EFFICIENCY AND COMMERCIAL POLICY IN RAILWAY TRANSPORT IN EUROPE: A NON-PARAMETRIC ANALYSIS *

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Abstract

One of the reasons explaining the market and financial decline of the European railway sector is its deficient productive and commercial policy. The aim of this study is to analyse technical and revenue efficiency for the period 1970-98, in order to assess whether recent changes in organisation and management have significantly influenced companies' efficiency levels. Four areas of reform are analysed: separation of infrastructure from operations, changes in legal structure, regulation of fares and public regulation of railway investment. Though it is too soon to determine their definitive effect, our results suggest that these measures, and especially the first mentioned, seem adequate to favour more efficient behaviour of the companies at a technical level. However, at allocative and revenue level no significant modifications are observed in efficiency levels.

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1. Introduction.

One of the greatest concerns of European policy relating to the railway sector has been its constant and progressive financial deterioration. From the first European directives aimed at bringing order to this sector (Directives 1191/69 and 1107/70) to the White Paper of 1998, one of the European Union's main objectives has been the financial health of the sector, which is a necessary condition for the proper and efficient working of both the sector itself and of the transport market as a whole. A simple analysis of the results of the sector during the last twenty years serves to verify that this objective, far from being achieved, has constituted an important problem which some states have only very recently tried to deal with by taking drastic measures.

The literature on transport economics has usually been concerned almost exclusively with analysing productivity and costs in the sector, the most frequent topics being evolution of costs, and analysis of economies of scale, density and scope (see the survey by Oum et al., 1999). Productivity and its decomposition has also been studied under different approaches (see Cowie and Riddington, 1996; Cantos et al., 1999; Cantos and Maudos, 2000; or Coelli and Perelman, 2000). These studies show that, in general, companies have operated inefficiently, though a clear improvement can be appreciated in the general productivity of the sector during the last twenty years, due mainly to technical progress.

Despite improving levels of productivity, however, the companies' poor economic results suggest that measures aimed at reforming them have been clearly ineffective in improving their financial accounts. It is therefore of interest to analyse not only the companies' progress with regard to productivity levels and their determining factors, but also the importance of their commercial policy. This innovative approach leads us to the analysis of companies' commercial revenue, a question closely linked to pricing policy and the regulations affecting the commercialisation of railway services (regulations as to prices, service levels, maintenance of uneconomic lines, public service obligations, etc.).

Given the multi-product nature of the railway business, the analysis must be on a disaggregated basis. In this study we distinguish between passenger traffic and freight traffic. It is important to separate these two businesses, as freight traffic is of a more commercial character than passenger traffic, which is usually much more highly regulated and controlled.

This study centres on the analysis of the productive and commercial efficiency of European railway companies in the period 1970-1998. The main objective is to detect whether the organisational and management changes made by the companies, concentrated in the last four years of our sample, have produced significant variations in their levels of productive and commercial efficiency. To obtain the indicators of productive and commercial efficiency we will use the non-parametric technique Data Envelopment Analysis (DEA).

The railway industry has traditionally been considered the transport sector least amenable to the introduction of reforms and processes that affect its forms of organisation and management. However, during the last five years most of the European railway companies have undertaken, following European directives and recommendations[1] and changes in national norms, various processes of liberalisation and/or deregulation which to a greater or lesser extent have modified the companies' usual behaviour patterns.

The most important change at the European level was probably the separation between infrastructure and services, though the degree of separation is very different from one system to another. In this aspect, the Swedish experience was the pioneer within the European context. In 1988 the ownership of the infrastructure (in the hands of the state agency *Banverket*) was separated from operations (in the hands of the public operator *Statens Jarnvagar*). Although there does exist a system of free access by means of a bidding mechanism, there have been very few concessions of routes to private operators. The most radical experience is that of Great Britain, where the infrastructure passed to a new company, Railtrack, which was privatised in 1996. Passenger trains were to be run by twenty five private operators, adjudicated by

[1] Directives 95/18, 95/19, resolution ECMT 95/3 and the White Paper presented by the European Commission in 1996 and 1998 (CE, 1996 and 1998) have facilitated the processes of organic separation between infrastructure and services, of greater competition among operators and, in general, of greater independence of management from public administrations.

franchises of from seven to fifteen years. Other more modest experiences are those of France or Spain, where a body has been created to manage the infrastructures and to move towards their separation from services, though in practice these reforms do not seem to have had much effect for the moment.

Another aspect that has been notably modified in recent years is the mode of constitution or legal regime of the companies. In the 1970s and 1980s railway companies were public enterprises with very limited commercial autonomy. Currently most of them are companies subject to the private regime which, though keeping a public character, have achieved a high degree of autonomy and independence in their decisions. In some cases, such as Germany, plans exist to significantly reduce public participation in the sector. Once again, the most radical experience in this context has been the British case, in which the whole industry was privatised (both infrastructure and operations).

