Revue Internationale Multidisciplinaire
D'Economie et de Gestion
ISSN : 2724-7260
Volume 2 : Numéro 1

The impact of energy on the efficiency of the production of public road transport services in the Regional Transport Company of Sfax Tunisia (SORETRAS)

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Date de soumission : 17/09/2021

Date d'acceptation : 04/01/2022

Pour citer cet article :

Mezghani, M.A., & Boujelbene, Y. **(2021)**. « The impact of energy on the efficiency of the production of public road transport services in the Regional Transport Company of Sfax Tunisia (SORETRAS) », Revue Internationale Multidiciplinaire d'Ecomie et de Gestion « Volume 2 : Numéro1 » pp : 1-16.

Digital Object Identifier (DOI):

Abstract

The aim of this paper is to study empirically the energy efficiency of the production of public road transport services in the region Sfax-Tunisia: case of the regional transport company of Sfax (SORETRAS). To do this, we proceeded to synthesize the main works that dealt with this subject and we collected a database from the company during a period of study from 1986 to 2017. Indeed, the theory of Co-integration and error correction model were used to analyze the linear fit quality of the impact of energy on the energy efficiency of the SORETRAS.

Keywords :

Energy efficiency, Production service, Public road transport, Co-integration, Roots-Unitarians.

Introduction

Public road transport plays a crucial role in the economic and social development of a country. Transport mobility is generally considered to be one of the main and vital needs of the human being. This mobility allows agents to move from one place to another and accumulate industrial activities (Atabani et al (2011)). The sophisticated transport mobility system thus has a major impact in this economic development

In recent years, studies have shown that public road transport consumes a large share of primary energy on a global scale (Ong et al (2011)). Rapidly rising, particularly in emerging countries, for example China, a large part of Latin America (see Yan and Crookes (2007)). Besides, the world is currently facing a challenge of globalization, global warming and environmental pollution the latter has caused increased energy consumption. Emitting energy to economic sectors has adverse effects on the protection of the planet and especially on sustainable development, innovation and public health (Mahlia (2002)). In fact, the transport sector is threatening the environment and human health because of the massive use of fossil fuels and the high emission of greenhouse gases (Pucher et al (2005), Gasparatos & al. Liu & al (2013)).

The assessment of environmental performance and energy efficiency have become essential seeing the concern to the environmental issues and energy issues around the world (Zhou & al. (2014) and Wang & al. (2018b)). This efficiency plays a crucial role in the transport sector, let alone its negative impact on the environment (Xie and Hawkes (2015) and Xie & al. (2016)).

This article discusses the impact of energy on the efficiency of public road transport of the regional transport company of Sfax-Tunisia (SORETRAS-Tunisia). To achieve this goal, we will summarize the main empirical work that has addressed the effect of energy on transport efficiency in the first part. In the second part, we will empirically validate this impact from a database collected from SORETRAS-Tunisia during the period from 1986 to 2017, we will use the Co-integration theory to find a long-term relationship that connects the output of this company according to the explanatory variables and we will analyze the quality of the linear adjustment of this production within an error correction model (ECM).

1. Literature Review

Cullen and al. (2011) have shown that improving energy efficiency reduces energy shortage, decreases energy costs and decreases CO2 emissions. Patterson (1996) has put forward several definitions of energy efficiency and illustrated these indicators. Lovins (2004) defined this efficiency as a product, including all values and services, provided with the energy needed to feed. Hu and Wang (2006) have divided these indicators into two parts: one is the partial factor energy efficiency of the (PFEE) and the other is the total factor of the energy efficiency index (TFEE). The latter authors conducted an empirical analysis of the impact of energy on energy efficiency in many countries using nonparametric techniques, namely: Data Envelopment Analysis (DEA) and analysis of data and Stochastic boundaries (SFA). These techniques are still the most appropriate empirical validation methods. DEA and SFA are based on distance functions (Coelli et al., 2005).

Filippini and Hunt (2012) adopted the SFA to analyze residential energy efficiency in the United States for the years 1995-2007. Hu and Honma (2014) estimated this efficiency for fourteen developed countries during the period 1995-2005 by the SFA procedure. Also, Hu and Honma (2014) used Panel's parametric data technique to measure energy efficiency in Japan.

