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AN ANALYSIS OF TECHNICAL EFFICIENCY OF PUBLIC BUS TRANSPORT COMPANIES IN MOROCCAN CITIES

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Abstract
The aim of this paper is twofold. Firstly, it measures the relative efficiency of six public bus companies in the largest cities in Morocco for the year of 2013 and identifies, at the same time, potential efficiency improvements for each inefficient company. Secondly, it identifies the external factors that influences the measured efficiency. As a first step, the technical efficiency of the companies was measured using a Constant Return to scale model of Data Envelopment Analysis method (CRS-DEA). Further, the research identifies the percentage that a company needs to increase its outputs or reduce its inputs in order to achieve optimal efficiency. In the second step, certain external factors (namely those reflecting network structure, service characteristics, demographic and socio-economic conditions of cities) are regressed, upon the efficiencyscores, using a Tobit regression model. The study results concluded that companies of Casablanca and Marrakech cities are the best efficient of the sample and some exogenous factors may explain part of the inefficiencies of the other companies.
Keywords: Technical efficiency; Performance; Data Envelopment Analysis; Public bus transport.

1. INTRODUCTION

The performance analysis of public bus transport services is a crucial tool for transport companies. It generally allows them to verify whether the service is provided efficiently and effectively, to identify areas where performance improvement may be needed, to ensure that community and users are satisfied and to provide pertinent information to decision-making bodies (transport authorities and funding institutions...) in order to support them to make decision about where, when, and how service should be provided.

To gain significance, performance measurement needs to be compared to other measures in order to monitor progress and detect areas of performance improvements. Benchmarking is considered as the most effective technique to reach this aim by providing the managers of Bus Companies with the opportunity to compare performance against other companies operating in different geographical contexts. This technique identifies also the best-in public bus transport practices that every inefficient company can emulate to improve its efficiency.

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Among methods that have been widely used as a tool for analyzing efficiency in the public transport sector is Data Envelopment Analysis (DEA) method. This latter is a non-parametric technique whose purpose is to measure the relative efficiency of a set of organizational units transforming several inputs (resources) into several outputs (services). Application of DEA informs on the best performing units as well as on the improvement which is required by all the other entities in order to reach them (Georgios et al, 2014, p.84).This approach is widely applied because of some advantages namely it doesn't impose any particular functional form for the production frontier and it can handle multiple inputs and multiple outputs.

In the Moroccan context, no academic study, to our knowledge, has been performed to assess comparative efficiency of public bus transport by applying the DEA method. Thus, the main objectives of this paper are:

- To measure the relative technical efficiency of six companies in the largest cities in Morocco for the year of 2013 and to identify, at the same time, potential improvements for each inefficient company by applying DEA method.
- To identify the external factors that influences the measured technical efficiency by using a Tobit regression model.

The remainder of this paper is organized as follows. Firstly, the technical efficiency concept and DEA applications is reviewed as well as the organization and performance of public bus transport in Morocco are presented. Then, the methodological framework adopted is explained. Next, data, variables and DEA model specifications are exposed. Finally, results are discussed and concluding remarks are outlined.

2. LITERATURE REVIEW

The public transport literature generally distinguishes two dimensions of performance, namely efficiency and effectiveness (Wayne & Pamela, 1981). Efficiency is the relationship between the inputs (resources) and the outputs (production) of what is called "productive" or "technical" efficiency in the economic literature. On the other hand, effectiveness refers to the use of products to achieve goals or the consumption of services (Chu et al, 1992, p.223).

In this paper, we will focus on technical efficiency concept which was pioneered in a seminal paper by Farrell (1975). This later had introduced a method to decompose the overall efficiency of a firm to its technical and allocative components. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs (Coelli et al, 2005).

Based on the Farrell's research, efficiency measurement and estimation of frontiers had an explosive development over the past decades (Jarbaoui et al (2012). Among the frontier methods which widely applied in analyzing efficiency within different sectors, we found data envelopment analysis (DEA) which developed by

Charnes et al (1978) on the basis of Farrell's (1975) proposition of applying non-parametric approach for the measurement of technical and allocative efficiencies. DEA has been mostly applied in sectors of banking, health care, agriculture and farm, transportation and education (John S. Liu et al (2013)).