Of the countries that organically separated infrastructure from services, only the United Kingdom opted to privatise both. Most governments opted to keep the infrastructure in public hands, creating an independent public agency to manage it. Such is the case of Denmark, Finland, Holland, Norway and Sweden. France and Portugal established independent public enterprises to manage the infrastructure.

With regard to this point, state influence over decisions on investment by the companies in infrastructure, and especially in services, has been significantly reduced. Regulation of fares for passenger and freight rail traffic has also been substantially modified, having practically disappeared in the case of the latter. The situation regarding regulation of passenger fares is more diverse. Some countries (e.g. Finland, Germany, Sweden, or Switzerland) have eliminated any kind of regulation, while others such as France, Portugal, Norway or Ireland, fares for passenger services are still highly regulated.

This paper is structured as follows. Section 2 presents a description of the methodology. Section 3 describes the data and the qualitative information used in the study, while section 4 analyses the results obtained. Section 5 studies the effects of the reforms on the companies' inefficiency, and finally section 6 presents the main conclusions.

2. Methodology.

This section develops the methodology used in the study for calculating the indicators of inefficiency, and is structured in two parts. The first describes the various efficiency indicators used, and the relationships among them. The second part describes the particular methodology used to calculate the efficiency indicators by means of the non parametric technique DEA.

a) Efficiency indicators

Efficiency indicators are based on prior estimation or calculation of the production, cost, revenue or profit frontier. The *frontier* can be defined in each case for a set of observations, indicating that it is not possible to find any observation above it (in the case of production, revenue and profit functions) or below it (in the case of cost functions).

More specifically, the definition of the production frontier is associated with the maximum level of output attainable with a given level of inputs, or with the minimum level of inputs allowing production of a given level of output. Likewise the cost frontier corresponds to the minimum cost at which it is possible to produce a given vector of outputs, given the prices of the inputs. Finally, the revenue frontier is associated with the maximum revenue attainable given the prices of the outputs and the vector of inputs used.

The characteristic common to these three functions is optimality, as they all specify the maximum or minimum value that can be reached under certain conditions imposed by prices and technology, i.e. they describe a limit or frontier. The measures of efficiency are obtained by comparing the observed values of each company in relation to the optimum defined by the frontier estimated. When the optimum is defined by the production function the efficiency measure obtained is called *technical efficiency*. If on the other hand the comparison is in terms of an economic objective supposedly pursued by the companies (minimisation of costs, maximisation of revenue or profits), the measure of efficiency obtained is called *economic efficiency*. In our case, the type of efficiency analysed (revenue) responds to the economic objective of maximisation of revenue, and is based on the comparison of observed levels of revenue with the optimum levels as determined by the respective frontier.

More specifically, revenue efficiency relates the revenue generated with a given vector of production (R) to the maximum revenue possible as determined by the frontier (R^*) and is defined as the quotient between the maximum revenue achievable at the frontier given the prices of the outputs (R^*) and the observed revenue (R). Thus a revenue efficiency value of $RE=R^*/R$ implies that it would be possible to increase the company's revenue by ($RE-1$)·%, given the prices of its outputs.

Finally, once the revenue efficiency indicators (RE) have been obtained the next step is to analyse whether the companies do not achieve maximum revenue (i.e. are not efficient in revenue) because they do not produce the maximum output possible (technical efficiency) or because at given prices, they do not produce the right mix of outputs to maximise revenue (allocative efficiency).

Graph 1 illustrates the concept of revenue efficiency (RE) for the case of company A. This is defined as the quotient between the maximum revenue attainable given the prices of outputs, represented by its isorevenue line tangent to the frontier of possibilities of production $(R^E=r_1y^E{}_1+r_2y^E{}_2)$, and the observed revenue of the company $(R^A=r_1y^A{}_1+r_2y^A{}_2)$ (represented by the isorevenue corresponding to point A). The revenue efficiency of company A thus corresponds to the ratio $RE=R^E/R^A$. Technical efficiency (ψ) is obtained by means of the ratio (distance) between the revenue represented by the isorevenue line given by y^A and the revenue corresponding to the isorevenue line for y^{A*}, i.e. $\Psi=R^{A*}/R^A$. This distance indicates the potential increase in outputs that the company could obtain using the same quantities of inputs. Allocative efficiency (AE) is measured by the ratio of the revenue of economically efficient companies (R^E) to the technically efficient mix (R^{A*}), i.e. by the ratio $AE=R^E/R^{A*}$ (graphically by the distance between the two isorevenue lines). A company is efficient from the allocative point of view ($AE=1$) when it chooses the right mix of outputs to maximise its revenue. Note that we can decompose the measurement of revenue efficiency (RE) of company A into its technical component (ψ) and allocative component (AE) as follows:

