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PRODUCTIVITY GROWTH IN EUROPEAN RAILWAYS AND EXOGENOUS FACTORS THAT INFLUENCE ON ITS EFFICIENCY

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ABSTRACT

We analyzed the performance of the European railway public system for the years 2004-2012. In this period, numerous deregulation and liberalization steps were implemented with the aim to revitalize the railway. This paper estimates an input distance function, with stochastic frontier techniques in order to estimate productivity growth rates. Productivity is decomposed so as to account for the impact of technical efficiency change, technical change an scale change. The results suggest that while technical efficiency change and technical change improved productivity growth, whilst scale change contributed slightly negative. Most of TFP growth appears to be due to cuts in input usage as opposed to output growth or technological advance. Likewise, this paper has analyzed the impact of grants and reforms implemented on railways efficiency. Meanwhile, grants have improved efficiency, reforms have not had the expected results. The vertical separation has not had a positive effect on efficiency. In contrast, the opening market seems to lead to a greater efficiency gain.

Keywords: *Productivity, Efficiency, grants, vertical separation, liberalization,*
JEL Classification: D24, L22, L51, L53, L92

1. Introduction

Over the last decades of the century XX, the demand for transport in the Member States of the European Union has increased significantly. This period is characterized not only by the expansion of the road transport with door to door service, but also by air transport. Meantime, railway has suffered an important decline in its market share. European railway sector was characterized by state-owned monopoly railway companies, where the companies are responsible for managing infrastructure and transport operations, so their national market has been developing without competition. Moreover, there is a lack of interoperability between the different national systems. Given that facts, the consequences are fragmentation of the European railway systems, gradual loss of market share to other forms of transport which led to high financial losses the sector due to the services which are poor of quality, lack efficiency and productivity.

In this context, the European Union (EU) has launched a series of reforms to improve their economy efficiency. EU is focused on become railway transport in a real alternative to road and air transport. Thus, the reforms implementation should lead to the railway sector competitiveness growth and improvement its efficiency. While the majority of European countries have implemented some kind of reform in the railway sector, these measurements differ broadly in terms of their dates of implementation and their degree. Therefore, the main components of the reform are:

- Separation of infrastructure management from transport operations. This separation can be implemented in four options. First option, there is a vertical integration, a single entity manages and owns not only all the infrastructure facilities, but also operations, and both functions are accounting separation. This model has been the old model of the incumbent[5]. Second option, the partial integration, a single integrated undertaking managing infrastructure which provide transportation services under the umbrella of a holding company with organizational, accounting and legal separation. There is a division that manages infrastructure and enables access to railway facilities to others undertakings. Third option, the vertical unbundling which implying infrastructure management is separated from transport operations by law, so there is a full separation. The access to railway facilities is granted to others undertakings. Fourth option, the partial separation there is legal, but the main railway undertaking is responsible for key infrastructure management functions.
- Promoting competition, by allowing the third-party access to the infrastructure. European transport policy has placed more emphasis on transport of goods due to its advantages over other alternatives. On 1st January 2007 European rail freight market was fully opened to competition. Regarding passenger transport, the international services was opened in 2010. Despite of third-party access is granted, there is potential discrimination, which means that only a few numbers of competitors will get in.

There are many studies about the impact of European policy on railways efficiency. However, there is not unanimity in the results. The reason may be the lack of adequate and consistent data due to differences in the definitions of variables or by differences in estimation methods. Thus, Driessen et al. (2006) found that vertical separation does not seem necessary to increase production efficiency while tendering service franchised improves production efficiency. In Wetzel (2008) did not find positive effects produced by vertical separation. While the estimated results for third party access rights differ between passenger and freight transport. Access rights for passenger transport are found to negatively influence technical efficiency

[5] Incumbent is a state-owned company by the central government

whilst freight transport is found to positively influence technical efficiency. Asmield et al. (2009) showed that reforms have improved technical efficiency; however, the benefits of complete separation are unclear. Growitsch and Wetzel (2009) found that integrated railway systems are, on average, relatively more efficient than those which have opted for an institutional separation. Cantos et al. (2010) they showed that vertical separation process has a positive effect on the efficiency of European rail systems. In spite of these gains in efficiency becomes higher when is implemented with liberalisation measures. In Friebel et al. (2010) found that liberalization and vertical separation increases efficiency, however, it depends on the sequence in which the reforms are introduced. Cantos et al. (2012) found that vertical separation alone does not produce significant improvements on efficiency, in the case of opening market does increase efficiency, although the best way to promote increased efficiency is combining vertical and deregulation reforms. Beria et al. (2012) did not find significant differences between an integrated rail system and separate companies, while liberalization improves efficiency in some cases. While Mizutani et al. (2015) showed that optimal rail structure depends on intensity and type of traffic on the network. Countries should be free to choose between vertical integration and vertical separation.

This study, hence, has two principal objectives. The first is to measure the technical efficiency of European railways and provides Total Factor Productivity (TFP) growth estimates decomposed into technical efficiency change, technological change and scale effects. The second is to assess the impact exogenous operating characteristics on technical efficiency, particularly the variables related to the degree of separation between infrastructure management and operations, and the degree of market opening.

The remainder of the paper is organized as follows. In the next section the research methodology is established. Then the empirical results are reported and interpreted. Finally the paper concludes by summarizing the main research findings.

2. Methodology

The model used in this paper is drawn from Orea (2002) and Coelli et al. (2003). The production technology can be fully described by the input distance. The choice of the input distance function rather than an output distance function is driven by the nature of production and regulation in the railway industry. We assume that firms have a higher influence on the usage of inputs than on outputs. This assumption is support by the substantial proportion of state-controlled public transport requirements within rail passenger transportation and by the decreasing market share of rail transportation within both passenger and freight transport sector over the last decades (Coelli and Perelman, 2000).