The application of DEA in the public bus transport services had started in the 1990s. Several studies have used DEA in combination with other techniques (Regression analysis, statistical tests, Bootstrapping techniques…) for different purposes. Some studies aimed to benchmarking the efficiency of bus companies or measure the evolution of efficiency in the urban public bus sector (e.g. Cowie, 2002; Von Hirschhausen & Cullmann, 2010; Barros & Peypoch, 2010; Saxena & Saxena, 2010; Agarwal et al., 2011, Bugheanu, 2018). Others have examined the determinants of efficiency (e.g. Obeng, 1994; Kerstens, 1996; Nolan, 1996; Nolan et al., 2001; Boame, 2004; Kumar, 2011). Still others have compared the efficiency of management modes (e.g. Chang et al., 1992, Odeck & Sunde, 2001; Pina & Torres, 2006; Sánchez, 2009; Wang et al., 2015) or tested the effect of ownership on efficiency (e.g. Kerstens,1996; Viton 1997; Cowie & Asenova,1999; Pina & Torres, 2001; Odeck & Alkadi, 2003). Finally, the objectives, the DEA models, the variables and the results of these studies and others have been treated in detail by Borger et al (2002), Jarbaoui et al (2012), Daraio et al (2015) and Karim & Jawad (2017) to which the reader can refer.

In addition, the above studies have focused on different geographical contexts such as the United States (e.g. Obeng, 1994; Nolan, 1996; Viton, 1997; Nolan et al., 2001; Barnum et al., 2011). India (e.g. Agarwal et al., 2011; Kumar, 2011; Saxena & Saxena, 2010), Spain (Pina & Torres, 2001; Sánchez, 2009), Norway (e.g. Odeck & Sunde, 2001; Odeck & Alkadi, 2003), England (e.g. Cowie & Asenova, 1999;Cowie, 2002), Romania (Bugheanu, 2018), Canada (e.g. Boame, 2004), China (e.g. Wang et al., 2015), Germany (e.g. Von Hirschhausen & Cullmann, 2010), France (e.g. Kerstens, 1996), Portugal (e.g. Barros & Peypoch, 2010), Taiwan (e.g. Chang et al, 1992) and finally a context international (e.g. Pina & Torres, 2006).

In Moroccan context, no academic study, to our knowledge, has been performed to assess comparative efficiency of public bus transport by applying the DEA method. The only attempt is made by The Moroccan Public Transport Network (MPTN[1]) whose has carried out a comparison of the performance of public bus transport services in six cities using indicators and performance ratios according to the social, functional, economic and environmental stakes (Mustafa, 2015). The methodological approach used in this report do not give a complete picture of efficiency and it is insufficient to qualify the relative efficiency of companies. Also, the report doesn't discuss the potentials performance improvements needed and doesn't identify the external factors that influence the measured efficiency.

[1]MPTN is an offshoot of the Municipal Cooperation Program-CoMun Local and participative governance in the Maghreb, initiated in partnership between the Directorate General of Local Authorities (DGCL) and the German Technical Cooperation (GIZ). It consists of the largest cities and aims, through a structured and periodic exchange, to achieve the objectives of capitalization and sharing of good practices as well as the capacity building of decision-makers and local executives in charge of urban public transport.

Therefore, the objective of this paper is to benchmark the technical efficiency of six companies of public bus transport and to identify potential improvements for each inefficient company by applying the DEA method. Further, the research identifies, by using a Tobit regression analysis, the external factors that affect the estimated efficiency.

3. THE PUBLIC BUS TRANSPORT SERVICES IN MOROCCO: ORGANIZATION AND PERFORMANCE

The municipalities (Cities), alone or in the framework of inter-municipal cooperation, are in charge of urban public transport, with the support and supervision of the central government. Indeed, the Organic Law N° 113-14 attributes to the municipality a general competence in the management and equipping of local public services, including urban public transport. In addition, the central government supports and supervises the municipalities through the Ministry of the Interior, which is the Ministry responsible for the sector. It is responsible for the support and supervision of urban transport activities in urban areas, in addition to the design, implementation and monitoring of specific measures taken at the State level to promote the sector.

