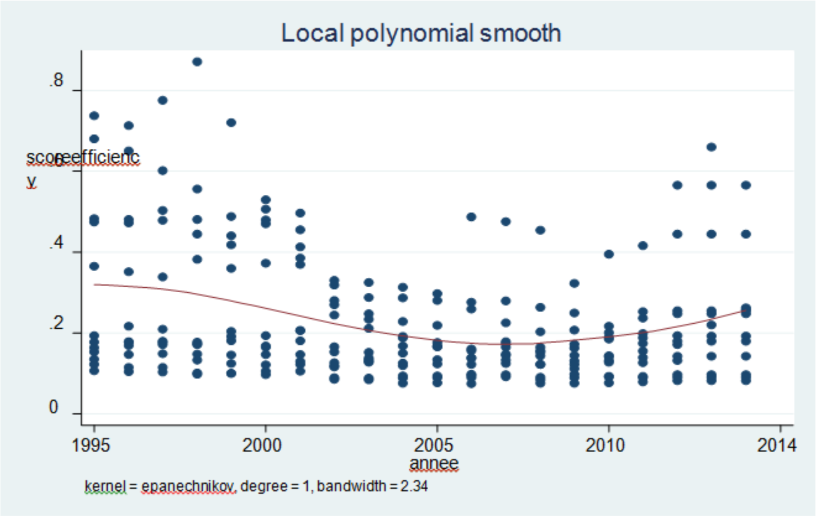

Figure 8: Normal Stochastic Boundary Trend (Model 1)

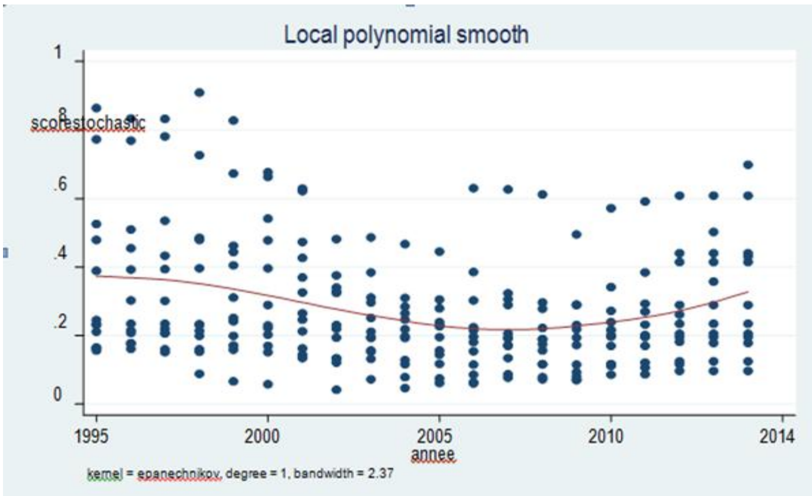

Figure 9: Differential boundary trend (model2)

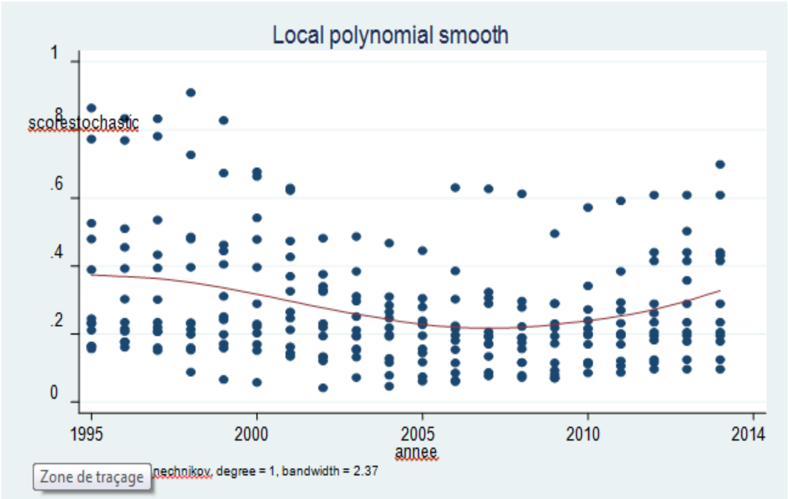

Figure 10: Extraction trend between normal stochastic boundary and differential stochastic Boundary (model 3)

Conclusion

This article examines the efficiency of public road transport companies. To achieve this goal, previous major empirical work that has addressed the impact of efficiency on improving the wealth of road companies has been synthesized. This efficiency was also validated from a database extracted from the Tunisian Ministry of Transport during the period 1995-2014 on annual frequencies for a sample of twelve Tunisian public road transport companies namely: Beja, Bizerte, Gabes , Gafsa, Jendouba, Kairouan, Kasserine, Kef, Medenine, Nabeul, Sfax and Sousse. In addition, the DEA method was used to empirically validate this efficiency.

Efficiency scores for the normal stochastic frontier (model 1), differential stochastic frontier (model 2) and extraction between the normal stochastic frontier and the differential stochastic frontier (model 3) were identified. The work was supported by graphs that show the influence of the different determinants of the production function on these boundaries.

This work could be enriched by parametric validation by adopting the Panel procedure with fixed or random individual effects by referring to the Hausman Arbitration Test (1978) and GLS estimation procedures. Also, the use of other non-parametric tools namely the stochastic procedure. A comparative analysis between parametric and non-parametric techniques will be made to identify suggestions to improve the efficiency of Tunisian public transport companies.

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