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Abstract

A vast amount of literature is devoted to analyzing the effects of deregulating and restructuring measures in the European railway sector and the results are not totally unambiguous. The contribution of this paper to the existing literature is twofold. Firstly, we estimate efficiency levels derived from two alternative approaches: a non-parametric DEA analysis and a parametric stochastic frontier production. Using two different approaches allows us to test if the heterogeneous results obtained in the literature are due to the different approaches used to measure efficiency. Secondly, we update the sample introducing a data panel with information on 23 national rail systems, and covering data from 2001 to 2008. It is fundamental to use extended and updated data covering the more recent period and more countries, given that most deregulation measures have been implemented in the last few years.

Key words

Efficiency, railways, regulation.

Resumen

Los resultados obtenidos por la literatura acerca del efecto de las medidas de desregulación y restructuración implantadas en el sector ferroviario europeo son en muchos casos poco concluyentes. Este documento de trabajo ofrece estimaciones de los niveles de eficiencia de los sistemas ferroviarios europeos a partir de dos aproximaciones distintas: análisis DEA no paramétrico y fronteras estocásticas de producción. Esto permite comprobar hasta qué punto la heterogeneidad de resultados en este ámbito puede deberse al método utilizado para medir la eficiencia y la productividad en este sector. Además se utiliza una muestra ampliada y actualizada mediante un panel de datos con información sobre 23 sistemas ferroviarios nacionales a lo largo del periodo 2001-2008. Esto es importante dado el carácter reciente de la mayor parte de la desregulación.

Palabras clave

Eficiencia, ferrocarriles, regulación.

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1. Introduction

DURING the past fifty years, the most common market structure in many countries' rail sectors was a single, state-owned firm, entrusted with the unified management of both infrastructure and services. Despite some differences in their degree of commercial autonomy, the traditional methods of regulation and control of this sort of company have been relatively homogeneous. In general, it was assumed that the monopoly power of the national company required price and service regulation to protect the general interest. In addition, there was an obligation on the part of the companies to meet any demand at those prices. The closure of existing lines or the opening of new services required government approval. Thus, competition was rare and often discouraged, and the preservation of the national character of the industry was considered the key factor governing the overall regulatory system.

The worldwide restructuring of the rail industry began with timid reforms. Many countries began by replacing their national railways with autonomous commercial bodies possessing independent, realistic balance sheets, in which only public service obligations could be explicitly subsidized by the government. Other countries opted to substitute their old geographically-based management with a multi-divisional structure, defined by the companies' different lines of business or services.

The rail industry in Europe has been restructured on two levels: the vertical dimension, which involves the relationship between infrastructure and operations, and the horizontal dimension, which covers the relationship between the various services that use the infrastructure. In other words, restructuring measures can be classified depending on the extent of vertical separation introduced after the change, and on the degree of competition (and private participation) allowed in the industry after the reform.

With respect to the first dimension, there are three main options for the vertical organization of the railway industry: (i) *vertical integration*, (ii) *competitive access*, and (iii) *vertical separation*.

The first option corresponds to the traditional, historic model of railway organization described above, where a single (usually public) entity controls all the infrastructure facilities as well as the operating and administrative functions. Many European countries still maintain this type of organization.

Less frequent, competitive access is characterized by the existence of an integrated operator, who is required to make rail facilities (tracks, stations, etc.) available to other operators on a fair and equal basis through the trading of, for example, circulation rights. This has the advantages of integration (economies of scope, coordinated planning and reduction of transaction costs), but its overall effectiveness may be jeopardized if the integrated company has incentives to leave out other operators. This type of structure is the least developed in Europe, and only Germany, Switzerland and Italy maintain a vertically integrated structure, where trackage rights are used by operating companies (mainly freight operators).

Alternatively, in the complete vertical separation scenario, the management and the ownership of facilities is fully separated from other rail functions. This measure has been developed in many European countries. This is very attractive because although infrastructure may remain a natural monopoly, it is separated from rail services, where potential competition among different operators is possible. In general, the main advantage of this vertical unbundling is that rail transport is placed in a similar situation road transport, especially regarding the tariff system and infrastructure planning. However, the vertical unbundling of the rail industry also implies several disadvantages. The main problem is the potential loss of economies of scope derived from the joint operation of tracks and services.