Since the 1980s, the authorities have called on the private sector to strengthen bus transport networks in some cities due to the inability of public companies (the autonomous municipal companies of transport) to meet the growing demand and due to their financial imbalance. This recourse was often done through the concession of lines to be served by different companies, which resulted in the presence of several companies in the same territory. However, since the promulgation of Law N° 54-05 on the delegated management of Public services in 2006, the contract is awarded to a single company covering the territory of a municipality or even several municipalities.

At present, public bus services are provided exclusively by private companies, with the exception of Safi city which uses an autonomous municipal company of transport and the agglomerations of Rabat Salé-Témara and surrounding centers which have called upon a local public company to replace a failing private company.

The number of delegated management contracts for public urban bus transport, in the course of execution, is 40, of which 17 have been concluded since 2006, covering 260 municipalities. The duration of the contracts is between 10 and 15 years. In 2013, urban transport included a fleet of 3,273 vehicles, 99% of which is operated by delegated companies. The companies in charge of the sector achieved a turnover of 1 790 MAD (in Million Moroccan Dirham (MAD)) and employed a workforce of 12 950. The number of passengers in 2013 reached 850 million passengers, 96% were transported by the delegated companies and 4% by the municipal company of Safi (Public finance court, 2014).

The evaluation of the performance of public bus transport services in a systematic way is virtually absent in the Moroccan context for a multiple reasons.

At local level, there is a lack of effective institutions in the most major cities in monitoring and evaluating the bus transport services performance (World Bank, 2015). Moreover, the monitoring mechanisms stipulated by the delegated management law n° 54.05, in particular the permanent control services "SPC", suffers from a set of malfunctions as a service that lacks sufficient informational means, material and human resources and the absence of an integrated information systems (between delegated company and delegating authority) allowing to generate in favor of delegating authority a comprehensive information in terms of activity volume and performance or technical follow-up of the Buses (Public finance court, 2014). At central level, the Ministry of Interior, which is responsible for the supervision, financial and technical support of local urban transport, is currently relying on mainly non-computerized monitoring systems, which are limited in depth and scope (World Bank, 2015). Furthermore, the studies analyzing the public bus transport performance in Morocco's cities are very few. The few attempts are made by non-governmental organizations (e.g. Lidia, 2014; Mustafa, 2015), international institutions (e.g. World bank & CETE de lyon, 2006; World bank, 2015) and academic studies (e.g. Karim & Jawab, 2017; Akoudad & Jawab, 2018). In this paper, we provide a preliminary analysis of technical efficiency of public bus transport companies. Due to the unavailability of data for all city companies, we will focus only on companies in six major cities. The urban population of these cities represents nearly 50% of the total urban population in all Moroccan cities in 2013. Table 1 contains some information about the six cities and their companies.

TABLE 1 - INFORMATIONS ABOUT THE SIX CITIES AND THEIR COMPANIES.

Cities	Agadir	Casablanca	Fez	Tangier	Marrakech	Rabat-Salé
Population size	828 000	3 358 000	1 106 000	750 000	1 195 000	1 805 000
Urbanized area (km²)	138	195	78	77	100	100
Urban lines	22	70	53	26	20	55
Delegating authority	Agadir City + (8 surrounding municipalities)	Casablanca City + 10 surrounding Municipalities	Fez City	Tangier City	Marrakech City	IMCE named "Al Assima"
Delegate company	Private company					Public company
Monitoring body	MC+ PCS	Inoperative MC + PCS	PCS	MC+ PCS	MC+ PCS	Inoperative PCS
Contract regime	Delegated management				Concession agreement	Delegated management
Start	September, 2010	November, 2004	September, 2012	June, 2014	February, 1999	2012
Duration (years)	15	15	15	10	15+5	For a Transitory period
MC=Monitoring Committee; PCS = Permanent control service; IMCE = Inter-municipal cooperation entity						

Source: Author's using data extracted the two reports of MPTN (Lidia, 2014; Mustafa, 2015)

3. METHODOLOGICAL FRAMEWORK

In this section, we present the mathematical formulas of CCR model for calculating efficiency scores and the percentage of input reduction/output augmentation for potential performance improvement. We also present the Tobit regression model for identifying the external factors that influence the measured efficiency.