Lundgren et al. (2016) estimated energy efficiency and energy demand in manufacturing sectors for Swedish firms by the SFA technique. He (2011) used a Shepard distance function and constructed an SFA model to empirically validate energy efficiency for 36 industrial sectors in China during the years 1994-2008. He (2011) found that the industrial average of efficiency is equal to 0.76 during these years and the energy policy contributes to increasing energy efficiency and reducing the State's ownership.

Lin and Du (2013) estimated the efficiency of Chinese energy sources during the 1997-2010 period by the SFA method as Zhou et al. (2012). Lin and Wang (2014) have adopted the SFA technique to address energy efficiency for China's iron and steel industry. Lin and Long (2015) analyzed energy efficiency using the SFA approach for the Chinese chemical sector. Ouyang et al. (2018) used the SFA technique to estimate energy efficiency for 30 regional public transport companies in China and concluded that this efficiency has lowered energy prices.

Feng and Wang (2017) studied the energy efficiency of regional public transport companies in China through the DEA procedure. Wang et al. (2018a) observed the decrease of this efficiency for these companies by adopting the same procedure of Feng and Wang (2017).

Aggarwal and Jain (2016) have developed another scenario-based energy efficiency analysis technique as an important tool for estimating the impact of public transport on future energy demand and emissions of CO2 transport passengers in the Delhi area.

Chavez-Baeza and Sheinbaum-Pardo (2014) proposed a bottom-up model for estimating historical trends in energy demand. This model is based on air pollutant criteria and emissions of greenhouse gas effects explained by passenger car traffic in Mexico City metropolitan to build a baseline scenario and two other scenarios extended to 2028.

Palander (2016) studied the impact of heavy and heavy vehicles on the environment and Finnish industrial forest energy efficiency. For this, this author used the synchronized calculation procedure.

Sanches-Pereira and Gómez (2015) analyzed the development of the Swedish biofuel system and evaluated its impact on the achievement of 10% of renewable fuels in 2020. Sanches-Pereira and Gómez (2015) built a park of vehicles independent of fossil fuels in 2030. Cong et al. (2017) examined the entire supply chain of biomass energy, production and distribution of biogas substitution on the economy and the environment in Denmark.

Browne et al. (2012) presented a new methodological framework that can be used to qualitatively identify and assess fuel barriers to the environment. As well as, these authors have also proposed instruments and policies that can overcome these obstacles. Hannan et al.

(2014) have shown that the use of electricity instead of fuel for hybrid electric vehicles is a challenge to protect the environment.

Guo et al. (2018) have defined the key sectors of China's energy consumption and CO2 emissions from the point of view of the input-output relationship and the elasticity of energy demand. He et al. (2005) analyzed current and future oil consumption and CO2 emissions for China's road transport sector, and emphasized that fuel-efficient vehicle technologies must meet standard fuel economy standards.

Yan and Crookes (2009) studied the future trends in energy demand and greenhouse gas emissions in the Chinian road transport sector and assessed the reduction in energy efficiency as a result of these emissions. Lin and Liu (2017) applied the energy efficiency model incorporating energy-efficient output growth and energy conservation from China's transportation sector. Xu and Lin (2015) used Panel data and non-parametric regression models to study the main factors that influence CO2 emissions in China's transport sector.

He and Zhan (2017) have proposed an extended standards activation model to investigate the relationship between personal standards and the consumer interests of electric vehicles. Using the fuel life cycle assessment, Ma et al. (2017) conducted a quantitative analysis of battery electric vehicles in China and forecast performance in terms of energy saving and reducing CO2 emissions.

Aldenius and Khan (2017) suggested that transport is a public power that can influence public policies from available means such as: public markets where private cars dominate road transport. Ahlgren et al. (2017) argued that Sweden can be self-sufficient in renewable energy by 2030 without the use of agricultural land. These authors have shown that these energies have positive effects on the accumulation of road transport production in this country.

2. Empirical validation

In this article we will try to empirically validate the effect of Tunisian transport from a practical case of the Sfax road company. For this, we collect a database in this company during a period of study from 1986 to 2017 on annual frequencies. The variables used in this article are: the numbers of employers for this company, the size of networks, the production of this company approximated by the revenues generated for the Sfaxien Company of the road transport, the numbers of the travelers, the Park and the energy estimated by the Fuel. We will use the output of this society as an endogenous variable and the other variables as explanatory variables. We use statistical position, dispersion and shape indicators to study the quality of estimation, fitting, symmetry and flattening of each variable. The first table corresponds to the descriptive statistics for these variables.

