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Full Length Research Paper

Economies of scale and density in the public rood transport sector in Tunisia

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This study seeks to broaden the knowledge in the impact of the economies of scale and density drawn in and by the road transport sector in Tunisia so as to not only grasp the possibility of a substitutability of the production factors used but also highlight the importance of the global productivity achieved in the operation of means of transport for the users and the community. The study of the twelve urban, suburban and interurban regional public road transport companies of passengers and goods in Tunisia reveals the existence of a homogeneity in the total production of these companies which vary with the size of the networks, the number of stops, the number of employees, although it exists a strong heterogeneity concerning.

Keywords: Economics of scale, Economics of density, Transport sector, Translogaritmic function, Increase, Innovation, Management.

PREVIOUS RESEARCH FINDING

During the last decades, many scientific analytical and empirical works have attempted to study the findings of the economies of scale and density in the public road transport sector. In the seventies of last century these works were interested in the concept of the substitutability, their total productivity and the relative concept to price elasticity and costing as well as economies of scale and density.

The previous main empirical woks were based on cost estimates and production technology that can influence the charging structure in the transport sector. More precisely, these inputs were based on linear cost functions, Cobb-Douglas functions, Keller functions and Diwert second order translog arbitrary cost.

Many researches were undertaken on road transport building on a sequence of function of translogarithmic cost (Ayadi A and Hammami S 2012).

We can mention that of Viton (1981), on a sample of 54 urban and suburban American agglomerations for the year 1975, who estimated his function by Sure-Zeller method (1962). The last drew that the American group bus network produces short-term and long-term rising economies of scale and density.

Viton (1981) also noticed the existence of substitutability between the two factors of production, that's to say the two inputs: work and energy (AES, $\square^{\wedge}_{LF}$

= 0,22) while stating that labor demand for urban small transport firms is inelastic to the price (η_{LW} = -0,03); which is not the case for the large firms (η_{LW} = -0,19). Besides, he concluded by maintaining that the energy demand is elastic to the price according to the various classification of the different firms with (η_{FC} = -0,19 à 0,57).

For their part, Karlaftis and Mc Carthy (2002) estimated function of the variable translogarithmic cost from a sample of 256 urban and suburban group haulers in the period of time between 1986 and 1994 in the United State. Through their model, on the basis of Sure-Zeller method, they used the cluster analysis which allowed them to identity the gathering of individuals who shared the same attributes.

Moreover, resorting to the variable (vehicles/miles) measuring the output in the road transport sector, they reached the following results: the existence of a common and increasing economy of scale and density with (ES = 1, 28) and (ED = 1, 33) where the two inputs work and energy are complementary ($ú_{LF}$ = -0, 55).

The demand of work and that of faintly elastic compared with their prices with (η_{LW} = -0, 17) and (η_{FC} = -0, 45). These results concern a common sample.

On the other hand, when the sample was divided into six groups, the authors concerned affirmed the existence of an economy of scale and density between a constant value evolving towards another one sharply increasing ES (0,99 à 11) ; ED (0,99 à 20).

As a result, the two inputs work and energy are at the same time substitutable and complementary according to each group of haulers ($ú_{LF}$ = 0,63 à -0,53); while the demand of work and that of energy are faintly elastic comparing to their price (η_{LW} = -0,16 to -0,24) ; (η_{FC} = -0,45 to -0,17).

Keho.Y (2005) analyzed the contribution of the public investments to the private capital formation in Ivory Coast, using a co-integration test and an estimation of error correlation during the period 1965-2001.

His analysis was concerned with the impact of the global public investment on the private investment which gave rise to a positive, significant relation between the two variables that means the first investment exerted a ratchet effect on the second one? This public capital was divided on six main components (education transport and communication, services, health, agriculture, mines and industries) and had a positive compact on the accumulation of the private capital with long term elasticity varying between (0.54) and (0.80) and this is thanks to the contribution, especially, of the transport, communication and education sector, since the compact exerted by the other sectors is not significant.

Keho (2005) concluded by stating that the politic of public investment in the economic infrastructure is in the transport and communication sector or in the formation of human capital is an efficient instrument to stimulate growth and development of the private investment forming a fundamental factor for the attractiveness of the direct foreign investments.