An input distance function measures how much the input usage can be proportionally reduced while holding the output fixed vector. The distance function can be defined as:

$$D_I(x, y, t) = \max\{\delta : (x/\delta) \in L\ (y)\} \quad (1)$$

Where the input set $L(y)$ represents the set of all input vectors x that can produce the output vector y, t is a time trend introduced to account for technical change, and δ measure the proportional reduction of the input vector x. This function is non-decreasing, positively linearly homogeneous, concave in x and increasing in y (Coelli and Perelman, 2000). The distance function, $D_I(x, y, t)$, will take a value which is greater than or equal to one if the input vector, x, is an element of the feasible input set, $L(y)$. That is, $D_I(x, y, t) \geq 1$ if $x \in L\ (y)$. Furthermore, the distance function will take a value of unity if x is located on the inner boundary of the input set. Given the input distance function measures, technical efficiency values equal to unity identify efficiency firm using an input vector located on the production frontier. Technical efficiency values between zero and unity to inefficient firms using an input vector above the frontier

To estimate the input distance function we adopt a translog function form because unlike a Cobb-Douglas form assumes the output elasticities do no vary with variations in input levels, the scale elasticities is also constant and a substitution elasticity equal to unity for all firm, translog does no impose such restrictions, is flexible, easy to calculate and permit to imposition of homogeneity (Coelli et al., 2005). Thus, the translog input distance function for K (k=1,…,K) inputs and M (m=1,…,M) outputs and we write by convenience $x^{*} = x_{\text{ki}}/\text{x}_{\text{Ki}}$ can be written as:

$$-\ln x_{\text{Kit}} = \alpha_0 + \sum_{\text{m}=1}^{\text{M}} \alpha_m \ln \text{y}_{\text{mit}} + \frac{1}{2}\sum_{\text{n}=1}^{\text{M}}\sum_{\text{m}=1}^{\text{M}} \alpha_{mn} \ln \text{y}_{\text{mit}} \ln \text{y}_{\text{ni}} + \sum_{\text{k}=1}^{\text{K}} \beta_k \ln x^{*}_{\text{kit}}$$

$$+ \frac{1}{2}\sum_{\text{k}=1}^{\text{K}}\sum_{\text{l}=1}^{\text{K}} \beta_{\text{li}} \ln x^{*}_{\text{kit}} \ln x^{*}_{\text{lit}} + \sum_{\text{k}=1}^{\text{K}}\sum_{\text{m}=1}^{\text{M}} \delta_{\text{km}} \ln x^{*}_{\text{kit}} \ln \text{y}_{\text{mit}} + \lambda_1 \text{t} + \frac{1}{2}\lambda_{11}\text{t}^2$$

$$+ \sum_{\text{m}=1}^{\text{M}} \rho \ln \text{y}_{\text{mit}}\, \text{t} + \sum_{\text{k}=1}^{\text{K}} \psi \ln \text{x}^{*}_{\text{ki}}\, \text{t} + \sum_{\text{p}} \xi_{\text{p}} \text{z}_{\text{pit}} + \text{v}_{\text{it}} - \text{u}_{\text{it}} \quad (2)$$

Where i and t are respectively firm and time indices, $\text{y}_{\text{m,i,t}}$ and $x^{*}_{\text{k,i,t}}$ denote the output and input quantity, and $\alpha, \beta, \delta, \rho, \psi$ y ξ are unknown parameters to be estimated. The input distance function must be symmetric and homogenous of degree +1 in inputs. Symmetric requires the restrictions:

$$\alpha_{\text{m,n}} = \alpha_{\text{n,m}} \text{ (m, n = 1,…, M) and } \beta_{\text{l,i}} = \beta_{\text{i,l}} \text{ (l , i = 1,…,L)} \quad (3)$$

The restrictions required for homogeneity of degree +1 in inputs are:

$$\sum_{\text{k}=1}^{\text{K}} \beta_{\text{k}} = 1, \ \sum_{\text{l}=1}^{\text{K}} \beta_{\text{kl}} = 0, \ \sum_{\text{k}=1}^{\text{K}} \delta_{\text{km}} = 0, \ \sum_{\text{k}=1}^{\text{K}} \psi_{\text{kt}} = 0 \quad (4)$$

The estimation method used in this paper is stochastic frontier analysis (SFA), simultaneously introduced by Aigner et al. (1997) and Meeusen and van den Broeck (1977). It involves specifying a parametric form which estimates a distance function with a composed error term, $\varepsilon_{\text{it}} = \text{v}_{\text{it}} - \text{u}_{\text{it}}$, that includes a standard error term v_{it}, accounting for measurement errors and other random factors, as well as, a non-negative random error term u_{it}, which representing technical inefficiency. Thus, $\text{v}_{\text{it}} \sim \text{N}(0, \sigma^2_{\text{v}})$ represents random error and is assumed to be independent and identically distributed, and $\text{u}_{\text{it}} \sim \text{N}^{+}(0, \sigma^2_{\text{u}})$ are assumed to measure time-varying inefficiency and are therefore drawn from an independent half-normal distribution that is truncated at zero.

We apply the true fixed effects model recently proposed by Greene (2005), this model employs maximum likelihood techniques to allow the inefficiency to vary over time and controls for firm-specific unobserved heterogeneity that unrelated to inefficiency. We have included ρ exogenous operating characteristics and dummy variables, whose impact on input requirements is captured in the term $\sum_{\text{p}} \xi_{\text{p}} \text{z}_{\text{p,i,t}}$. These fixed effects allow us to control for further factors influencing input requirements that have not been specifically controlled in the model. Given the linear non-interactive specification of the z factors, they will not appear in the derivation of the generalized productivity index and thus do not alter its derivation or decomposition. However, their inclusion will improve the model specification by allowing capture better the true underlying relationship between input requirements and outputs.