3.1. Data Envelopment Analysis (DEA)

Based on the efficiency concept initiated by Farrell (1957), DEA, developed by Charnes et al., (1978) and Banker et al., (1984), is used to evaluate the relative efficiency of organizational units that transform resources (inputs) into services (outputs). These units are called Decisions Making Unites (DMUs). The DEA technique involves the use of linear programming methods to construct a non-parametric piecewise surface (or frontier) over the data. The efficiency measures are then calculated relative to this surface (Coelli et al., 2005, p.162). DMUs located at the frontier have a score of 1 (or 100%) while those below the frontier have a score less than 1 (or 100%) and therefore have a scope for improvement of their performance. Note that no DMU can be greater than the efficiency frontier because it is not possible to obtain a score greater than 1 (100%). DMUs at the frontier serve as peers (or benchmarks) for inefficient DMUs. These peers are associated with observable best practices.

The two basic models of the DEA method most used in the literature are CCR and BCC (named after the initials of their developers). The CCR model developed by Charnes, Cooper and Rhodes, (1978) assumed constant returns to scale (a model also named Constant Returns to Scale-CRS-) whereas the BCC model, developed by Banker, Charnes and Cooper (1984), assumed variables returns to scale (model also named variable returns to scale -VRS-)

In addition, a DEA model (CRS or VRS) can be oriented towards inputs or outputs. In an inputs-oriented approach, the DEA model minimizes inputs for a given level of outputs. In an outputs-oriented approach, the DEA model maximizes outputs for a given level of inputs.

On another note, the use of the VRS model may lead to biased performance estimates because this model tends to increase scores and is not robust and stable in the observation of outliers (Tsamboulas, 2006). Moreover, the CRS model proved to be more restrictive than the VRS model (Cooper et al., 2006). It is more appropriate for analyzing the performance of road networks (Gianfranco et al., 2014). For these reasons, the CRS model is adopted in this paper.

3.2. Mathematical formulas of CCR-DEA model

Considering a set of n DMUs, each DMU uses a number m of inputs and a number s of outputs, $\mathrm{x_{io}}$ is the amount of the input i used by the DMUo and $\mathrm{y_{ro}}$ is the amount of the output$r$ produced by the DMUo.

Following the CRS model with an output orientation, the relative efficiency score of the DMUo is obtained by solving the following linear programming model (according to the notation of Zhu (2014)):

$$\text{Maximise } \emptyset_o + \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+) \quad (1)$$

Subject to:

$$\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = \emptyset y_{ro} i = 1,2, \dots . m \ (2)$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{io} r = 1,2, \dots . s \ (3)$$

$$\lambda_j \geq 0 \qquad j = 1,2, \dots , n \ (4)$$

Where:

- $1/\emptyset_o$ is the efficiency score of DMU^o that using m inputs to produce s outputs

- s_r^+ Outputs slacks;

- s_i^- Inputs slacks;

- λ_j represents the weight associated with the outputs and inputs of the DMUo.

- ε is a non-archimedean value

The interpretation of results of this model can be summarized as:

- DMU^o is efficient if and if only 1/$\emptyset_o = 1$ and $s_r^+, s_i^- = 0 \ \forall_j = 1, \dots , n; r = 1, \dots , s; i = 1, \dots , m$

- If $1/\emptyset_o = 1,$ then the DMU under evaluation is a frontier point. i.e., there is no other DMUs that are operating more efficiently than this DMU. Otherwise, if ($\frac{1}{\emptyset} < 1$), then the DMU under evaluation is inefficient. i.e., this DMU can either increase its output levels or decrease its input levels.