The horizontal level reforms in Europe have been very moderate, and have consisted mainly of new operators entering the freight sector and of a franchising system in passenger services. (see Cantos et al., 2010 for a review of the "pros and cons" of the different restructuring measures in the European rail sector).

The results provided by the literature are not totally unambiguous. Recently, Friebel et al. (2005) carried out an analysis of some of the restructuring measures in the sector for the period 1995-2000, focussing on measures designed to separate the industry vertically. Their results suggest that, in general, the reforms have furthered more efficient behaviour; however, these reforms must be carried out sequentially. Driessen et al. (2006) study the efficiency of a sample of European companies for the period 1990-2001. These authors do not come to a decisive conclusion on the impact of vertical separation of infrastructure and operations. They find that vertical separation does not seem to be necessary to achieve an increase in productive efficiency, although tendering processes do appear to favour an increase in efficiency. In all events, these authors acknowledge that many of the predicted effects may still not have been in evidence, since the sample period ended in 2001.

More recently, Wetzel (2008) has analysed positive and negative effects of regulatory reforms. At the same time, the separation variable within her estimations doesn't reveal a statistically significant influence on technical efficiency, while the estimated results for third party access rights differ between passenger and freight transport as well as international and domestic services[1]. Access rights for international services and those for domestic railways providing passenger transport are found to negatively influence technical efficiency, whereas access rights for domestic railways providing freight services are found to positively influence technical efficiency.

Finally, Cantos et al. (2010) suggest that the processes of vertical separation have had a positive effect on efficiency for European railway systems. However, these gains in efficiency become higher when the process has been completed with horizontal level reforms, especially if new operators are allowed entry to the freight sector. On the contrary, the measure of establishing franchising in passenger services does not seem to affect efficiency.

Our paper tries to solve some limitations of the aforementioned papers. We update and extend the sample, considering 23 European countries and the period 2001-2008. At the same time we estimate efficiency indexes using different methods, and we analyse the similarities among them.

2. Methodology

WE are going to employ two basic different methodologies. The first one is a typical non-parametric approach, and the second one is based on the estimation of a parametric distance function.

2.1. Model 1

We follow the standard procedure in the non-parametric approach, in which it is assumed that for each period t a set of N railway systems (i = 1,..., N) produces M outputs (m = 1,…, M) using K inputs (k = 1,…, K). The measurement of technical cost efficiency

[1] Growitsch and Wetzel (2009) find that for a majority of European railways economies of scope exist.

(input-oriented) under variable returns to scale using DEA is obtained by solving the following problem for each period and each railway system j:

$$\begin{aligned}
Min \quad & \theta_j^{VRS} \\
s.t. \quad & \sum_i \lambda_i y_{im} \geq y_{jm} \quad \forall m \\
& \sum_i \lambda_i x_{ik} \leq \theta_j^{VRS} x_{jk} \quad \forall k \\
& \sum_i \lambda_i LT_i \leq LT_j \\
& \lambda_i \geq 0; \sum_i \lambda_i = 1; \quad i = 1,\dots,N
\end{aligned} \tag{1}$$

From the solution of this problem for each of the N companies of the sample we obtain N optimal solutions. Each optimum solution θ^{VRS} is the input-oriented technical efficiency measure of each company which, by construction, satisfies $\theta^{VRS} \leq 1$. Those companies with $\theta^{VRS} < 1$ are considered cost technical inefficient, while those with $\theta^{VRS} = 1$, are catalogued as cost technical efficient, since they stand at the frontier[2]. Given the particular nature of the railway business, in which companies operate with very heterogeneous lengths of track (LT), in order to avoid the bias that this could lead to, the standard DEA problem has been adapted to the case of the railway companies by adding the restriction $\sum_i \lambda_i LT_i \leq LT_j$. This implies that company j will be compared with a linear combination of companies that operates in countries with equal or lesser length of track. With this restriction we try to make comparisons between companies with similar network characteristics, and therefore with similar infrastructure characteristics.

Note that if the restriction $\sum_i \lambda_i = 1$ is removed from the linear programming exercise defined in [5] we obtain the technical inefficiency under constant returns to scale (θ^{CRS}).