[1] $$RE = \frac{R^E}{R^A} = \frac{R^E}{R^{A*}} \frac{R^{A*}}{R^A} = AE\ \psi\ .$$

b) Estimation of revenue efficiency by non-parametric techniques

Efficiency indicators can be obtained by many techniques. However, parametric stochastic techniques (SFA) and non-parametric ones (DEA) are those preferred by researchers. Each technique has its own virtues and disadvantages[2]. Thus the SFA approach requires distributional assumptions to be made which in most cases are somewhat arbitrary[3]. Moreover, the studies that have compared them have found the true distributions of inefficiencies to be much more symmetrical than the distributions usually imposed[4]. The availability of panel data allows the use of techniques that relax these assumptions, estimating efficiency by means of a parametric frontier without assuming any distributional form for inefficiency. However, such techniques only allow estimation of one inefficiency per company, common to the whole period. This implies assuming that the companies do not vary their style of management during the period analysed, and the longer the period, the riskier the assumption[5].

Once the method of estimating the frontier has been determined, the next problem presented by parametric methods is the choice of a functional form for it. This question is important, as some authors, such as McAllister and McManus (1993) and Berger and De Young (1997), have demonstrated that the results are sensitive to the functional form selected[6].

The use of non-parametric techniques to calculate the frontier is an alternative

[2] See Pastor (1996).
[3] Page 906, Berger and Mester (1997).
[4] See Bauer and Hancock (1993) and Berger (1993).
[5] In the context of panel data, this assumption of inefficiency invariant over time can be relaxed using different specifications of the efficiency term (see a *survey* of these specifications in Cornwell and Schmidt, 1996). However, it is necessary to impose a structure on the type of variation. In order to avoid the problem of assuming a particular type of distribution, Berger and Mester (1997) use panel data and apply the *distribution free approach*.
[6] The problem is that simple functional forms do not fit the data as they are too restrictive. These problems of imperfect fit to the sample even appear with flexible functional forms such as the translog, so these authors propose the estimation of even more flexible functional forms such as the Fourier. However, the problem with the Fourier functional form is the large number of parameters that have to be estimated, preventing its use when the sample is too small.

in many cases preferable to parametric techniques, because they enable efficiency measures to be obtained without needing to assume any distribution function for inefficiencies or to specify any functional form for the frontier. Also, unlike panel techniques, they do not avoid the problem of assuming a distribution function for inefficiency in exchange for doing without the time dimension of efficiency. However, these techniques do not consider the existence of an error term, so its existence may skew the results.

This study uses the non-parametric DEA technique to calculate revenue efficiency indices. The frontier is obtained by means of linear combinations of efficient companies in the sample. Although non-parametric techniques have been widely used to obtained cost efficiency, they have never been used to estimate revenue efficiency for railway companies.

To illustrate the non-parametric methodology for calculating revenue efficiency, let us suppose there are N companies ($i=1,...,N$) which produce a vector of q outputs $y_i=(y_{i1},...,y_{iq}) \in \Re^q_{++}$ which they sell at prices $r_i= (r_{i1},...,r_{iq}) \in \Re^q_{++}$ using a vector of p inputs $x_i=(x_{i1},...,x_{ip}) \in \Re^p_{++}$

The revenue efficiency of company j can be calculated by solving the following linear programming problem. (see Färe et al, 1997),

$$\text{[2]} \quad \begin{array}{ll} Max & \sum_q r_{jq} y_{jq} \\ s.a. & \sum_i \lambda_i y_{iq} \geq y_{jq} \quad \forall q \\ & \sum_i \lambda_i x_{ip} \leq x_{jp} \quad \forall p \\ & \lambda \geq 0; \quad i=1,...,N \end{array}$$

the solution of which corresponds to the vector of outputs $y^*_j=(y^*_{j1},...,y^*_{jq})$ and of demand for inputs $x^*_j=(x^*_{j1},...,x^*_{jp})$ which maximise revenue given the prices of outputs (r). This solution is obtained from a linear combination of companies that produces at least as much of each of the outputs using the same amount of inputs or less. If this hypothetical company were subject to the output prices faced by company j it would have revenue of $I^*_j=\Sigma r_{jq}\cdot y^*_{jq}$ which, by definition, will be equal to or greater than those of company j ($I_j=\Sigma r_{jq}\cdot y_{jq}$).

Once this problem has been solved, revenue efficiency (RE_j) can then be calculated as follows:

$$[3] \qquad RE_j = \frac{I^*_j}{I_j} = \frac{\sum_q r_{jq} y^*_{jq}}{\sum_q r_{jq} y_{jq}}$$

$RE_j \geq 1$ represents la ratio between the maximum revenue (R^*_j), associated with the production of the vector of outputs y^*_j which maximises company j's revenue, and the observed revenue (R_j).