Piancenza estimated a function of a variable translogarithmic cost by the maximum likelihood method using a cross-sectional database with a trend where its sample containing 45 transport company giving urban and suburban vehicles haulers during a period of six year from 1993 to 1999 in Italy. He used as variables the « place-vehicle/kilometers » and average speed as output. The chosen sample is heterogeneous; which encouraged him to work on a common sample and a classified one composed of divers group. He could draw the existence of an economy of short and long term growing density.

These authors chose, as inputs, two variables representing the work factor which corresponds to the number of half time and full time employees; the capital factor contains the number of used buses. Furthermore, they have also chosen 2 outputs: « Place/km and Vehicle/ Kilometers ».

They noticed in their study that the economy of scale is increasing for small and medium-size enterprises and that there's a small increase of the technical efficiency during the average of the period. There is also a low increase of the average efficiency due to additional constraints.

Starting from these analytic and empirical results which are coherent and pertinent as for the study of the existence of an economy of scale and density in the urban, suburban and interurban road transport operation for certain developed and developing countries; starting from that we are going to wonder if such situations exist or not in the Tunisian public road transport? In other words does transport operation generate an economy of scale and density or not? In both cases how to grasp these situations? The answers for these questions prompt us to undertake an empirical analysis.

Empirical validation

The data base extracted from the directorate general research and planning of the ministry of transport and from regional public road transport company balance sheets (land transport directorate). This base has a double dimension individual or spatial and temporal. The first corresponds to the twelve regional transport companies which are: Beja, Bizerte, Gabes, Gafsa, Jendouba, Kairouan, Kasserine, Kef, Medenine, Nabeul, Sfax and Sousse. The second represents the period from 1995 to 2014[1] on annual basis.

The analysis of the economy of scale and density in the public transport sector requires the implementation of a road infrastructure and the use of production factors. The optimal allocation of these factors, that's to say the labor and the rolling stock, is the fundamental determinant of the total factor productivity.

The combination of these two productions factors requires a dose of technology to achieve a certain level of

Table n°1 : The indicators of positions

Indicators / Variables	Average	Médian	Maximum	Minimum	Observation
Log(Y)	9.97798	10.00462	11.51692	4.884089	240
Log(SN)	8.704679	8.772821	11.48018	3.763987	240
Log(NS)	9.0342	8.954139	11.54245	4.145513	240
Log(F)	5.132474	5.02703	10.23917	4.110874	240
Log(NE)	6.13845	6.001403	10.23917	5.293305	240

Table n°2 : The indicators of dispersions

Indicator / Variables	The Variance	Standard deviation	Coefficient of variation
Log(Y)	0.725634	0.8518415	0.0853721
Log(SN)	0.6426829	0.801675	0.092097
Log(NS)	0.4907143	0.70051	0.0775398
Log(F)	0.589895	0.7680462	0.1496444
Log(NE)	0.5253896	0.7248376	0.1180815

Tableau n°3 : The indicators of forms

Indicators / Variables	Kurtosis	Skewness	Jarque & Berra	Signifiance of JB
Log(Y)	7.385253	-.8213214	0.0853721	0.9741264
Log(SN)	8.172581	-.9443931	0.092097	0.961352
Log(NS)	12.84983	-1.121977	0.0775398	0.951423
Log(F)	25.42775	3.741124	0.1496444	0.901423
Log(NE)	13.6683	2.448337	0.1180815	0.914212

Table n° 4 : Total matrix correlation

Variables / Variables	Log(Y)	Log(TR)	Log(NS)	Log(F)	Log(NE)
Log(Y)	1.0000				
Log(SN)	0.8743	1.0000			
Log(NS)	0.8620	0.9382	1.0000		
Log(F)	0.5659	0.7160	0.6627	1.0000	
Log(NE)	0.6897	0.7278	0.6893	0.9288	1.0000

output. The last represents the public transport service in our article. Our base for the temporary individual data concerns the explanatory and endogenous variables including: the Size of Network (SN), the Number of Stops (NS), the Fleet (F), the Number of Employees (NE) and the Production (Y).