- The left-hand-side of the envelopment models is usually called the "Reference Set", and the right-hand-side represents a specific DMU under evaluation. The non-zero optimal λ_j^* represents the benchmarks for a specific DMU under evaluation.

3.3. The potential efficiency improvements:

Inefficient DMUs can improve their efficiency by adjusting the level of their outputs and inputs. One of the important results of the DEA technique is the proposition of these adjustments that the DMUs should make if they want to be (100%) efficient (or the efficiency score equal to 1/reduce inefficiencies).

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In the CRS output-oriented Model, the outputs slacks indicate the need for further augmentations in corresponding outputs whereas inputs slacks signals any additional reductions of inputs which could be reduced by the efficient levels of outputs.

The DEA method defines not only the levels of input-output slacks but also the levels of input-output targets which are the projected values on the frontier. From the equation of model (1), the levels of inputs-outputs targets are defined by the following formula:

$$y^{*}_{ro} = \phi^{*} y_{ro} + s_i^{+*};\ r = 1,2, \dots . s. \quad (5)$$

$$x^{*}_{i0} = x_{i0} - s_i^{-*};\ i = 1,2, \dots m. \quad (6)$$

Where,

x^{*}_{i0} is the input target i for the DMU^{o},

y^{*}_{ro} is the output target r for the DMU^{o};

x_{i0} is the actual input i for the DMU^{o},

y_{ro} is the actual output r for the DMU^{o},

ϕ^{*} is the efficiency score for the DMU$^{o;}$

s_i^{-*} is the optimal input slacks et s_i^{+*} is the optimal output slacks.

Potential improvements indicate the percentage that a DMU needs to increase its outputs or reduce its inputs to become 100% efficient (or to achieve an efficiency score of 1).

The percentage of output augmentation and input reduction for the i-th DMU is calculated as follow:

$$\% \text{ of output augmentation}: = \left(\frac{y^{*}_{ro} - y_{ro}}{y_{ro}}\right) * 100 \quad (7)$$

$$\% \text{ of input reduction}: = \left(\frac{x^{*}_{i0} - x_{i0}}{x_{i0}}\right) * 100 \quad (8)$$

3.4. Tobit Regression Model

Operating efficiently is a major challenge for bus companies, as multiple exogenous factors influence, simultaneously, their efficiency. These so-called environmental variables are not traditional inputs or outputs and are supposed to be beyond the control of the company's management (Coelli et al., (2005)). These external factors may explain the differences in efficiency.

In order to identify these external factors, the "two-stage" approach, recommended by Coelli et al., (2005), can be adopted. Indeed, the first step of this technique is to calculate the efficiency scores using only traditional inputs and outputs in the DEA models. In the second step, the efficiency scores, obtained in the first step, are regressed on the factors of interest. The results of the regression are used to identify external factors that influence efficiency scores to a statistically significant degree.

According to the "two-stage" approach, the second step aims to regress the efficiency scores on certain external factors. Since these scores range from 0 to 1, the dependent variable of the regression model takes a censor form (below and above, respectively). Using a linear regression model will provide biased estimates. Therefore, the appropriate approach is the Tobit regression model (Tobin, 1958). The Tobit Standard model can be written as follows:

$$y^* = x_i(\beta) + u_i, u_i \sim NID(0, \sigma^2) \quad (9)$$

$$y_i = y^* : \text{If } \; y^* > 0 \quad (10)$$

$$y_i = 0 : \text{If } \; y^* \leq 0 \quad (11)$$

Where y^* is a latent variable that linearly depends on x_i via a vector (β) which determines the relationship between the independent variable and the latent variable y^*. Moreover, there is an error term distributed according to a normal law u_i to capture the random influences on this relation. The observable variable y^* is defined as being equal to the latent variable when the latent variable is greater than zero and null otherwise.