Technical and allocative efficiency

One of the advantages of DEA is the ease with which efficiency can be decomposed into its technical and allocative components. The measurement of technical efficiency from the revenue perspective (efficiency that increases outputs) is obtained by solving the following problem:

$$[4] \qquad \begin{array}{ll} Max & \Psi_j \\ s.a. & \sum_i \lambda_i y_{iq} \geq \Psi_j y_{jq} \quad \forall q \\ & \sum_i \lambda_i x_{ip} \leq x_{jp} \quad \forall p \\ & \lambda \geq 0; \quad i = 1,\ldots,N \end{array}$$

Each one of the N optimal solutions Ψ will be the indicators of technical efficiency of each company which, by construction, satisfy $\Psi \geq 1$. Those companies with $\Psi > 1$ are considered inefficient, while those with $\Psi = 1$, situated at the frontier, are catalogued as efficient.

Finally, the allocative revenue inefficiency (*AE*) for each company is calculated through the quotient between the measurements of revenue efficiency (*RE*) and of the corresponding technical efficiency (Ψ), $AE=RE/\Psi$.

3. The data and information used.

The sample contains 17 companies for the period 1970-1998[7]. The data are taken from reports published by the *Union Internationale des Chemins de Fer* (UIC).

To represent revenue (*R*), we differentiated between the revenues from passenger traffic and those from freight traffic. As variables representing the vector of outputs we used the numbers of passenger-km (y_1) and of freight ton-km (y_2). We chose this specification for two reasons. The first is that the prices of outputs can be proxied simply, as the quotient between the revenue generated by passenger (freight) traffic and the volume of traffic generated in terms of the number of passenger-km (ton-km). The second reason noted by some authors such as Oum and Yu (1994) is that this proxy for output is desirable when the basic aim of the study is the analysis of government policies. In this sense, the levels of efficiency evaluated by this type of measurements reflect the combined effects of the more or less efficient performance of the companies and of the restrictions imposed by the regulating authority.

The variables used to represent inputs are the numbers of workers, of locomotives, of units of rolling stock, and the value of the costs of materials and outside services. Finally, we also introduce the number of kilometres of track, as an indicator of the size of the company's network.[8]

As already indicated, the main objective is to verify whether some of the most significant changes in the system of organisation and management of the railways of Europe have helped to improve commercial policy and their level of efficiency.[9] For

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[7] The information is not complete for all years and all companies. In particular, information on the British BR is incomplete for the periods 70-73 and 95-98, and for 1998 not all the information is available for the companies CFL, CH, CIE and NSB.

[8] For a detailed analysis of the variables used, see Cantos et al (1999).

[9] The absence of statistical information for the British railway industry from 1995 onwards has prevented us from obtaining the efficiency indicators for this country, so unfortunately we have been unable to verify

this purpose, on the basis of the information supplied by the reports of the ECMT (*European Conference of Ministers of Transport*), the degree to which each company has advanced will be defined at four different levels:

1. Degree of organic separation between infrastructure and services (SEPARAT).
2. Companies' legal mode of constitution (LEGCONST).
3. Level of regulation of passenger fares (TARIF).
4. Degree of state influence over railway investments (STATE).

On the basis of this information, different dummy variables were constructed in order to test the importance of these reforms with regard to their impact on the different concepts of efficiency.

Regarding the degree of organic separation between infrastructure and services (SEPARAT) five levels are distinguished, in increasing degree of separation:

1. No separation.
2. Separation of accounts only.
3. Infrastructure as a separate division of the operator.
4. Infrastructure as a separate unit, but subsidiary to the operator.
5. Infrastructure as a unit totally separate from the operator.

In relation to the legal regime of the companies (LEGCONST), four distinct levels have been defined, which in increasing order of degree of independence or autonomy would be as follows:

1. Public Companies with a very narrow margin of commercial autonomy.
2. Public Companies with a wider margin of autonomy (most companies operate under program-contracts with the State).
3. Public Companies under the private company regime. In some cases (e.g.

whether significant changes have occurred in efficiency as a result of the drastic reforms introduced in that year.

Germany) there are specific plans to privatise part of the sector.
4. Completely private companies.

The levels of regulation of passenger fares (TARIF) are as follows:

1. Regulation of fares on all passenger services.
2. Regulation of fares on all domestic services.
3. Regulation of fares on subsidised services.
4. Regulation of fares on some specific services.
5. No type of regulation.

Finally, in relation to the degree of government influence over investment decisions (STATE), three levels are distinguished:

1. Low (when, for example, every investment program requires government approval only as a formality).
2. Medium.
3. High (when, for example, every investment program requires government finance or a system of public guarantees).