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.

Tableau N°1 : Descriptive statistics

	LPRODUCTION	LPARK	LWORKFORCE
Mean	17.08364	5.840911	7.211996
Median	17.12778	5.831814	7.191806
Maximum	18.01675	6.131226	7.325149
Minimum	16.26048	5.602119	7.157735
Std. Dev.	0.549386	0.142189	0.041096
Skewness	0.050710	0.548107	0.916086
Kurtosis	1.783506	2.429281	3.094513
Jarque-Bera	1.986859	2.036542	4.487720
Probability	0.370304	0.361219	0.106048
Observations	32	32	32
	LPRODUCTION	**LPARK**	**LWORKFORCE**
Mean	17.08364	5.840911	7.211996

We can see that the averages are very high for these explanatory and endogenous variables. The standard deviations are very small; hence the linear adjustment of each variable to the mean is very good. The information is asymmetrical for the explanatory and endogenous variables since the Kurtosis statistics are different to three. But the number is symmetrical because the Kurtosis statistic is equal to three. All, the explanatory variables are shifted to the right because the Skewness statistics are strictly greater than zero. On the other hand, the endogenous variable has a flattening or a parabolic branch of asymptotic direction towards the axis of abscissa since the statistic of Skewness is equal to zero. All, the variables follow the normal law because the statistics of Jarque & Berra, for these variables, are inferior to the chi-square law with two degrees of freedom. Also, these Jarque and Berra statistics for these variables are statistically insignificant. The median shares the increasing cumulative frequencies, of each variable, in two parts: one part lower than the median while the other is higher. This median is very high for each component of road transport production in Sfax. We used the natural logarithmic operator to bring this database closer to the data. We study the meanings of Causalities between the variables and the qualities of precision from the Variance-Covariance matrix.

Tableau N°2 : Variance-Covariances Matrix

	LPRODUCTION	LPARK	LWORKFORCE	LENERGY	LNETWORKS
LPRODUCTION	**0.292393**	0.070593	0.012356	0.294574	0.045492
LPARK	0.070593	**0.019586**	0.002823	0.073937	0.009225
LWORKFORCE	0.012356	0.002823	**0.001636**	0.014635	0.001715
LENERGY	0.294574	0.073937	0.014635	**0.320579**	0.033654
LNETWORKS	0.045492	0.009225	0.001715	0.033654	**0.021612**

The variances are shown in the diagonal of this matrix and we found that these variances are very small. Hence, the precision quality of each variable is very good. In addition, there is a positive and weak correlation between the output of the Sfaxien road transport company and the explanatory variables. We analyze the existence or absence of a multicollinearity problem between the explanatory variables from the Correlation matrix.

Tableau N°3 : Correlation Matrix

	LPRODUCTION	LPARK	LWORKFORCE	LENERGY	LNETWORKS
LPRODUCTION	1.000000	0.932841	0.564904	0.962153	0.572277
LPARK	0.932841	**1.000000**	**0.498705**	***0.933090***	**0.448399**
LWORKFORCE	0.564904	**0.498705**	**1.000000**	**0.639004**	**0.288366**
LENERGY	0.962153	***0.933090***	**0.639004**	**1.000000**	**0.404324**
LNETWORKS	0.572277	**0.448399**	**0.288366**	**0.404324**	**1.000000**

There is a problem of multicollinearity between the park and the energy. On the other hand, there is no problem between the remains of the explanatory variables. We will study the stationarity of each component of our database level and difference first from the Dickey-Fuller test (1979-1981) in the results are presented in the table below.

Tableau N°4 : Dickey-Fuller Test (1979-1981)

	Delays	Models	In level		In first difference	
			T-Statistiques	Valeurs Critiques	T-Statistiques	Valeurs Critiques
LPRODUCTION	1	M2	0.187887	-2.960411	-8.578879	-2.963972
LPARK	1	M3	-3.396160	-3.562882	-9.467224	-3.568379
LWORKFORCE	2	M3	-3.364225	-3.568379	-4.750062	-3.574244
LENERGY	2	M3	-2.404596	-3.568379	-4.893162	-3.574244
LNETWORKS	1	M2	-2.016218	-2.960411	-4.744121	-2.963972