4. DATA AND DEA MODEL SPECIFICATIONS

4. 1. Inputs/Outputs variables and DEA model specifications

Borger et al (2002) reported in their literature review on the performance of the UPT that an important distinguishing feature of the work identified is the diversity of inputs and outputs used. This diversity demonstrates that there is no consensus on the use of well-defined inputs and outputs. In this study, we have selected these variables mainly in terms of their relevance in the literature and the availability of data.

With respect to inputs variables, the most frequently used in the bus transport literature are those reflecting Capital, Labor and Energy (Borger et al, 2002). Capital is measured by the total number of Bus fleet. Labor is measured by the total number of employees and energy is measured by the total litters of consumed fuel. In our case, Due to the unavailability of energy and Labor data, we used only two variables reflecting the capital: the size of bus fleet (total number of buses) and the operating network (total length of urban bus network).

The definition of output variables is indeed subject to many debates. Some authors support the use of so-called supply-oriented output indicators (eg, vehicle-km or seat-km). While others support the use of so-called "demand-oriented" output indicators (eg the number of passengers carried or the number of passenger-kilometers). However, it is now widely accepted that the complexity of the transit business objectives and the heterogeneity of the transport outputs imply that the demand and supply characteristics are both relevant (Borger and Kerstens, 2007, p.697). To this end, some authors have used outputs that reflect both approaches (Viton, 1997, Odeck and Sunde, 2001, Odeck and Alkadi, 2003, Pina and Torres, 2006, Sánchez, 2009; Saxena and Saxena, 2010). Following this approach, we will use as outputs the following indicators: Bus-Km (total kilometers traveled by buses annually) and total number of passengers (Total number of passengers transported annually) that reflects the two approaches.

The inputs selected in this study are predefined in the specifications and in the contracts established with the delegating authorities. Company managers seek to maximize service delivery rather than minimizing the quantities of these inputs. Therefore, the output-oriented approach in the DEA model is chosen.

It is important to mention that the number of transported passengers in 2013 is only available for the companies of Rabat-salé and Tangier Cities. The other companies have data that vary between 2008 (Marrakech), 2010 (Fez, Casablanca) and 2012 (Agadir). For the purpose of comparison, we will consider all data for 2013.

Table 2 presents the DEA model and their corresponding input-output variables. Table 3 provides a summary description of the data in 2013.

TABLE 2 - DEA MODEL

DEA Model	Model Orientation	Input variables	Output variables
CRS-DEA Model	Output-oriented model	-Total number of Bus fleet -Total length of urban bus network (km)	-Bus-km ; Total passengers

TABLE 3 - SUMMARY DESCRIPTION OF DATA IN 2013

Variables	Inputs		Outputs	
	Total number of Bus fleet (Bus)	Total length of urban bus network (km)	Bus–km (in millions Km)	Total passengers (in Millions of Persons)
Mean	313.5	439.67	16321.33	56537.50
SD	257.98	233.22	13678.81	44047.97
Min	77	207	4202	16165
Max	674	795	39915	142042

4.2. Environmental variables

The environmental variables, included in the Tobit regression analysis and that are likely to influence the efficiency of bus transport companies are those reflecting the structure of bus network, the service characteristics and the demographic and socio-economic conditions of cities of our sample. Note that many other variables may be included in the regression analysis, but their corresponding information is unfortunately not available, the variables involved in our regression analysis are shown in Table 4.

TABLE 4 - ENVIRONMENTAL VARIABLES

Variables reflecting the structure of bus network and the service characteristics		
Name	**Definition**	**Unit**
Network Density (Netw_Dens)	The ratio of bus network Length to the urbanized area	Km²
The average length of lines (Aver_LL)	The ratio of bus network length to the number of lines	Km
Headway time (Head_Tim)	Time between Buses past a Stop point	Min
Variables reflecting demographic and socio-economic conditions of cities		
Household expenditure (Hous_Expend)	Average annual Household expenditure	1000MAD/year/House
The average price of the ticket (Aver_PricTick)	The average price of ticket adapted to standardized lengths of 10 km for urban line.	MAD/10Km
Population Density (Pop_Dens)	The ratio of total Population to urbanized area	Inhabitant /km²

4.3. Source of Data

Most of data used in this study are extracted from the two reports of MPTN (Lidia, 2014; Mustafa, 2015). Other additional data has been collected by authors from the administration's (including the provinces) and the companies in charge of the public transport.