Table 1 presents a description of how far each company has advanced in each of these four different aspects. The depth of the reforms varies widely from country to country. Thus, for example, it is the British system that has advanced most in all the areas of reform that we are analysing. Greece and Ireland, on the other hand, have carried out very little reform, being the only two countries that have not advanced in the separation of infrastructure from services. Other cases, such as France (SNCF) and Portugal (CP), have opted to carry out a complete process of organic separation between infrastructure and services, though advancing hardly at all in the other areas of reform. The situation of each country is individual and differentiated, denoting still the lack of a common European legislative and operational framework, which may constitute a brake on the development of the sector.

(Insert table 1)

4. Results.

The results relating to the indicators of technical inefficiency (Ψ), revenue inefficiency (*RE*) and allocative inefficiency (*AE*) are given in tables 2, 3 and 4 respectively. The indicators have been separated into periods of five years in order to show their evolution over time. With regard to the indicators of technical inefficiency, the results are similar to those obtained in Cantos *et al.* (1999). We observe that the most efficient companies were the Swiss CFF, the Dutch NS and the Swedish SJ, which behaved efficiently throughout the period. The most inefficient companies throughout the period were the Greek CH and the Irish CIE.

(Insert tables 2, 3 and 4)

Table 3 provides information on revenue efficiency (*RE*) and table 4 on allocative inefficiency (*AE*). It is worth noting that the Swiss CFF and the Dutch NS are efficient in revenue as well as technically. This denotes that these companies are also allocatively efficient. In the period 90-95, when the Swedish railway system underwent a thorough restructuring, the Swedish company SJ behaved inefficiently in revenue whereas previously it had been efficient. This inefficiency can be explained by a sub-optimum distribution of the output mix which prevents maximisation of revenue. The reason for this efficiency is therefore only allocative, not technical. It can also be observed that neither technical nor revenue efficiency levels significantly improved over the period.[10]

An interesting exercise consists of drawing up a table with the coefficients of correlation between the various concepts of efficiency estimated. In particular, the ranking correlation coefficients appear in table 5.

(Insert table 5)

Firstly, all the coefficients are observed to be positive, and also statistically

[10] Cantos et al. (1999) concluded that the improvements in efficiency in the period 1970-94 were not significant, and that the improvements in productivity were due to technological progress.

significant, with a notably high correlation between technical efficiency and revenue efficiency. This result shows that the most revenue-efficient companies were also the most technically efficient. We also find that the most efficient companies in allocation were the most efficient both technically and in revenue. This result reinforces the idea that the companies that make an effort to improve their efficiency do so at both technical and allocative levels, and therefore in revenue.

5. Reforms and efficiency.

In this section we will analyse the reasons that may explain the efficiency indicators obtained in the above tables, with special reference to the organisational reforms and changes as potential influences on these indicators. As we have seen earlier, the 1990s (especially the second half) were a period of reform of the railway transport sector in most European countries. These reforms varied in intensity and extent in each specific case, though the objective pursued was always to increase both productive and commercial efficiency of railway services. The intensity of these reforms also varied considerably between countries, as we have seen. The analysis of the reforms will centre on the four areas described above: separation between infrastructure and services, changes in the legal constitution of the companies, degree of regulation of fares and freight rates, and of government influence over investments.

On the basis of the inefficiency levels obtained for each country during the sample period, we can analyse the effectiveness of these reforms on technical, allocative and total efficiency in revenue. When valuing the results it must be borne in mind that in most cases the reforms are very recent and, therefore, the analysis centres on the very short term results of these reforms. Naturally, the structural reforms undertaken imply notable changes in the organisation of the sector. However, in the short term the necessary adjustments that any structural change involves may exceed the possible positive effects.

Given that the efficiency indicators obtained are truncated variables, following the practice habitual in the literature, we have analysed the relationship between inefficiency and reforms by estimating Tobit models. The dependent variable is always the logarithm of the efficiency indicator. As explanatory variables we introduce a set of time *dummies* so as not to confuse the effect of the reforms with possible effects common to all the countries, e.g. due to the economic cycle. The effect of the reforms is introduced by means of a *dummy* that takes the value 0 for the period before the reform in each country and 1 after the reform in each case (LECONST for changes in the legal status of the company, SEP for the separation between transport infrastructure and services, STAT for government regulation of investments and TAR for autonomy in pricing).

Table 6 offers the results for the relationship between the reforms and technical inefficiency (ψ). Columns 1-4 show a significant negative relationship between reforms and inefficiency, i.e. the companies reduced their technical inefficiency following a reform of any kind.[11] The results seem to indicate that the separation between infrastructure and transport is the type of reform most closely linked to gains in efficiency.

Table 7 presents the results regarding the relationship between introducing a reform of each type and total revenue inefficiency (*RE*). In this case only separation between infrastructure and services seems to have had significant effects (column 2). Table 8 enables us to understand better the difference between the results obtained for technical inefficiency and those obtained for total inefficiency. According to the results of table 8, the reforms never generated gains in allocative efficiency, and indeed the opposite may have occurred: during the period analysed they may have generated increases in allocative inefficiency[12]. The possible beneficial effects on technical inefficiency therefore do not exist in terms of total revenue inefficiency due to the influence of allocative inefficiency.