One limitation of this model is that any time-invariant inefficiency is absorbed by the firm-specific fixed effects. Hence, for short panels with presumably constant efficiency over time, the model estimates unreliable inefficiency terms (Saal et al., 2007). However, since our panel set covers a relatively long time of 9 years in which the European railway sector was subject to substantial restructuring and deregulation process and we assume time-variant inefficiency.

The model estimates are obtained by maximum likelihood estimation. The method of Jondrow et al. (1982) is used to obtain point estimates of u_{it} (Greene, 2004).

$$E(u_{it}|\varepsilon_i) = \frac{\sigma\lambda}{1+\lambda^2} + \left[a_{it} + \frac{\phi(a_{it})}{\Phi(a_{it})}\right] \quad (5)$$

Where $\sigma^2 = (\sigma_u^2 + \sigma_v^2)$; $\lambda = \sigma_u/\sigma_v$; $a_{it} = -\lambda\varepsilon_{it}/\sigma$; and $\phi(a_{it})$ y $\Phi(a_{it})$ represent the standard normal density and cumulative distribution evaluated at a_{it}, respectively. The λ parameter represents the relative contribution of the inefficiency and noise component to the total error term. If $\lambda \rightarrow 0$ all deviations from the best-practice frontier are due to noise, and if $\lambda \rightarrow +\infty$ are due to inefficiency.

Once the input distance function has been estimated, the parameter estimates can be used to calculate the TFP change. Following Orea (2002), TFP change is decomposed into technical efficiency change, TE, technological change, TC, and a scale effects, SF, as shown in Eq. 6:

TFP = TE + TC+ SF (6)

According to Coelli et al. (2003), TFP change for the $i-th$ firm between the period t and t + 1 is calculated as:

$$\ln\left(\frac{TFP_{it+1}}{TFP_{it}}\right) = [\ln TE_{it+1} - \ln TE_{it}] + \frac{1}{2}[(d\ln D_{it+1}/dt) + (d\ln D_{it}/dt)]$$

$$+\frac{1}{2}\sum_{m=1}^{M}[(SF_{it+1}\epsilon_{mit+1} + SF_{it}\epsilon_{mit})(\ln y_{mit+1} - \ln_{mit})] \quad (7)$$

Where TC change is measured by the mean of the partial derivatives of the input distance function with respect of time evaluated at the period t + 1 and t.

$$\delta\ln D_{it}/\delta\, t = \lambda_t + \lambda_{tt}t + \sum_{m=1}^{M}\rho_{mt}\ln y_{mi} + \sum_{k=1}^{K}\psi_{kt}\ln x_{ki}^{*} \quad (8)$$

On the other hand, SF measure requires the calculation of output elasticities at the period t+ 1 and t.

$$\varepsilon_{m,i,t} = \delta\ln D_{it}/\delta\ln y_{m,i,t} = \alpha_m + \sum_{m=1}^{M}\alpha_{mn}\ln y_{mit} + \sum_{k=1}^{K}\delta_{km}\ln x_{kit}^{*} + \rho_{mt}t \quad (9)$$

So input distance scale factor SF_{it} for the $i-th$ firm in the $t-th$ period is:

$$SF_{it} = \left(\sum_{m=1}^{M}\varepsilon_{mit} + 1\right)/\sum_{m=1}^{M}\varepsilon_{mit} = 1 - RTS_{it} \quad (10)$$

Where RTS_{it} is the scale elasticity for the $i-th$ firm in the $t-th$ periods. The input distance function is homogeneous of degree one in inputs, the input change weights sum to unity in this index. However, the output weights do not sum to unity. For an input distance function RTS_{it} is equal to the negative of the inverse of the sum of the output elasticities. Thus, with constant returns to scale RTS = 1. In contrast, if increasing (decreasing) returns to scale, RTS > 1 (RTS < 1) are given.

3. Data description and variables

The aim of this paper is to analyse how reforms launched by EU have improved the efficiency and productivity of the incumbent. Likewise, we include several exogenous factors to analyses how they influence on efficiency.

The sample data is limited to the former state railway undertakings or their successors. In order to compare observations between countries, samples are generated by aggregating the data of the successor undertakings in countries where there is more than one company. For example, in Spain there are two companies, Adif manages the infrastructure and Renfe runs transport operations. Meanwhile, in Germany there is only one company called Deustche Bahn.

Data set were received from several sources: Railisa database and synopsis of the International Union of Railways (UIC), Eurostat database, the annual reports of the rail operators and infrastructure manager, website of the Statistical Office and the data published in the Rail Liberalisation Index 2004 – 2007 – 2011. This study is conducted with a multi-output technology and multi-input production. Since each country has unique characteristics that directly affect the efficiency manner. Railway systems are included with different shapes and sizes: vertically integrated, separated legally, with varying degrees of openness, systems where the carriage of passengers or goods or mixed predominates, with significant grants to transport operations and to maintenance of infrastructure. Data includes some characteristic of railway infrastructure and operations for 15 European countries from 2004 to 2012. Moreover, we selected this time frame because it covers the implementation of the liberalisation reform in the majority of countries. As we use a multi-output technology, Netherland, Denmark and Romania are not included in the sample because they sold their freight division. We had to exclude other countries from our analysis due to poor data.

Railway systems can offer a variety of services, in order to collect the characteristics of service production, we select as outputs variables: the number of passenger-km transported, is the number of passengers carried by kilometre travelled by each of them; and the number of tonne-km corresponds the number tonnes carried multiplied by the distance travelled per tonne. As Oum and Yu (1994) point out these outputs measures, compared to other measures like passenger train-km and freight train-km, also take into account the possible influence of government and regulatory restrictions on capacity allocation.