We use a Dickey-Fuller type test (1979) for the endogenous variable and the two explanatory variables LPARC and Networks since the optimal number of delays for these variables is equal to one. The T-Statistics for these variables in level are above the critical values of Mackinnon (1996) at the risk threshold of 5%. This endogenous variable and the natural logarithm of networks are modeled by a model with constant and without trend (M2). The natural logarithm of Park is specified by a model with constant and with trend (M3). After a single difference these variables become stationary, that is to say, integrated order one since the difference T-Statistics are below these critical values of Mackinnon (1996). We verify the non-stationarity of two explanatory variables: Logarithm of the numbers and logarithm of energy by a Dickey-Fuller-Augmented Unit Root Test (1981) because the optimal number of delays for these variables is equal to two. . These two variables are specified by a model with constant and with trend (M3) and the calculated student level values are higher than the critical values of Mackinnon (1996). Hence, these variables have unit roots and after a single difference these variables are stationary. All these variables are stationary after a single difference and we use the Co-integration theory to avoid the existence of a fallacious relationship from the usual estimation techniques. For this, we will refer to the Engle and Granger step method (1987) to estimate the following nonlinear long-term relationship:

$$\Pr oduction_t = A(ParK)_t^{\beta} (Enregy)_t^{\alpha} (Workforce)_t^{\chi} (Networks)_t^{\theta} \exp(\varepsilon_t)$$

We use the log-log operator to linearize this relation above:

$$L\,\mathrm{Pr}oduction_t = Log(A) + \beta Log(Park)_t + \alpha Log(Enregy)_t + \chi Log(Workforce)_t + \theta Log(Networks)_t + \varepsilon_t$$

In the first step of the Engle and Granger (1987) method, the ordinary (OLS) least squares procedure will be used to reduce the output of the Sfaxien road transport company to the logarithm of the vehicle fleet (Log (Park)).), the natural logarithm of energy (Log (Energy)), the number of workers in logarithms and the networks of this society. The result, from the estimation of the long-term relationship generated by this first step, is shown in the table below.

Tableau N°5: Estimation of the long-term road transport relationship in Sfax

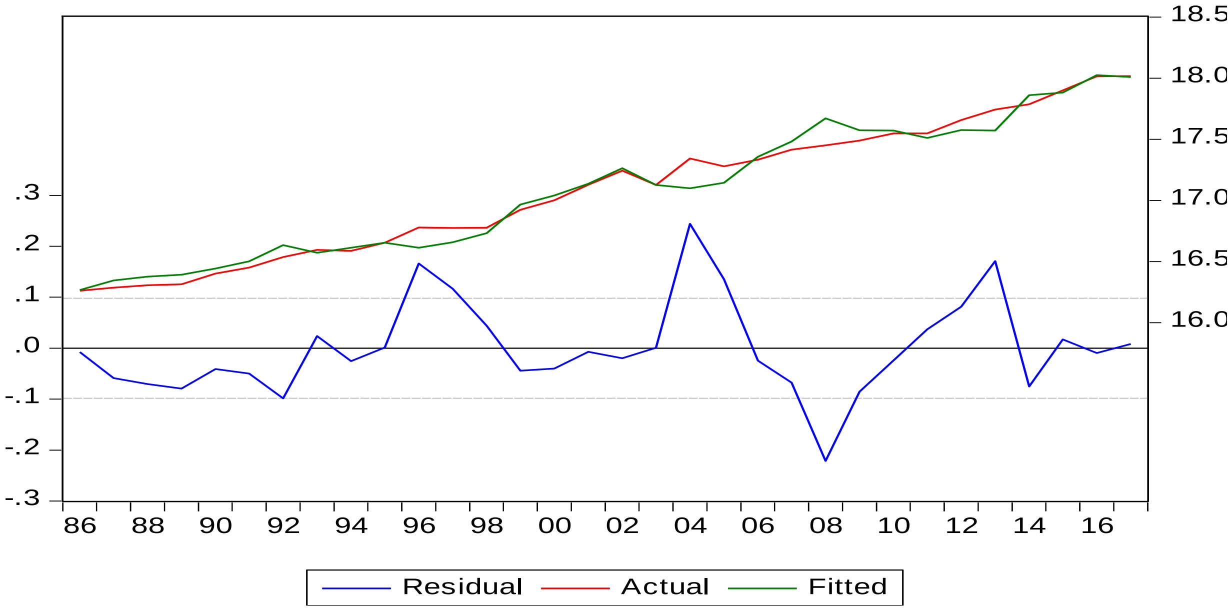
Variable	Coefficient	Standard deviations	T- Statistics	Significance
LPARK	0.360102	0.380143	0.947281	0.3519
LWORKFORCE	-1.067460	0.600950	-1.776287	0.0870
LENERGY	0.801922	0.103206	7.770084	0.0000
LNETWORKS	0.787165	0.133282	5.906013	0.0000
C	3.586723	4.316981	0.830841	0.4134