(Insert tables 6, 7 and 8)

Until now we have analysed only the possible impact associated with the implementation of reforms in the fields indicated. However, the reforms have had very

[11] Due to the efficiency indexes are equal or bigger than one, a negative sign of the parameter indicates that the analysed reform increased (decreased) the efficiency (inefficiency) of the companies.
[12] This result is the one produced, as we have remarked, following the reform of the Swedish railway system in 1989.

different range and depth in different countries. The possible differential impact of the reforms can be analysed in terms of their aggressiveness. Using the indicators that give a higher value to the reform the greater its intensity, we have obtained the correlations with respect to the average levels of inefficiency of each company during the period 1995-98. This period was chosen because by then all the companies that underwent reforms had already implemented them. The results appear in table 9. All the correlations are negative and their magnitude is especially important for the intensity of the separation between infrastructures and transport. The magnitude of the correlation is, furthermore, greater in the case of technical inefficiency. In the case of allocative inefficiency the correlations are the smallest. These results with respect to the relationship between gains in efficiency and the intensity of the reforms are in line with those obtained when analysing the impact of the mere carrying out of any reform.

(Insert table 9)

Altogether, the evidence is not conclusive[13] because the analysis only considers the very short term effects, given the recent implementation of the reforms. However, the results seem to indicate that the reforms, especially those linked to separating management of infrastructure from management of transport, and to a lesser extent to increasing autonomy in pricing policy, are associated with subsequent reductions in the levels of technical inefficiency. The more intense the reform in these two fields, the greater the effects seem to be. However, the reforms do not seem to have generated significant increases in allocative efficiency. The result of all this is that in the short term the reforms do not seem yet to have had any important effect on total revenue inefficiency.

[13] In fact the inclusion of individual dummies poses certain problems, preventing the estimation of Tobits as the algorithms do not converge. Using Ordinary Least Squares (OLS) the inclusion of the dummies causes the reducer effect of the inefficiency of the reforms to disappear. However, given the character of truncated variable of the indicators of inefficiency, estimations by OLS are unsuitable in this case.

6. Conclusions

Railway transport has traditionally been the industry within the transport sector most reluctant to introduce reforms and changes to modify its systems of organisation and management. This has been one of the reasons used to explain the decline of the railways experienced in Europe in the last 25 years (ECMT, 1998). This study has shown that the companies scarcely improved their technical and revenue efficiency indicators in the period 1970-98. This result is yet another sign of the deficient commercial and productive policy of the sector, which also explains the aforementioned decline.

Nevertheless, the period 94-98 saw notable reforms and structural changes which appreciably modified the operating and management systems of the railway companies. Though it is early to guess the full importance of these measures, this paper has aimed to study whether the initial impacts of such reforms go in the direction of improving the companies' efficiency indicators, which have scarcely improved over the long period 70-98.

We have tested the effectiveness of four types of reforms: degree of separation between infrastructure and services, changes in the legal constitution of the companies, degree of regulation of prices and degree of government influence over investments. Some of these aspects, such as the separation between infrastructure and services, are crucial for the subsequent development of the sector, which is placing its bets on a structure of vertical disintegration that separates both ownership and management of infrastructure and operations.

Although the results cannot be interpreted as totally conclusive, it seems that of all the reforms carried out, the separation between infrastructure and services has achieved the most beneficial impact, especially on the level of technical efficiency. The rest of the reforms analysed (i.e. changes in the legal constitution and in the degree of government influence over investment) do not seem to have significantly improved companies' efficiency in either the technical or the allocative aspect.

Thus, although we will have to wait some time before evaluating the definitive effectiveness of all these reforms, some of their first results already seem to have been positive. At all events, there are also costs in these processes of widespread reform that should also be properly evaluated. Thus in the United Kingdom, and in the countries that have most de-regulated their railway sector, there are general problems of coordination between the body owning the infrastructure and the operators, widespread complaints about poor quality of service, as well as an insufficient volume of investment in the infrastructure to guarantee proper quality and safety of the service. It therefore seems clear that although the reforms begun may help to improve the companies' indices of efficiency and productivity, at the same time mechanisms must be introduced to minimise the problems or costs caused in the sector by these reforms.

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Gráfico 1: Revenue, technical and allocative efficiency.