5. RESULTS AND DISCUSSIONS

5.1. Analysis of efficiency

Efficiency scores are calculated using the DEAP software (developed by Coelli (1996)). Table 5 illustrates the distribution of scores assigned to the DEA model.

TABLE 5 - EFFICIENCY SCORES

Cities	Score	Peers
Agadir	0.851	Casablanca; Marrakech
Casablanca	1	Casablanca
Fez	0.782	Marrakech; Casablanca
Marrakech	1	Marrakech
Rabat-Salé	0.877	Casablanca
Tangier	0.83	Marrakech; Casablanca
Mean	**0.89**	

The analysis revealed that the companies serving bus transportation in Casablanca and Marrakech Cities are the most efficient of the sample, which means that these companies were able to achieve the highest level of kilometers travelled by Buses (Bus-km) and to attract the most passengers given the resources at their disposal (the number of Buses and Network length). This may be explained by the fact that these companies have mastered over time their production process and have been able to adapt their offers on demand. They have been operational since 2004 and 1999 respectively. In contrast, the company of Fez city is the least efficient with a score of 0.765. This may be explained by the fact that this company has just taken over from the former public company (the Autonomous Urban Transport company of Fez) in September 2012 and therefore it has not yet mastered its production process and has not yet been able to adapt to customer demand (2012-2013, one year of service).

In general, the efficiency score of the sample is moderate. The average score of efficiency is 0.89. The poor performance of companies may be explained by structural deficiencies in the urban transport sector, namely under-investment in infrastructures (roads, rolling stock, etc.), poor management of Traffic and parking, a lack of financial, social and environmental sustainability and poor institutional coordination at the local level (World Bank, 2015).

5.2. The potential efficiency improvements

The efficiency scores showed that four out of six companies are inefficient. These companies can improve their efficiency by adjusting the level of their outputs and inputs while comparing their peers. One of the important results of the DEA technique is the proposition of these adjustments that inefficient companies should to make if they want to be best efficient (or the efficiency score is equal to unity).

Table 6 provides the target values of the inputs and outputs derived from the CRS-DEA model. To explain the results, take the case of a single company, for example, the worst performer of the sample (company of Fez city). The efficiency score of this company is 0.782, which implies that this company could become efficient if all its outputs are proportionally increased by 20%[2]. However, even with this proportional increase required in all

2(1/(0.782(φ))-1) where 1/φ is the technical efficiency scores of an outputs-oriented model reported by the DEAP software.

outputs, this company would not achieve best efficiency. In order to project this company on the efficiency frontier, other "slack" adjustments are necessary because non-zero input-output slacks appear for this company.

The company operating in Fez city has to make three adjustments to become efficient. First, it should increase all its outputs by 20%. Second, it should increase the number of Bus-kms and total passengers by 27.91% respectively. However, despite the increase in its output, it still does not perform well. No other output can be increased. Thus, the company should also reduce his bus network length by 30.06%. The first adjustment is known as a radial adjustment, while the second and third types of adjustments are known as slack adjustments (Kumar, 2011). A similar interpretation can be used for other inefficient companies.

Finally, it is interesting to note that company managers should be aware that some of these performance improvement options (and target values) may not be practical. They can choose to implement only some of these potential improvements (especially the increase in outputs) because the quantities of inputs selected in this study are predefined in the specifications and in contracts established with delegating authorities. Their change should be the subject of a prior agreement between the company and the delegating authority.