[2] From an intuitive point of view, to analyse the efficiency of the productive scheme of company j (y_j, x_j) the problem constructs a feasible scheme as a linear combination of the schemes of the N companies of the sample which using $\theta_j x_j$ inputs produces at least y_j. Thus (1-θ_j) indicates the maximum radial reduction to which the vector of inputs of company j can be subjected without altering the observed levels of output, so that θ_j is the indicator of technical efficiency. In the case where $\theta_j = 1$, this means that no linear combination of companies can be found that with less input obtains the same amount of output, so the company is catalogued as efficient. In all other cases, $\theta_j < 1$, indicating that the productive scheme of company j is inefficient, as there is a feasible alternative scheme that obtains the same quantity of output using $\theta_j x_j$ inputs, its over-use of resources being quantified by comparison with the alternative scheme as $(1-\theta_j)x_j$.

Therefore, the input-oriented scale inefficiency (SE^I) can be calculated by means of the following ratio $SE^I = \theta^{VRS} / \theta^{CRS}$.

2.2. Model 2

In this case, to estimate the distance function we adopt a translog (transcendental-logarithmic) function form.

$$\begin{aligned} \ln D_{oi} &= \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mi} + \frac{1}{2}\sum_{n=1}^{M}\sum_{m=1}^{M} \alpha_{mn} \ln y_{mi} \ln y_{ni} + \\ &+ \sum_{k=1}^{K} \beta_k \ln x_{ki} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{li} \ln x_{ki} \ln x_{li} + \frac{1}{2}\sum_{k=1}^{K}\sum_{m=1}^{M} \chi_{km} \ln x_{ki} \ln y_{mi} \end{aligned} \tag{2}$$

where y_{mi} is the output m of the rail system i, and x_{ki} is the input k of the same rail system i. Additionally homogeneity and symmetry restrictions are imposed. Then, as a particular case the homogeneous function of degree g must fulfil the following condition:

$$D_0 (x, g y) = g D_0 (x, y) \text{ for } g > 0 \tag{3}$$

If we choose one of the m outputs we can rewrite the translog function:

$$\begin{aligned} \ln(D_{oi} / y_{Mi}) &= \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y^*_{mi} + \frac{1}{2}\sum_{n=1}^{M}\sum_{m=1}^{M} \alpha_{mn} \ln y^*_{mi} \ln y^*_{ni} + \\ &+ \sum_{k=1}^{K} \beta_k \ln x_{ki} + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \beta_{li} \ln x_{ki} \ln x_{li} + \frac{1}{2}\sum_{k=1}^{K}\sum_{m=1}^{M} \chi_{km} \ln x_{ki} \ln y^*_{mi} \end{aligned} \tag{4}$$

In order to estimate the distance function we apply stochastic frontier analysis (SFA), a method simultaneously introduced by Aigner et al.. (1977) and Meeusen and van den Broeck (1977). SFA is a parametric method which estimates a production function with a "composed error term" (ε_{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}, representing technical inefficiency.

Then the technical efficiency of the *i-th* firm in the *t-th* time period is predicted by the conditional expectation of exp ($-u_{it}$), given the random variable ε_{it}.

$$D_{0i} = E[\exp(-u_{it})/\varepsilon_{it}] \tag{5}$$

To investigate the influence of regulatory and environmental conditions on efficiency, we follow two different specifications. In the first one, we use a typical two stage approach where after the estimation of the distance function, we estimate in a second equation the determinants of the inefficiency indexes.

Assuming that the environmental factors directly affect technical efficiency, the inefficiency effect model is specified as:

$$\mu_{it} = \delta_0 + \sum_{j=1}^{J} \delta_j z_{jit} \tag{6}$$

where μ_{it} is the mean of the truncated normal distributed inefficiency term; z_{jit} denotes the *jth* ($j = 1, 2, ..., J$) environmental or regulatory factor of the *i-th* firm in the *t-th* time period expected to influence technical efficiency; and δ are unknown parameters to be estimated. In a second stage approach, equation (6) is estimated once the efficiency levels have been estimated using the distance function approach.