Regarding the inputs, the variables selected are: the number of employees[6] of the state railway companies, the number of rolling stock used for both freights and passengers, and the variable network length as a proxy for capital stock. We consider network length, since it is a long-lived asset, as a quasi-fixed built in the past and financed by capital grants from the government.

Further we included six variables in a linear non-interactive way into the input distance function. By this specification it influences the input distance function estimates, but does not appear in the TPF calculation. We use environmental variables, as well as, regulatory variables to measure the impact of the regulatory conditions on efficiency.

Our model specification includes the following exogenous environmental variables. Network density (netden) is the network length in km divided by square area km of the country. This variable should reflect the impact of differences in network structure and density on the production process and on the input

[6] Employees can perform different functions to rail transport, that is to say, they can perform other activities such as road transport or logistics services

requirements. As Farsi et al (2005) showed that high density networks have a more complex shape than less dense networks and are usually in areas located in areas with higher population density. Another variable related to the characteristics of the network is electrified track (%elect) as a percentage of the total, it is highly probable that a higher degree of electrification will improve efficiency levels, as it is to expected that will reduce the levels of labour.

For European railways, public grants provide essential funds for infrastructure maintenance and to boost passenger and freight transport that depends on political decisions of States. The railway tends to be an instrument of policy decisions rather than truly independent companies, even if companies emphasize independently and are free to behave commercially, the role of politics is crucial in some fields. In the case of the grants for maintenance or renewal of the rail network (gr_i), the infrastructure manager receives an amount of money from the state for maintenance or renewal of the rail network. The operating grants (gr_o), as a rule, they are state compensation to railway undertaking for the provision of the Public Service Obligation[7]. Countries provide public service contracts through public procurement procedures or directly. These contracts are related to the provision of passenger transport service suburban and middle distance.

As we can see in table 1, all variables show a significant amount of variations due to heterogeneity of the sample railway systems. For example, in Spain and France the railway undertakings provide mainly passenger services, meanwhile in Germany and Czech Republic they concentrate on freight services. Furthermore, the network length of Germany's railway system is 123 times longer than in Luxembourg. Also, an important part of the variation is a function of time. In the period 2004 - 2012 the number of passenger-km increased by 10.48% and number of tonne-km decreased by 2.94%, while in the same period the number of employees and rolling stock decreased by 10.32% and 16.44% respectively.

[7] The Public Service Obligations are passenger transport services that are considered of general interest. State imposes the rail operator performing unprofitable services, either by the route, frequencies, schedules or quality of rolling stock. The operator receives financial compensation for the cost incurred by the provision of such services.

Table 1: Descriptive Statisitics

Average values during the period 2004-2012

		Outputs		Inputs			Environmental variables			
Country	Railways firms	Passenger/ Km (10^6)	Tonne / Km (10^6)	No. of Employees (10^3)	No. of Rolling stock (10^3)	Network length Km	Network density (10^{-1})	% network electrified (10^{-2})	Operat. grants (10^3)	Infraestr. grants (10^3)
Belgium	SNCB	10,050	7,245	36.84	14.84	3,532	1.16	85.31	0.73	0.40
Czech Rep.	SZDC / CD	6,694	14,991	55.80	35.70	9,484	1.20	32.74	0.40	0.32
Germany	DB	76,037	99,324	235.67	124.13	33,924	0.95	57.84	5,32	1,61
Ireland	CIE	1,755	0,168	4.85	1.37	1,919	0.27	2.71	0.09	0.19
Spain	ADIF / RENFE	20,702	9,203	28.54	16.50	13,385	0.26	60.63	0.40	0.76
France	RFF / SNCF	82,248	33,248	165.0	45.11	29,649	0.55	51.75	8,40	1,13
Italy	FS	43,914	23,347	89.36	47.09	16,462	0.55	70.80	0.74	1,82
Luxemburg	CFL	0,323	0,337	3.06	3.82	0,275	1.06	95.27	0.17	0.26
Austria	ÖBB	9,480	20,973	44.91	24.92	5,392	0.64	65.13	0.68	1,30
Portugal	REFER / CP	3,645	2,276	7.75	4.15	2,803	0.30	52.60	0.03	0.04
Slovenia	SZ	0,794	3,619	8.13	4.07	1,224	0.60	41.05	0.05	0.13
Slovakia	ZSSR / ZSR	2,264	8,361	38.82	16.40	3,623	0.74	43.36	0.20	0.09
Swedeen	BV / SJ	6,406	16,053	12.50	7.70	9,908	0.22	79.82	0.02	0.03
Norwey	BANEVERKET/ NSB	2,617	2,458	14.81	2.30	4,139	0.13	63.61	0.24	0.56
Switzerland	CFF	15,714	12,234	27.23	13.12	3,146	0.76	100.0	0.88	2,07
	Mean	18,844	16,922	51.15	24.08	9,258	0.63	0.60	1,22	0.72

Source: International Union of Railways, Eurostat database and Annual Reports

Key elements in the European railway reforms have been to promote a step-by-step market opening mainly concerning freight transport combined with some degree of vertical disintegration of infrastructure management and operation of services, unbundling of other railway functions, and introduction of infrastructure access charging (Di Pietrantonio and Pelkmans, 2004). Thus, our paper uses two dummy variables. We consider whether the incumbent has chosen an institutional separation, that is to say, there is an unbundling vertical. The other variable is relative to the opening degree of railway systems. These two variables are beyond the control of state undertakings, but significantly affect their levels of efficiency.