We approximate the variable size of network by the total length of lines reserved for the twelve regional transport companies in Tunisia. We also estimate the variable number of stops by the stop indicating the place where vehicles stop to pick up or drop the passengers which concern the collection centre for captive transport. Furthermore, nous we determine the variable. Vehicle Park building on the acquired vehicles on the occasion of the creation or extension of the urban and interurban public transport service or the renewal of the used park for these services: buses, coaches, articulated buses, comfort coaches and minibus, etc. This

Noticing that the information concerning 2014 are approximate; they estimated from anterior data. allows us to calculate the number of employees by the total number of the company employees which is composed of: The administrative staff, the working and technical staff. Finally we estimate the production of the public transport service in the regional companies as a homogenous variable marked (Y). The variable production is calculated from the vehicle/kilometers travelled. This production gives a better representation not only of the average

Table n° 5 : The tests of homogeneities-heterogeneities		
	Homogeneity of constantes	Homogeneity of coefficients
$Log(Y_{it})$	55.06 (0.000)	0.63 (0.9124)

Table n°6 : Static estimation				
Indicators / Variables	Estimation Within		Estimation GLS	
	Coefficients	Significativities	Coefficients	Significativities
Log(SN)	0.7710577	0.000	0.7770208	0.000
Log(NS)	0.1827413	0.000	0.1844504	0.000
Log(F)	0.5667019	0.000	0.5901751	0.000
Log(NE)	0.5098013	0.000	0.5415531	0.000

Tableau n°7 : Hausman test (1978)	
	$Log(Y)_{it}$
Stat-Hausman	$\chi^2(4) = 2.98$ (0.5604)

efficient capacity used to guarantee the service, but also of the distance traveled by the vehicles simultaneously.

To study the economies of scale and density in the public road transport for the twelve regional Tunisian companies from 1995 to 2014 on annual frequency, we refer to an artificial econometric model. Historically, the economies of scale and density are expressed by the production of the public transport service of these regional companies. This production (Y) corresponds to the endogenous variable for our data base. Or the other hand? The explanatory variables are: the size of network (SN), the number of stops (NS), the Fleet (F), the number of employees (NE) and the production (Y).

Indeed, empirically speaking, the link between the economies of scale and density in the public road transport sector in Tunisia concerns, the total length of lines reserved for the twelve regional transport companies (TR) the number of vehicle stops to pick up or drop the passengers (NS) the vehicle acquired on the occasion of the urban and interurban public transport service or the renewal of the fleet (F) and the number of employees (NE) to establish this link between these different variables, we refer to the main works of Viton (1981), De borger (1984), d'Obeng (1985), Thiry and Lawarée (1987) et d'Abbes and Bulteau (2003), to draw a base model which is presented in the form of the fallowing Cobb-Douglass function:

Y □□ □ □ □ □ □ t □1995□ 2014 et i *A* ' □1,.....,12

□*S* □*N* *i* □*F* □ *i*

N □ *S* □ □*NE* □ *i* *e it*

iti *it* *it* *it* *it*

To test the homogeneity of all the coefficients and constants of our below reference model and to give an exact specification to this model, we use the logarithmic linear operation on the right and on the left. After its transformation our modal takes the following from:

$Log(Y_{it}) = Log(A_i) + \beta_i Log(SN)_{it} + \gamma_i Log(NS)_{it} + \delta_i Log(F)_{it} + \varphi_i Log(NE)_{it} + \varepsilon_{it}$

To give an exact specification of the temporal-individual double dimension we use Fisher homogeneity and heterogeneity tests. For this purpose, we adopt the two statistics of fisher (F1 et F3) to identify the common and different feature of all the parameters of our base model relating to the twelve regional public transport companies (SRT) in Tunisia for the period 1995-2014.