Alternatively, Battese and Coelli (1995) suggest to estimate the distance function and the determinants of the inefficiency in an only step. This one-step approach can provide more reliable predictors of firm-specific efficiency than using a two-stage approach. Following to Coelli and Perelman (1999):

$$D_{0i} = E[\exp(-u_{it}/\varepsilon_{it})] = \left\{ \exp[-\mu_{it} + \frac{1}{2}, \sigma_*^2] \right\} \left\{ \Phi[\frac{\mu_{it}}{\sigma_*} - \sigma_*] / \Phi[\mu_{it}/\sigma_*] \right\} \tag{7}$$

where $\Phi(\cdot)$ represents the distribution function of the standard normal random variable,

$$\mu_{it} = (1-\gamma) + [\delta_0 + \sum_{j=1}^{J} \delta_j z_{jit}] - \gamma \varepsilon_{it}, \ \sigma_*^2 = \gamma(1-\gamma)/\sigma^2, \ \gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \tag{8}$$

In any case, we must note that one-step Battese-Coelli inefficiencies can be hardly compared with inefficiencies obtained with the other techniques. The reason is that these inefficiencies are the inefficiencies explained by the set z of explanatory variables. The inefficiencies obtained from the other techniques are estimates of total inefficiency. If inefficiency is poorly explained by the set z of explanatory variables, the levels of inefficiency cannot be properly compared.

Finally, this analysis requires to define different dummy variables associated to the processes of vertical and horizontal separation to reflect the organisational and regulatory changes occurring in each railway system. To this end, three dummy variables were defined that describe two distinct levels in the reform process carried out in the sector. Information from the "Railway time-series data" for 2005 published by the UIC and from other relevant sources (Nash and Rivera-Trujillo 2004; Driessen et al. 2006; and IBM and Humboldt University of Berlin 2004) was consulted in order to reflect these changes. We distinguished the following levels of reform for the period 2001-2008:

— VERT: takes a value of 1 for countries that, during the years in which this situation was maintained, separated at an organic level the ownership of infrastructure from that of operations. The sector is thus characterised by its vertical separation into two different bodies: one being the owner of the infrastructures and the second consisting of all operations. This type of separation is defined as institutional separation.
— FREEOPEN: takes a value of 1 when the entry of new operators is allowed in the freight sector (competition in the market) regardless of whether the industry has been separated vertically or not.
— PASSTEND: takes a value of 1 when a franchising system has been introduced (competition for the market) in passenger services. This variable takes a value of 1 in the same way as the previous dummy, regardless of whether the industry has separated at a vertical level or not.

Furthermore, we introduce the length of rail track and the density of the country (population divided by the area) as potential determining factors of the inefficiency.

3. Data

THE data correspond to a sample of 23 European railway systems from 2001 to 2008. The information was taken from the reports published by the Union Internationale des Chemins de Fer and, occasionally was completed with data published in the companies' statistical memoranda. Specifically, the different railway systems established in each country are evaluated. We have a lot of heterogeneity in the sample. There are rail systems run by one single company with vertically integrated infrastructure and operations, and horizontally integrated operating services. Over the last years, as many of the railway systems began to be separated both vertically and horizontally, different companies took over the management of the railway system. In this case, the data corresponding to all the companies making up the railway system are aggregated for each variable.

Two outputs and three inputs are considered. The variables selected as outputs are the number of passengers-km transported (PKT) for passenger transport, and tonnes-km transported (TKT) for freight transport. In the case of input variables, the following are considered:

— Number of employees in all the railway systems making up the railway system (EMP)
— A representative measure of the rolling stock calculated as the number of coaches, railcars, locomotives and wagons and multiple-unit trailers available (ROLL).
— Number of km of railway infrastructure in each country (LLT).