One factor that may impact benchmarking analysis and railway efficiency is the difference in railway system structure. In reference to the degree of separation of infrastructure management and transport operations, European legislation does not require the complete separation of infrastructure from operations. What it does require is that if infrastructure management is not an independent organization, a separate organization should be in charge of the allocation of capacity and the establishment of fees. The degree of separation extends from purely accounting separation to a complete ownership. In our paper, there is full ownership separation in the areas of infrastructure and operations in Czech Republic, Spain, France, Portugal, Slovenia, Sweden and Norway. In these countries there is vertical separation, a state-controlled firm owns the infrastructure and provide network access and services to numerous railway undertakings. However, many countries argue that institutional separation would diminish the advantages of vertical integration and would not be effective in raising economic welfare. In the group of countries that have not opted vertical separation, there are countries that have chosen the legal, organizational and accounting separation within a holding company as Austria, Belgium, Germany and Italy. While in Ireland, Luxembourg, Slovenia and Switzerland have opted for an accounting separation only.

By the other hand, competition requires the commitment of governments to promote competition by removing barriers of access to the network and guarantee fair competition between different railway undertakings. The design of competition is not straightforward in the case of railways. Railway reforms have been moderate in Europe and have consisted mainly of new undertakings entering the freight sector and of a franchising system in passenger services (Cantos et al., 2012). The market opening is still very different in Europe, where network access is legally guaranteed for domestic and foreign rail freight transport undertakings in Europe. Differences exist in granting permission for domestic services in passenger transport. In this segment only Sweden and Great Britain have fully liberalized their markets, while Austria, Czech Republic, Germany, Italia and Netherland have opened their own market to a limited extent. We use IBM studies on market opening rail in Europe in 2004, 2007 and 2011 to classify the degree of market opening between all European countries.

Then we define our two dummy variables as:

s_ins: takes a value of one for countries, which the ownership of infrastructure is separated fully and institutionally from that of operations during the years of sample.

d_open: takes a value of one when the entry of new operators is allowed in the railway sector, regardless of whether or not the industry has been separated vertically.

Table 2 shown the organizational models and degree of market opening

Table 2: Organizational models of the European Rail System

Degree of separation	Degree of opening market	
	High	Down
Full separation	Bulgaria, Denmark, Great Britain, Netherland, Norway, Romania, Sweeden	Finland, Greece, Portugal, Slovakia, Spain
Partial separation	Czech Rep.	France
Partial integration	Austria, Belgium, Estonia, Hungary, Germany, Italy, Latvia, Poland	Lithuania
Full integration	Ireland, Luxemburg, Slovenia	Switzerland

Source: Autor

Regarding Czech Republic and France, two different entities were created. However, infrastructure maintenance and some infrastructure enhancement are still managed by company makes transportation operations based on a contract. Therefore we do not consider an institutional full separation. In fact, such a mix or hybrid structure is more similar to an organizational separation with separated divisions for infrastructure management and operations within a holding company, as examples Germany or Italy. In the case of Spain, its railway system was separated in 2005. In reference to the degree of liberalisation, Czech Republic, Belgium and Norway are moved from down to high degree of opening market in this period.

4. Empirical Result

This paper uses a parametric mathematical program called Frontier 4.1, developed by Coelli (1996) to estimate the efficiency levels of the sample. The parameter estimates for the function input distance oriented represented by Equation 2 shown in table 3.

Tabla 3. Estimated input distance function parameters

Variables	Parameter	Coef.	T- ratio	Variables	Parameter	Coef.	T- ratio
ln Y_1	α_1	-0.5902***	-0.89	netden	ξ_1	-4.2571***	-4.26
ln Y_2	α_2	-0.3517***	-0.67	%elect	ξ_2	1.4151***	1.66
0,5·(ln $Y_1)^2$	α_3	-0.1144***	-0.22	gr_o	ξ_3	0.0457***	0.09
0,5·(ln $Y_2)^2$	α_4	-0.2236***	-0.47	gr_i	ξ_4	0.0026***	0.03
ln Y_1 ln Y_2	α_5	0.1670***	0.35	s_ins	ξ_5	-0.3721***	-0.41
ln X_1	β_1	0.5525***	0.7	d_open	ξ_6	0.0501***	0.14
ln X_2	β_2	0.0428***	0.05				
0,5·(ln $X_1)^2$	β_3	0.2596***	0.28				
0,5·(ln $X_2)^2$	β_4	-0.6081***	-0.69	Sigma squared	σ^2	0.0185***	0.76
ln X_1 ln X_2	β_5	0.2849***	0.39	Gamma	γ	0.9288***	0.99
ln Y_1 ln X_1	δ_1	0.0160***	0.01				
ln Y_1 ln X_2	δ_2	-0.0506***	-0.08	Log likelihood function		135.79	
ln Y_2 ln X_1	δ_3	0.3372***	0.43	RST		1.062	
ln Y_2 ln X_2	δ_4	-0.0326***	-0.05				
t	λ_1	0.0002***	0,00				
0,5·t^2	λ_2	-0.0059***	-0.08				
ln Y_1 t	ρ_1	-0.0076***	-0.27				
ln Y_2 t	ρ_2	0.0037***	0.14				
ln X_1 t	ψ_1	0.0585***	0.33				
ln X_2 t	ψ_2	-0.0269***	-0.15				

Y_1 is passenger-km , Y_2 is tonne-km, X_1 is employees, X_2 is rolling stock, X_3 is network lentgh and therefore the dependet variable is -ln X_3

Source: Author using data from Frontier 4.1

We first consider the impact of the ξ_p exogenous factors on estimated input requirements. Regarding exogenous environmental variables, the netden coefficient ξ_1 is negative and statistically significant. The increase ξ_1 involves that it is possible to provide a service better suited to the needs of customers. If the outputs increase the consumption of inputs will do it too. In order to ξ_2, ξ_3 y ξ_4 all of them have a positive influence on the efficiency. The increase of the length of electrified network improves the efficiency very positively by reducing the number of employees. In the case of the grants, meanwhile the coefficient operating grants is statistically significant, for infrastructure grants is not the equal. It should be notice that while transport operating grants have increased by 22.37%, infrastructure grants have decreased by 2.17% in the same period.