The acceptance of this long-term relationship is subject to stationarity in the level of the residue. For this, we study the presence or absence of unit roots in level for this residue, the long-term relationship, in the result is presented in the table below mentioned.

Table 6 : Stationarity in the residual level of the long-term relationship

	delays	T- Statistical	P-Critical value 5%	Model
Residue	2	-3.464641	-1.952066	M1

The residue is stationary in level since the Student's statistic is lower than the (P) critical value of Mackinnon (1996) at the risk threshold of 5%. Hence, we accept the long-term relationship that has been estimated by MCO. All the explanatory variables, except the workforce, have positive and significant effects on the accumulation of wealth in the Sfax road transport company. The number of workers has negative and significant impacts on the production of this company. The average effect of omitted variables has a negative and insignificant role in this production. Hence, a good modeling of this production from these explanatory variables which can be verified by the following graph:



We observe from this graph that the observable values of this company's production approach the estimated values of this production and the residue is very minimal. We can analyze the fit quality of this relationship within an error correction model (ECM) in the result is shown in the following table:

Table 7 : Estimation of the model with correction of error

Variable	Coefficient	Standard deviations	T- Statistics	Significance
Δ LPRODUCTION$_{t-1}$	0.028416	0.166960	0.170194	0.8663
Δ LPARK$_t$	-0.127150	0.259779	-0.489453	0.6290
Δ LENERGY$_t$	0.589843	0.185660	3.176999	0.0041
Δ LWORKFORCE$_t$	-0.742569	0.452873	-1.639683	0.1141
Δ LNETWORKS$_t$	0.331268	0.167752	1.974746	0.0599
RESIDUE$_{t-1}$	-0.383305	0.155418	-2.466279	0.0212

The estimation of the error-correction model, which includes the short-term equilibrium where the variables are stationary by the first difference effect and the long-run equilibrium where these variables are stationary by the linear combination, the MCO method gives expected and significant coefficients with a significant and negative adjustment rate. Hence, 38.33% of imbalance will be rectified by the force of the recall and the internal and external policy of the society of road transport Sfaxienne.

We apply the multi-variate approach of Johansen (1995) to detect the number of Co-integration relationships. Also, we will use the maximum likelihood technique to estimate the

VECM model. For this, we refer to trace tests and maximum eigenvalues to determine the number of Co-integrating vectors. But before using these tests, it is necessary to determine the optimal number of autoregressive vector (VAR) delays based on both the AIC and Schwartz information criteria and the likelihood ratio statistic. The table below represents the optimal number of VAR delays.

Table 8 : Optimal number of VAR delays

X_t = ($LPRODUCTION_t$, $LPARK_t$, $LENERGY_t$, $LWORKFORCE_t$, $LNETWORKS_t$)				
Delays	**1**	**2**	**3**	**4**
AIC	-29.6395	-29.9161	-29.9262*	-29.8941
Schwartz	-29.1378*	-28.9929	-28.5786	-28.1190
LR	88.4774 (0.0000)	36.2399 (0.06801)[1]		28.0604 (0.3051)

From these two information criteria and from the likelihood[2] ratio test above, we can conclude the existence of three delays for this multi-dimensional autoregressive vector X_t. The table below shows the number of Co-integrating vectors.