TABLE 1: **Average values for the variables (2001-2008)**

	Pass-km (millions)	Ton-km (millions)	EMP (thousands)	ROLL	LLT (km)
Austria	8,761	18,176	46	22,082	5,786
Belgium	9,041	8,309	39	17,414	3,502
Bulgaria	2,538	5,041	35	15,391	4,215
Czech Rep.	6,749	16,313	69	42,967	9,492
Denmark	5,478	1,941	12	5,783	2,122
Finland	8,017	13,287	21	15,614	5,827
France	72,307	45,918	164	64,555	29,456
Germany	68,707	75,502	201	132,844	34,901
Greece	1,806	581	8	4,326	2,476
Hungary	7,000	8,127	48	20,314	7,951
Ireland	1,745	305	6	2,115	1,919
Italy	47,158	21,589	101	63,333	16,538
Luxembourg	297	461	3	3,476	275
Netherlands	14,176	3,848	26	7,353	2,809
Norway	2,406	2,723	9	3,086	4,111
Poland	17,818	45,115	134	93,835	19,738
Portugal	3,591	2,474	9	4,923	2,840
Romania	7,895	13,656	69	63,501	11,007
Slovak Rep.	2,352	9,809	38	19,897	3,647
Slovenia	778	3,239	8	5,100	1,229
Spain	19,888	11,820	23	19,780	12,853
Sweden	6,042	12,945	12	9,466	10,004
Switzerland	14,716	12,216	29	17,967	3,357
Total	**14,934**	**15,530**	**51**	**30,532**	**9,013**

4. Results

THE table 2 presents the results for inefficiency indicators for the countries considered in the sample. The one-step Battese-Coelli estimates are not shown because the problems of comparability discussed in section 2.

TABLE 2: **Inefficiency levels**

	DEA		BC
	CRS	VRS	
Austria	0,960	0,975	0,468
Belgium	0,709	0,742	0,439
Bulgaria	0,384	0,442	0,183
Czech Rep.	0,532	0,553	0,241
Denmark	0,811	0,953	0,797
Finland	0,986	0,988	0,532
France	0,952	0,996	0,398
Germany	0,834	0,997	0,350
Greece	0,360	0,668	0,280
Hungary	0,456	0,484	0,256
Ireland	0,631	1,000	0,365
Italy	0,845	0,969	0,370
Luxembourg	0,477	1,000	0,426
Netherlands	1,000	1,000	0,785
Norway	0,782	0,920	0,358
Poland	0,724	0,923	0,288
Portugal	0,672	0,889	0,569
Romania	0,435	0,457	0,208
Slovak Rep.	0,559	0,605	0,229
Slovenia	0,845	0,969	0,300
Spain	1,000	1,000	0,606
Sweden	1,000	1,000	0,486
Switzerland	1,000	1,000	0,953

The CRS results are broadly comparable for the common railway systems to the ones obtained in Cantos et al. (2010) using that same technique for the period 2000-2004. For example, in that paper Austria, Finland, Netherlands, Spain, Sweden and Switzerland were at the frontier over the period 2000-2004. As for the new countries added to the sample, our results show that Central and Eastern European countries are not at the frontier, Slovenia (0.845 using CRS) being the closest to it.

As it was only to be expected, the VRS results show an equal or higher efficiency level for each railway system. The changes are especially noticeable for small countries such as Greece, Luxembourg, Portugal and Ireland.

The results from the two-step Battese-Coelli method show much lower efficiency levels than the CRS and VRS methods. The question about to the sensitivity of efficiency results to the method used has a clear answer. There are differences between the results from each method and for some countries those differences are quite significant.

However, the point is how big those differences are in general terms. Are those differences of such a magnitude that the whole picture of relative performance among railway systems changes? In particular, we are interested in the analysis of the differences among the rankings obtained from the different approaches, instead of the value of each indicator. Then the Spearman's rank correlation coefficient is an appropriate measure to do this type of analysis.

TABLE 3: **Correlation coefficients**

	CRS	**VRS**	**BC (2 steps)**
CRS	1		
VRS	0.724	1	
BC (2 steps)	0.726	0.718	1

The table 3 coefficients show a positive and sizeable correlation between methods as far as rankings are considered. Each method gives its particular results for each railway system, but the ranks are not too unrelated.

Our main aim is to consider the effect of deregulation on railway efficiency and whether it depends on the particular technique used in the analysis. Therefore in this section we analyse whether the vertical or horizontal separation processes have encouraged a more efficient behaviour considering each of the previous efficiency analysis (second stage analysis) and the Battese-Coelli method in one step (which estimates efficiency and its determinants at the same time).

In order to carry out this analysis, table 4 presents the results where determinants of efficiency are analyzed. The first column obtains the results of a Tobit regression where dependent variable is the efficiency indicator and the independent variables are the indicated ones in table 4. VRS and BC (2 steps) present the results of a Tobit regression too. BC (1 step) presents the efficiency analysis directly obtained in the one step approach.