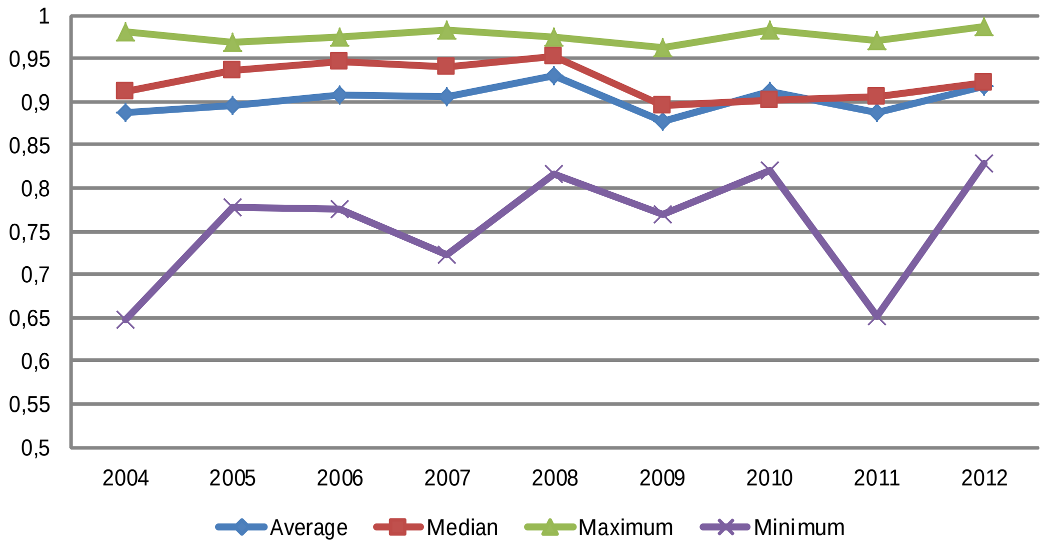
Regarding the degree of vertical separation the incumbent, ξ_5, showed a negative and statistically significant coefficient, this mean that unbundling separation can generate inefficiency due to coordination problems, deficiencies in infrastructure investment or loss of economy of scale inter alia. By other hand, the degree of market opening has a positive effect on efficiency. So competition improves production processes and companies become more efficient.

Focus on FTP growth, the output, input and time variables are normalized around their mean values, the first-order coefficients can be interpreted as output and input elasticities. All first-order coefficients are statistically significant and have the expected signs. The estimated input distance function is decreasing in outputs and increasing in inputs. Furthermore, the input distance function is homogeneous of degree one in inputs, so the input change weights sum to unity in this index. The β parameters reveal that input elasticities for employees, rolling stock and network length are respectively 0.552, 0.043 and 0.405[8], implying a labour intensity of the European railway sector. However, the output weights do not sum to unity. The negative of the inverse of the sum of the first-order output coefficients is 1.062, indicating increasing returns to scale at the sample average firm. Evaluating the returns to scale on the firm-specific level show that the average and median valour of returns to scale are 1.063 and 1.074, respectively, and 54 percent of all observations reveal increasing returns to scale. These results show the difficulty of implementing a transport policy valid for every country. The reason must be sought in each country's railway system has unique characteristics, such as density network, topography, degree of congestion, population density, regulatory and so on, that it makes difficult to apply the same solutions for all countries. The coefficient of time (t) is 0.025 and it can be interpreted as the rate of technical change achieved by the sample average firm in the mid year of the sample. Meanwhile, t^2 is negative indicating that the rate of technological change decreases over time. The ψ_m parameters suggest that the labour elasticity increases over time and, hence, implies labour-saving technical change. This is motivated by optimizing processes coupled with the reduction of excess production capacity in the sector. Conversely, the rolling stock and network density elasticity decreases over time, as $\psi_3 = -(\psi_1 + \psi_2)$. This result is consistent with an industry that has reduced its labour by 10.32% and rolling stock by 17.44%. Finally, the value of γ equal to 0.92 this means that most of the variation component due to error is technical inefficiency term.

The development of technical efficiency over time derived from the input distance function estimates is illustrated in figure 1. Average and median show a slight increase in the period. From 2004 to 2008 there is a relatively continuous increase of scores. However, average down the years 2009 and 2011 influenced by the global financial crisis that began in mid-2007 and the Euro crisis that started in 2010. The minimum technical efficiency scores show a significant increase by 28%, suggesting a convergence of technical efficiency levels within European railway system over time. Overall, the difference between the minimum and maximum technical efficiency scores decreased from 0.33 in 2004 to 0.16 in 2008, 2010 and 2012.

[8] Since x_3 has been used as a numeraire, the network length can be recovered as $e_3 = 1 - e_1 - e_2$

Figure 1. Development of Technical Efficiency Scores



Source: Author using data from Frontier 4.1

The results of the FTP change decomposition calculated from the estimates of the input distance function by employing the Malmquist productivity index approach describe in equation 7 are reported in table 4 and figure 2.

Tabla 4. Average growth rates of FPT and its componentes (in %)

Period	Efficiency change	Technological change	Scale effect	FPT growth
2004-2005	1.20	2.53	-0.03	3.70
2005-2006	1.45	1.82	0.15	3.41
2006-2007	-0.26	1.12	0.26	1.12
2007-2008	2.94	0.45	-0.24	3.14
2008-2009	-6.03	-0.21	-0.22	-6.46
2009-2010	3.89	-0.84	-0.18	2.86
2010-2011	-3.08	-1.40	0.23	-4.25
2011-2012	3.76	-2.00	0.02	1.78

Source: Author using data from Frontier 4.1

The technical efficiency change shows two scores negative very meaningful in the period 2008-2009 and 2010-2011. These scores are influenced by the global financial crisis of 2007 which had major effects place in 2008 and the Euro crisis started in 2010. Nevertheless, the cumulate average efficiency change index indicates an overall positive impact by 3.87% on average TFP growth.