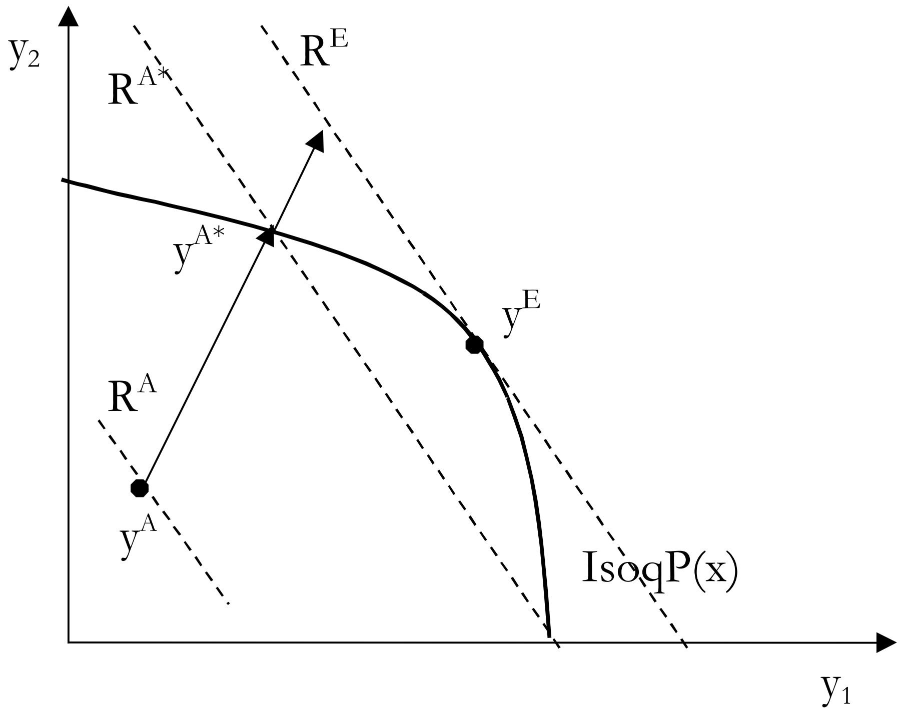

Table 1. State of the reforms (1998)

		SEPARAT	LEGCONST	TARIF	STATE
BR	**Un. Kingd.**	5	4	4	2
CFF	**Switzerland**	3	3	5	2
CFL	**Luxemb.**	5	3	1	1
CH	**Greece**	1	2	2	2
CIE	**Ireland**	1	2	1	2
CP	**Portugal**	5	2	1	1
DB	**Germany**	3	3	5	2
DSB	**Denmark**	5	3	2	2
FS	**Italy**	3	3	3	1
NS	**Holland**	4	3	2	2
NSB	**Norway**	5	3	1	2
OBB	**Austria**	2	3	4	2
RENFE	**Spain**	3	2	4	2
SJ	**Sweden**	5	2	5	2
SNCB	**Belgium**	2	3	3	2
SNCF	**France**	5	2	1	1
VR	**Finland**	5	3	5	2

Fuente: ECMT

Table 2. Technical efficiency (ψ)

		1970-74	1975-79	1980-84	1985-89	1990-94	1995-98
BR	**Un. Kingd.**	1.63	1.60	1.50	1.23	1.18	n.a.
CFF	**Switzerland**	1.00	1.00	1.00	1.00	1.00	1.00
CFL	**Luxemb.**	1.00	1.00	1.00	1.00	1.01	1.23
CH	**Greece**	1.37	1.52	1.56	1.44	1.60	1.69
CIE	**Ireland**	2.93	2.23	1.73	1.29	1.33	1.29
CP	**Portugal**	1.00	1.00	1.00	1.00	1.10	1.08
DB	**Germany**	1.04	1.05	1.00	1.00	1.09	1.2
DSB	**Denmark**	1.29	1.35	1.32	1.21	1.42	1.18
FS	**Italy**	1.01	1.00	1.07	1.05	1.03	1.00
NS	**Holland**	1.00	1.00	1.00	1.00	1.00	1.00
NSB	**Norway**	1.13	1.02	1.17	1.18	1.56	1.16
OBB	**Austria**	1.05	1.06	1.02	1.01	1.01	1.00
RENFE	**Spain**	1.00	1.00	1.10	1.01	1.13	1.02
SJ	**Sweden**	1.00	1.00	1.00	1.00	1.00	1.00
SNCB	**Belgium**	1.29	1.23	1.26	1.00	1.00	1.05
SNCF	**France**	1.00	1.00	1.00	1.00	1.05	1.04
VR	**Finland**	1.08	1.00	1.00	1.00	1.00	1.00
TOTAL		1.19	1.18	1.16	1.08	1.15	1.10

Table 3. Revenue efficiency (RE)