The descriptive statistics

In this statistical study we are going to choose the

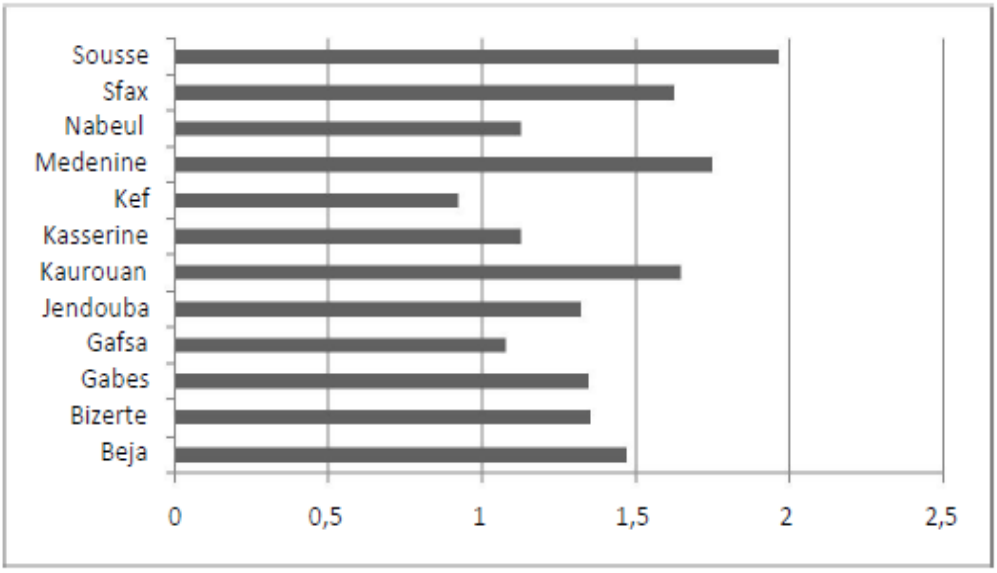
Table n°8 : Estimation of Random individual effects		
Indicators / Variables	Estimation GLS	
	Coefficients	Significant
Log(SN)	0.7770208	0.000
Log(NS)	0.1844504	0.000
Log(F)	0.5901751	0.000
Log(NE)	0.5415531	0.000
Estimation of Random individual effects		
Beja constant	1.470082	0.000
Bizerte constant	1.352885	0.001
Gabes constant	1.345887	0.001
Gafsa constant	1.076482	0.008
Jendouba constant	1.323406	0.000
Kairouan constant	1.64515	0.000
Kasserine constant	1.126698	0.002
Kef constant	0.9230292	0.013
Médenine constant	1.749658	0.000
Nabeul constant	1.126266	0.007
Sfax constant	1.626183	0.000
Sousse constant	1.967576	0.000

indicators of positions, dispersions and forms in order to study the normality, the adjustment and the estimation quality of each component of our base model. For this goal, the following tables correspond to a descriptive analysis of the explanatory variables and the endogenous variable during a period of study from 1995 to 2014 on annual frequency concerning the twelve regional transport companies.

From this table, we can conclude that on one hand, that the average for the five explanatory variables and the production of the companies transport services are a little high since the values of these variables are quite strong the median which shares the cumulated increasing frequency of each variable of our theoretical model which is grouped also into two is also strong for the explanatory variables and the endogenous variable of the base model. On the other hand, we must study the quality of estimation and the adjustment each component of this model by the indicators of absolute and relative dispersions. In order to achieve this, the table bellow corresponds to the dispersion criteria of these variables.

From the result of this table, we observe that the quality of estimation of these variables is very good since the variance of each variable below is too low. The linear adjustment of each previously mentioned variable is efficient because the standard deviations are low as well. Therefore we can conclude that is exists a good linear adjustment for the explanatory variables and the endogenous variables of our base model. Furthermore, it's necessary to study the normality of each variable of our reference model by the bias of the indicators of forms and Jarque and Berra statistics presented in the following table.

This table shows that these variables follow a normal law because the statistics of Jarque and Berra are two degrees of freedom lower than the critical value of Khi-two. Likewise, these variables are asymmetric since the statics of Kurtosis are greater than three. Thus, we conclude that all these variables have parabolic branches with asymptotic direction towards the abscissa axis but these statics of Skewness tend this to zero. We could conclude that the production, the size of network and the number of stops are shifted to the left. However, the other variables are shifted to the right.



Dependencies relationships

The study of dependencies relationships between the explanatory variables and the production of public transport services for the twelve regional companies during a period of study from 1995 to 2014 on annual frequencies is given the total matrix correlation describing the interrelations between the variables of our model.

From this matrix we can say that it exists positive dependencies relationship between the endogenous variable and all the explanatory variables. Thus, there is a positive dependence between the production of public transport services for the regional companies, the size of the network, the number of stops, the vehicle fleet and the number of employees. So it exists, by the end of the day, a positive correlation between the number of employees and the other explanatory variables. The vehicle fleet exerts positive influences on the production, the size of the network and the number of employees. That's to say the transport services provided by these companies are according to the vehicle park, the more we increase the number of vehicles in use the more the available seats increase. We notice that the dependencies between the explicatory variables and the endogenous variable are very high.

So, there's a strong correlation between the explanatory variables. As a result, there will be a multi-colinearity problem between these explanatory variables.