TABLE 4: Determinants of inefficiency

	CRS		VRS		BC (2 steps)		BC (1 step)	
	Coeffic.	**t-stud**	**Coeffic.**	**t-stud**	**Coeffic.**	**t-stud**	**Coeffic.**	**t-stud**
LLT	-.51e-05	-1.04	-.17e-05	-2.61	.112e-05	3.11	-.91e-05	-1.09
DENS	-.0009	-1.65	-.0006	-0.98	-.001	-2.74	-.006	-4.17
VERT	-.123	-1.37	-.041	-0.90	-.029	-0.44	-.075	-1.16
PASSTEND	-.365	-2.37	-.721	-3.61	-.302	-2.73	-.954	-3.78
FREEOPEN	-.209	-1.96	-.031	-0.25	-.084	-1.07	-.121	-1.70
CONST	.923	9.10	.382	3.13	1.099	14.80	.904	4.35
Log-lik		-13.35		-13.53		-79.63		
Pseudo R2		0.118		0.120		0.149		
N. observ					129			

For CRS, VRS and BC (2 steps) the dependent variable was defined as the logarithm of the inverse of the efficiency shown on table 1. Therefore a positive sign means that the explanatory variable has a negative effect on efficiency, a negative sign the opposite. For the BC (1 step), given that the inefficiency term is negative, the interpretation of the sings of the variables is the same as in the other approaches.

The results show that the vertical separation of the railway industry (VERT) is not statistically significant whichever method we use (although the sign indicates that vertical separation leads to efficiency gains). However, the adoption of a franchising system in passenger services (PASSTEND) has a significant negative sign using any of the four methods. According to these results this kind of deregulation has a positive effect on efficiency, this impact being especially important in the BC (1 step) estimation (-0.954).

Cantos et al. (2010) found the strongest effect on efficiency in the case of the reforms allowing the entry of new operators in the freight sector. Table 4 shows that this variable is only significant at 5% when we use the CRS approach. This result indicate (0.209) a negative impact of this kind of horizontal reform on inefficiency (i.e. a positive effect on efficiency). This effect would be smaller than for franchising in passenger services (-0.365) but still quite relevant. Interestingly in Cantos et al. (2010) competition in the freight market was also significant but smaller (-0.142) and competition in the passenger services market was not significant. Since the technique in Cantos et al. (2010) was also CRS DEA the different results could be attributed to the addition of new countries or the enlarged period until 2008 instead of 2004. We must remember that it is only to be expected that some of the benefits from this kind of reforms are achieved only after a period of adaption.

The results show that reforms of the railway systems in Europe have contributed to raise their efficiency although the effect seems to depend on the specific type of reform. However, the estimated size of these effects and their relative importance in each case depend on the particular method of analysis. The process of separation of infrastructure from operations by itself does not have significant effects on efficiency. On the other hand, introducing or favouring competition inside the rail markets has significant positive effects on efficiency although their magnitudes for the freight sector and passenger services vary with the estimation method.

5. Conclusions

THIS study used both non-parametric programming techniques and parametric stochastic frontiers to estimate the levels of efficiency in a sample of 23 European railway systems for the period 2001-2008. Results show that the particular estimated level of efficiency of each national system depends on the technique, though there is an appreciable degree of consistency between all those techniques in terms of rankings.

The analysis of the determinants of efficiency confirms that its levels in countries that only adopted vertical reforms are not significant different from those in countries that have introduced no reforms. Therefore these results suggest that any positive effects coming from this type of reform will need the whole reform package including also horizontal reforms. Favouring competition by franchising services or allowing new entrants has a positive effect on the levels of efficiency although its estimated size differs depending on the technique used. Our results show that higher efficiency gains are produced when passenger services are franchised that when free entry is allowed in the freight sector. In any case, we can conclude that efficiency gains are basically produced when competition is promoted in the rail industry. In contrast, vertical separation process, by itself, does not produce significant improvements in efficiency. This result coincides with recent empirical evidence.

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NOTA SOBRE LOS AUTORES - *ABOUT THE AUTHORS**

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