Regarding technological change shows a cumulative growth rate by 1.46% over the whole period. This increase is mainly due to the introduction of modern trains, the application of new technologies in traffic management and improvements network infrastructure and services (Cantos et al. 1999). However, as we can be seen from 2008 technological change is reduced significantly, possibly due to budgetary constraints. Therefore policies to foster innovation and the development of railways play an important role on increasing productivity and efficiency.

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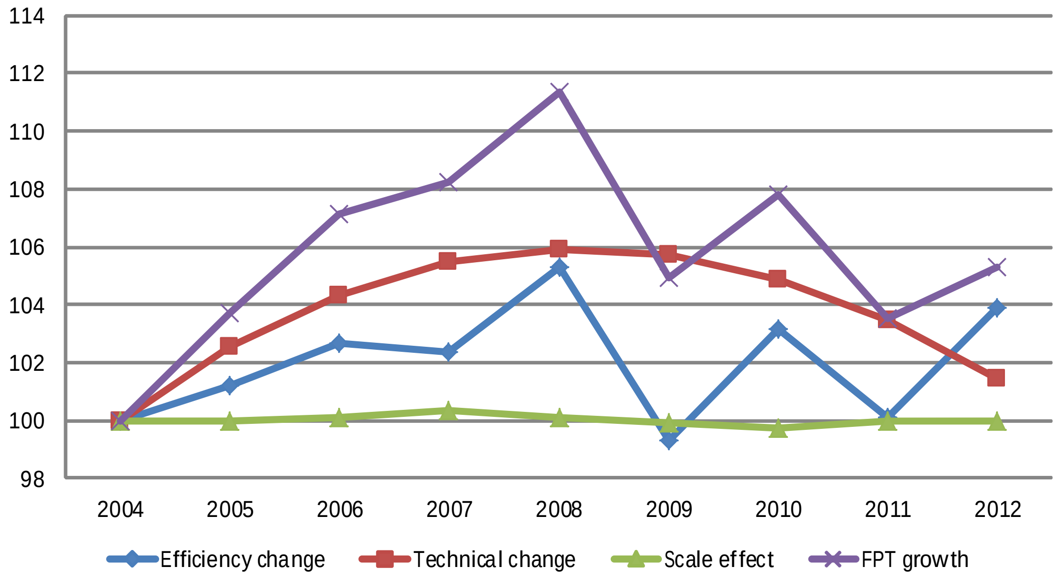
Figure 2. Cumulative indeces of average TFP growth and its components



Source: Author using data from Frontier 4.1

The scale effects did not have influence on productivity growth. So the cumulate average scale effects index indicates a small negative influence of scale effects on average TFP growth by -0.02% in the observed period. So the measurements to promote competition in t railway transport and to become in alternative means of transport to road transport and air, did not have worked well. Undertakings have focused on passenger transport and reduced the volume of freight transported.

Finally, the cumulative average TFP growth index indicates an average productivity growth of 5.31% over the whole period. The improvement on efficiency change and technical change has increased average productivity in the European railway system. Meanwhile, scale effects scale effects are slightly negative. It should be noted that TFP growth only shows negative values for two periods. These values are influenced by global financial crisis and Euro crisis that reduced very significantly the productivity growth. Most of TFP growth appears to be due to cuts in input usage as opposed to output growth or technological advance. This result is similar to that obtained by Coelli and Perelman (2000). The sample data reveal an increase in production by 3.94%, while labour and rolling stock are reduced by 10.32% and 17.44% respectively.

5. Summary and Conclusions

We analyzed the performance of the European railway public system for the years 2004-2012. The sample is composed by the former state railway undertakings or their successors. In this period, numerous deregulation and liberalization steps were implemented with the aim to revitalize the railway. The measures introduced seeking to improve efficiency and productivity through the opening of markets step by step. We use a methodology proposed in Orea (2002) and Coelli et al. (2003) to estimate a generalized Malmquist index approach to decompose TFP growth into different components: technical efficiency change, technological change and scale effects.

The propose of this paper is to analyse productivity growth in fifteen national railway systems in Europe over the period 2004-2012 and the effects of the organisational reforms and deregulations process on efficiency. The results indicate that in general, the reforms appear to have been beneficial in terms of efficiency and productivity growth. However, the reforms proposed by the EU have developed in an unfavourable economic context that may have affected the results.

Our model suggests that European railway system is indeed characterized by increasing returns to scale. TFP growth estimates show that efficiency technical change and technological change are positive, meanwhile, scale effects are slightly negative. Average TFP growth was 5.31% over this period where the improved performance in European railways was primarily driven by substantial cuts in labour usage and rolling stock.

Referring to exogenous variables, the results are as expected. The network density increase reduces railway system efficiency due to greater usage of inputs. Moreover, a higher percentage of electrified networks improve efficiency by reducing labour. In relation to active policies to promote rail both operating grants and infrastructure grants have positive effects on efficiency. The railway needs a lot of financial resources but should be used in an efficient manner. Operating grants are needed to fund services that are considered of general interest. These grants are intended to make available to users transport services at affordable prices, lower than those required to cover costs. Grants for maintenance or renewal of the rail network are necessary to provide quality service and reliable.

Regarding to estimate the influence of regulatory changes on productivity growth, the processes of separation of infrastructure management and liberalisation within the railway sector are relatively recent in many countries. Our results suggest that the process of vertical separation has not had a positive effect on efficiency for the European railway systems. In contrast, the opening market seems to lead to a greater efficiency gain. The entry of new railway undertaking has significantly improved levels of efficiency in the industry. These results are according to most of papers to indicate that the effect of vertical separation is much less clear, but the opening market reforms have improved efficiency levels in the sector.