TABLE 6 - POTENTIAL EFFICIENCY IMPROVEMENTS

Cities		Agadir	Fez	Rabat-salé	Tangier
Target output values	Y1	11070.628	15942.417	28768.925	5064.485
	Y2	47087.488	65711.308	102377.442	19482.959
Target input values	X1	171	245	432.453	77
	X2	272	377.651	573	110.65
% of outputs augmentation	Y1	2155 (24.17%)	3478 (27.91%)	3546 (14.06%)	862 (20.53%)
	Y2	6997 (17.45%)	14337 (27.91%)	47947 (88.09%)	3318 (20.53%)
% of inputs reduction	X1	0	0	242 (35.84%)	0
	X2	0	162 (30.06%)	0	140 (55.92%)
Y1=Bus-km ; Y2= Passengers ; X1= Total Bus ; X2= Bus Network Length					

Source: Author's calculations

5.3. Analysis of the regression results

According to the Tobit regression results which are obtained from the use of GRETL Software (Table 7), we note that only two variables have a slightly, but statistically significant, effect on the technical efficiency of companies. These variables are reflecting the structure of bus network and service characteristics. These are Netw_Dens and Head_Tim variables. They both have a negative effect on technical efficiency. For the first, this means that companies tend to operate efficiently in cities with low network density. For the second, this implies that reducing the headway time improves the companies' technical efficiency. In other words, improving the quality of service, in particular the reduction of waiting times (shorter headway times), attracts more passengers to use Public buses and therefore improves the efficiency of company.

On the other side, the three variables that reflect demographic and socio-economic conditions of cities have a statistically insignificant effect on technical efficiency of companies.

TABLE 7 - REGRESSION ANALYSIS RESULTS

Variables reflecting the structure of bus network and the service characteristics			
	Coefficient	Std. Error	z
Netw_Dens	−0.0163514	0.00656046	−2.492**
Aver_LL	−0.00593001	0.00691360	−0.8577
Head_Tim	−0.0106229	0.00224262	−4.737***
Variables reflecting demographic and socio-economic conditions of cities			
	Coefficient	Std. Error	z
Hous_Expend	−0.00600920	0.0138080	−0.4352
Aver_PricTick	−0.0879189	0.0638925	−1.376
Pop_dens	1.16047e-05	9.35858e-06	1.240
Statistical significance: * (90%) ** (95%) *** (99%)			

Source: Author's calculations

6. CONCLUSIONS

In this paper, we conducted a comparative analysis of the technical efficiency of six public bus transport companies in major Moroccan cities in 2013. To this end, we used Data Envelopment Analysis method.

The DEA results revealed that the companies serving bus transportation in Casablanca and Marrakech Cities are the most efficient of the sample. The efficiency scores showed that four out of six companies are inefficient; the search results also identify potential performance improvements for each inefficient company. This result provides practical information to companies or delegating authorities on the percentage that a company needs to increase its outputs or reduce its inputs in order to achieve best performance.

In order to identify the environmental factors that influence the company efficiency, a second analysis step was conducted where the three measures of performance are regressed on certain factors using a Tobit regression model. The results showed that only two variables reflecting the structure of the network and the characteristics of the service have negative, reduced but statistically significant, effect on the technical efficiency of firms.

This study has a set of managerial and policy implications:

In managerial terms, the results inform company's managers about the position of their companies in terms of efficiency for the year of 2013. The results inform also the managers of inefficient companies on the margin of improvement of their performance. That is, the percentage that a companyneeds to increase its output or reduce its inputs to become efficient. The example of the Fez city has been explained in the results section.

In policy terms, the study identified external factors that impact the measured efficiency and are beyond the control of companies. As such, the delegating authorities' of cities, whose company's are inefficient, should act on these factors in order to help companies improving their performance. Hence, the structuring of bus networks and the creation of dedicated lanes are strongly encouraged in these cities.

The major contribution of this research is to capture a preliminary image on the efficiency of public bus transport in major Moroccan cities using limited available data. The results allow these companies to compare their efficiency to other companies in different geographical contexts and identify external elements that influence their performance.

As to shortcomings, the study is based on cross-sectional data in 2013, a time point that may not be representative because some companies have recently started their activity while others have started for years ago. In addition, some data were not available for this year. These limits may skew the search results. finally, and as a research prospect, we will consider expanding the size of our sample by adding more operators and collecting longitudinal data to exceed the above limit.

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