Specification Tests

The static estimate of the linear function, relating the logarithm of the productions of the public transport services according to explanatory variables in log for the twelve regional companies during a study period from 1995 to 2014 on annual frequencies, requires as in a first step, the homogenous or heterogeneous verification and specification of the generative process of individual-temporal data. On the econometric front, this comes down to test the equality of coefficients our theoretical model studied in its individual dimension. On the economic front, the specifications tests amount to determining if we have the right to suppose that this production is perfectly identical for the twelve Tunisian regional companies of public road transport; or it's quite the reverse; there are specificities which are peculiar to each company. Our theoretical model could be written in the following from:

$$Log(Y_{it}) = Log(A_i) + \beta_i Log(SN)_{it} + \beta_i Log(NS)_{it} + \beta_i Log(F)_{it} + \beta_i Log(NE)_{it} + \varepsilon_{it}$$

The innovations ε_{it} are supposedmean zero and to be «iid» with variance of σ_ε^2 , i $=1, N$. Thus, we supposeof our model can that the constants $Log(A_i)$ vary in the

Individual (With the exception of innovation variance which we suppose identical for all individuals) dimension…, but they are invariant in time. This model has many possible configurations (see Christophe Hurlin 2006)

This table below represents the tests of homogeneity heterogeneity of the model parameters.

From this table data, we conclude that all the production coefficients of the public road transport services are identical for the twelve regional companies even though the invariant effects are heterogeneous among these companies. Accordingly, our reference model is specified in the form of a panel with individual

effects taking these following specifications:

$Log(Y_{it}) = Log(A_i) + \beta Log(SN)_{it} + \beta Log(NS)_{it} + \beta Log(F)_{it} + \beta Log(NE)_{it} + \varepsilon_{it}$

Static estimate of the production of the public road transport services in Tunisia

The specification tests show that our theoretical model can be formalized as a Panel with individual effects. In order to estimate the production of the public transport services of the twelve Tunisia regional companies of road transport during the period from 1995 to 2014 on annual frequencies we use Within and du GLS techniques.

The following table recapitulates these two estimation procedures. In fact, in the observation of the static relation which links the production of the public transport services according to explanatory fundamental and behavioral variables?

From this table we could say that the estimation, using these two techniques, gives positive and significant results for all the explanatory variables of our reference model. The production of public transport services is elastic with respect to the size of network that means the growth of road networks has a big influence on the rise of this public production even on the presentation of the provided services. This result matches Hirshhausen and Cullmann work (2010) for collective public and private transport system in Germany. However, the production of public transport services is less sensitive but positive to the number of stops.

This interpretation is in agreement with Hirshhausen and Cullman's conclusion (2010) where the number of stops in Germany exerts a positive effect on the increase of production's volumes of the public services. The vehicle park, also, and the number employees have a positive impact on these volumes of transport production in Tunisia for both estimation procedures Within and GLS.

Nevertheless, to arbitrate between the two estimation techniques, we must turn to

Hausan's test (1979); the table below corresponds well to Hausan's test (1978) for the logarithm of the production of public road transport services.

CONCLUSION

This table shows that the production of public transport services for the twelve regional companies is specified by a Panel with random individual effects since Hausman's statistiques is lower than Khi-two is 4 degrees of freedom below. This drives us to stick with the estimation results of this production using GLS techniques. The elasticities of the public transport production with respect to the explicatory variables are positive and significant, that means it exists or strong sensitivity between this production, the size of the network, the number of stops, the vehicle park and the number of employees.

These results are expected because the accumulation of the production of the public transport services requires an innovation of lines. Such an innovation can have a positive effect for the existence of an economy of density in the management of Tunisian public road transport concerned companies. The improvements of stops or stations for the used vehicles as well as a well-planned, efficient staff increase of the regional transport companies can have a positive impact on the management of these data. The following table corresponds to the constant estimation or the Random individual effects for the twelve companies using the GLS technique.

Finally, we can indicate that the estimation of individual effects by the generalized least-square method GLS gives expected and significant results. The estimated values of the constants are also very low; these ones mean that the average effects of the omitted variables are very low. Hence, it's a question of a good specification of the production of the public transport service with respect to the explanatory services since the unforeseen uncertainties are so low. We represent these random individual effects in the next figure.

Thus, despite of the shortage in staff and in rotting stock which are necessary for a proper operation of the public road transport run by the twelve regional companies, the focus of our study, we could affirm, considering our study on the urban suburban and interurban transport network, that the situation requires a strengthening not only in the field of infrastructure but also in the operation of the public road transport lines in Tunisia.

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