Finally, the conclusions drawn from this study has the limitation that all European countries are not included. It also does not take into account aspects such as the load factor or energy efficiency that is important issues to consider in future studies.

References

1. Asmild, M., et. al (2009): ”Railway reforms: do the influence operating efficiency?”, *Transportation*, 36, 617-638.
2. Battese, G., and Coelli, T. (1992): ”Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India”, *Journal of Productivity Analysis*, 3, 153-169.
3. Battese, G., and Coelli, T. (1995): ”A model for technical inefficiency in a stochastic frontier production function for panel data”, *Empirical Economics*, 20, 325-332.
4. Beria, P., et al (2012): ”A comparison of rail liberalization levels across four European countries”, *Research in Transportation Economics*, 36, 110-120.
5. Cantos. P., Pastor. J., and Serrano, L. (1999): “Productivity, efficiency and technical change in the European railways: A non-parametric approach”, *Transportation*, 26 (4), 337-357.
6. Cantos, P., Pastor. J., and Serrano, L. (2010): “Vertical and horizontal separation in European railway sector and its effects on productivity”, *Journal of Transport Economics and Policy*, 44 (2), 139-160.
7. Cantos, P., Pastor. J., and Serrano, L. (2012): “Evaluating European railways deregulation using different approaches”, *Transport Policy*, 24, 67-72.
8. Coelli, T. (1996): ”A guide to frontier versión 4.1: A computer program for stochastic frontier production and cost function estimation”, CEPA working papers 96/97.
9. Coelli, T. Coelli, T., et al (2003): Una introducción a las medidas de eficiencia para reguladores de servicios públicos y de transporte, Banco Mundial. Ed. Alfaomega.
10. Coelli, T., et al (2005): An introduction to efficiency and productivity analysis, Springer, New York
11. Coelli, T., and Perelman, S. (1999): ”A comparison of parametric and no-parametric distance functions: With application to European railways”. *European Journal of Operational Research*, 117 (2), 326 - 339.
12. Coelli, T., and Perelman, S. (2000): ”Technical efficiency of European railways: a distance function approach”, *Applied Economics*, 2 (15), 1967-1976.
13. Di Pietrantonio and Pelkmans (2004): “The economics of EU railway reform”. BEEP friefing nº 8, College of Europe, Burges.
14. Driessen, G., Lijesen, M., and Mulder, M. (2006): ”The impact of competition on productive efficiency in European railways”, Netherlands Bureau for Economic Policy Analysis, CPB discussion paper nº. 71.
15. Farsi, M., et al (2005): ”Efficiency measurement in network industries: application to the Swiss Railways Companies”. *Journal of Regulatory Economics*, 28 (1), 69-90.
16. Friebel, G., Ivaldi, M., y Vibes, C.: ”Railway (De)regulation: a European efficiency comparison”, *Economica*, 77, 77-91.
17. Gines de Rus, M., and Campos, J. (2005): ”The foundations of the European transport policy, Fundación BBVA. http://mrpa.ub.uni-muechen.de/12395/
18. Greene, W. (2004): ”Distinguishing between heterogeneity and inefficiency: stochastic frontier analysis of the World Health Organization’s panel data on national health care systems”, *Health Economics*, 13, 959-980.
19. Greene, W. (2005): ”Fixed and random effects in stochastic frontier models”, *Journal of Productivity Analysis*, 23, 7-32.

20. Greene, W. (2005b): ”Reconsidering heterogeneity in panel data estimators of the stochastic frontier model”, *Journal of Econometrics*, 126, 269-303.
21. Growitsch, C., Wetzel, H. (2009): “Testing for economies of scope in European railways”, *Journal of Transport Economics and Policy*, 43 (1), 1-24.
22. Holvad, T. (2006):”Railway reforms in a European context”, Colloque « En route vers Lisbonne ».
23. IBM Global Business Services (2004): Rail Liberalisation Index 2004. Berlin
24. IBM Global Business Services (2007): Rail Liberalisation Index 2007. Brussels
25. IBM Global Business Services (2011): Rail Liberalization Index 2011. Brussels.
26. Jondrow, J., et al (1982): ”On the estimation of technical inefficiency in the stochastic frontier production function model”, Journal of Econometrics nº. 19, págs. 233-238.
27. Mizutani. F., et al (2015): ”Comparing the costs of vertical separation integration, and intermediate organizational structures in European and East Asian Railways”, *Journal of Transport Economics and Policy*, 49 (3), 496-515
28. Orea, L. (2002): ”Parametric decomposition of a generalized Malmquist Productivity Index”, *Journal of Productivity Analysis*, 18.
29. Oum, T., and Yu, C. (1994):”Economic efficiency of railways and implications for public policy. A comparative study of the OECD countries railways”, *Journal of Transport Economics and Policy*, 28, 121-128.
30. Saal, D., et al (2007): ”Determining the contribution of technical change, efficiency change and scale change to productivity growth in the privatized English and Welsh water and sewerage industry: 1985-2000”, *Journal of Productivity Analysis*, 28, 127-139.
31. Schmidt, P., and Sickles, R. (1984): ”Production frontiers and panel data”. Journal of Business & *Economic Statistics*, 2 (4), 367-374.
32. Wetzel, H. (2008): ”European railway deregulation: the influence of regulatory and environmental conditions on efficiency”, Working Paper Series in Economics 86, University of Lüneburg.
33. Wetzel, H. (2009): ” Productivity Growth in European Railways: Technological Progress, Efficiency Change and Scale Effects”, Working Paper Series in Economics 101, University of Lüneburg.