		1970-74	1975-79	1980-84	1985-89	1990-94	1995-98
BR	**Un. Kingd.**	1.66	1.64	1.57	1.32	1.45	n.a.
CFF	**Switzerland**	1.00	1.00	1.00	1.00	1.00	1.00
CFL	**Luxemb.**	1.00	1.02	1.00	1.00	1.23	1.59
CH	**Greece**	2.42	2.42	3.04	3.19	3.91	4.90
CIE	**Ireland**	3.61	2.34	1.81	1.53	1.39	1.36
CP	**Portugal**	1.52	1.04	1.00	1.00	1.12	1.13
DB	**Germany**	1.10	1.21	1.15	1.19	1.33	1.52
DSB	**Denmark**	1.33	1.41	1.35	1.24	1.45	1.30
FS	**Italy**	1.28	1.21	1.22	1.16	1.06	1.00
NS	**Holland**	1.00	1.00	1.00	1.00	1.00	1.00
NSB	**Norway**	1.15	1.05	1.19	1.35	1.71	1.26
OBB	**Austria**	1.07	1.13	1.26	1.20	1.14	1.07
RENFE	**Spain**	1.01	1.01	1.17	1.02	1.16	1.08
SJ	**Sweden**	1.00	1.00	1.00	1.06	1.36	1.08
SNCB	**Belgium**	1.35	1.42	1.68	1.41	1.46	1.39
SNCF	**France**	1.00	1.00	1.00	1.00	1.05	1.05
VR	**Finland**	1.10	1.02	1.00	1.00	1.00	1.00
TOTAL		1.35	1.29	1.32	1.28	1.40	1.35

Table 4. Allocative efficiency (AE)

		1970-74	1975-79	1980-84	1985-89	1990-94	1995-98
BR	**Un. Kingd.**	1.02	1.02	1.05	1.08	1.23	n.a.
CFF	**Switzerland**	1.00	1.00	1.00	1.00	1.00	1.00
CFL	**Luxemb.**	1.00	1.02	1.00	1.00	1.21	1.29
CH	**Greece**	1.82	1.60	1.98	2.24	2.66	2.96
CIE	**Ireland**	1.24	1.05	1.05	1.19	1.05	1.01
CP	**Portugal**	1.52	1.04	1.00	1.00	1.01	1.04
DB	**Germany**	1.05	1.14	1.15	1.19	1.23	1.27
DSB	**Denmark**	1.03	1.04	1.03	1.02	1.02	1.05
FS	**Italy**	1.26	1.21	1.15	1.10	1.03	1.00
NS	**Holland**	1.00	1.00	1.00	1.00	1.00	1.00
NSB	**Norway**	1.02	1.04	1.01	1.14	1.10	1.04
OBB	**Austria**	1.02	1.07	1.24	1.20	1.14	1.07
RENFE	**Spain**	1.01	1.01	1.06	1.00	1.03	1.06
SJ	**Sweden**	1.00	1.00	1.00	1.06	1.36	1.08
SNCB	**Belgium**	1.05	1.16	1.33	1.41	1.46	1.33
SNCF	**France**	1.00	1.00	1.00	1.00	1.00	1.02
VR	**Finland**	1.02	1.01	1.00	1.00	1.00	1.00
TOTAL		1.12	1.08	1.12	1.16	1.21	1.17

Table 5. Coefficients of ranking correlation between efficiency indicators.

	TE (Ψ)	RE	AE
TE (Ψ)	1.000	0.925*	0.580*
RE		1.000	0.752*
AE			1.000

The * indicates that the coefficient is statistically significant at 5%.

Table 6. Effect of reforms on technical inefficiency (ψ)

	(1)	(2)	(3)	(4)
LECONST	-0.256 (-3.32)			
SEP		-0.354 (-4.37)		
TAR			-0.284 (-3.67)	
STAT				-0.180 (-2.35)
LAUTO				
Log-lik	-228.1	-223.3	-226.8	-231.2
Obs.	480	480	480	480

Estadístico-t entre paréntesis

Table 7. Effect of reforms on total revenue inefficiency (RE)

	(1)	(2)	(3)	(4)
LECONST	-0.056 (-0.65)			
SEP		-0.168 (-1.97)		
TAR			-0.082 (-0.97)	
STAT				0.012 (0.13)
LAUTO				
Log-lik	-307.4	-305.7	-307.1	-307.6
Obs.	478	478	478	478

Estadístico-t entre paréntesis

Table 8. Effect of reforms on allocative inefficiency (AE)

	(1)	(2)	(3)	(4)
LECONST	0.020 (0.39)			
SEP		-0.046 (-0.89)		
TAR			0.004 (0.08)	
STAT				0.050 (0.93)
LAUTO				
Log-lik	-147.4	-147.1	-147.5	-147.0
Obs	478	478	478	478

Estadístico-t entre paréntesis

Table 9. Correlations between intensity of reforms and inefficiency (1995-98)

	TE (Ψ)	RE	AE
LECONST	-0.243	-0.272	-0.203
SEP	-0.365	-0.396	-0.320
TAR	-0.490	-0.179	-0.082
STAT	-0.079	-0.021	-0.002