Table 9 : Johansen Test (1990)

	Test λ_{trace}					**Test λ_{max}**				
Xt = ($LPRODUCTION_t$, $LPARK_t$**,** $LENERGY_t$**,** $LWORKFORCE_t$**,** $LNETWORKS_t$**)**										
Null hypothesis	r=0	r≤1	r≤2	r≤3	r≤4	r=0	r=1	r=2	r=3	r=4
Alternative hypothesis	r≥1	r≥2	r≥3	r≥4	r=5	r=1	r=2	r=3	r=4	r=5
Statistical value	98.23	50.30	24.37	8.0	1.49	47.93	25.93	16.37	6.5	1.5
Critical value at 5%	69.82	47.86	29.80	15.49	3.84	33.88	27.58	21.13	14.26	3.84

[1] The number in parentheses indicates the marginal asymptotic level, that is, the probability that the value of the calculated statistic exceeds the tabulated value. Thus, a marginal asymptotic level 99.7% or 89.78% means that for a threshold less than 99.7% and 89.78 the hypothesis H0, of a single delay, is accepted.

[2] The likelihood ratio test makes it possible to determine the optimal number of delays of the autoregressive vector processes; this test follows a Chi-square law with k degrees of freedom.

The trace test shows the existence of two Co-integrating vectors since the likelihood ratio statistic for the second delay is statistically significant. On the other hand, the test of the maximum eigenvalues verifies the existence of a single relation of Co-integration.

We use the maximum likelihood method to determine the Co-integrating number. But the linear adjustments in the results are shown in the table below.

Table 10 : Estimation of the VECM model by the maximum likelihood technique

The variables	Standard cointegrated vectors (matrix β)	Coefficients with error corrections (matrix α)
LPRODUCTION	1.000000	-0.176453***
LPARK	-0.288884	0.255173
LWORKFORCE	-1.082289***	0.543121***
LENERGY	-3.521000***	-0.159792
LNETWORKS	-0.886980***	0.257378
Constant	-1.98962	

The estimation of the Vector (VECM) Error Correction Model by the maximum likelihood method with respect to endogenous variable normalization yields expected and significant results. All the explanatory variables have positive and significant impacts at the risk level of 1%. Hence, these variables have crucial effects on the accumulation of the wealth of the Sfaxian road transport society. In addition, the speed of adjustment of the logarithmic output to a negative and significant coefficient, that is to say, it will have a recall force that reduces the deviation of this production towards a partially stable situation in the long term.

Conclusion

In this article we studied the impact of energy on the efficiency of regional public transport of Sfax-Tunisia. For this, we have synthesized the main empirical works that have dealt with this impact. We collected a database from SORETRAS-Tunisia during a period of study from 1986 to 2017 for the revenues of this company as a production and an endogenous variable. Also, we used the number of employees, the fleet of vehicles, the size of networks and energy as explanatory variables.

Statistical indicators of position, dispersion, and forms were used to demonstrate that these variables do not follow normal laws since the Jarques-Berra statistics are greater than the critical value of chi-square with two degrees of freedom. We also found that the accuracy quality is very good for these variables as well as the linear adjustments of these variables to the mean. We have attributed the different dependency relationships between explanatory and endogenous variables from the Variance-Covariance matrix. We have shown that there is no problem of multicolarity between the explanatory variables except for fuel variables and vehicle fleet.

We verified that these variables are integrated order-one from Dickey-Fuller's unit root tests (1979-1981) since in level the T-Statistics are higher than the tabulated values of Mackinnon (1996). We used Engle and Granger's double-step method (1987) and we regressed the production variable by the ordinary least squares (OLS) explanatory variables. We have verified that the residual of this regression is stationary in level and we have nested this regression within an error correction model (ECM). We found that the coefficient of this delayed residue is negative and significant hence, there is a corrective mechanism that brings the target of production back to a partially stable situation in the long term.

We identified the number of Co-integration relationships from Johansen's (1995) approach and used trace tests and maximal eigenvalues to find the optimal number of relationships. We estimated the Co-integrating vectors and the adjustments by the maximum likelihood technique.

Several observations and proposals are to be made on the impact of energy used on the efficiency of the production of SORETRAS public transport services, including:

- Increased consumption of fuels of all kinds (Diesel, gasoline, gas) that should be reduced by the policy to rationalize this consumption by using high-end lubricants that extends the period of the routine maintenance of the fuel. Rolling stock (buses, coaches, service cars and equipment); while improving the periods of this interview according to the mileage traveled which constitutes the product of the company.
- A periodic renewal of the operating fleet in accordance with the depreciation standards relating thereto (on average 5 years).

- Gradually eliminate the dilapidated fleet of coaches, buses and rolling stock by replacing it with new acquisitions, which park consumes a lot of energy given its age.

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