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# Do They Influence Operating Efficiency?

Mette Asmild, Torben Holvad,
Jens Leth Hougaard & Dorte Kronborg

Studiestræde 6, DK-1455 Copenhagen K., Denmark
Tel.: +45 35 32 30 82 – Fax: +45 35 32 30 00
http://www.econ.ku.dk

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# Railway reforms: Do they influence operating efficiency?

Mette Asmild*, Warwick Business School, UK

Torben Holvad, European Railway Agency, France

Jens Leth Hougaard, Department of Economics, University of Copenhagen, Denmark

Dorte Kronborg, Copenhagen Business School, Denmark

* Corresponding author: Mette Asmild, Warwick Business School, University of Warwick, Coventry, CV4 7AL, UK, tel: +44 (0)24 7652 4504, fax: +44 (0)24 7652 4539, e-mail: mette.asmild@wbs.ac.uk

**Abstract:** This paper considers railway operations in 23 European countries during 1995-2001, where a series of reform initiatives were launched by the European Commission, and analyses whether these reform initiatives improved the operating efficiency of the railways. Efficiency is measured using Multi-directional Efficiency Analysis, which enables investigation of how railway reforms affect the inefficiencies of specific cost drivers. The main findings are that the reform initiatives generally improve operating efficiency but potentially differently for different cost drivers. Specifically, the paper provides clear empirical evidence that accounting separation is important for improving operating efficiency for both material and staff costs, whereas other reforms only influenced one of these factors.

**Keywords:** European railways, reforms, operating efficiency, Multi-directional Efficiency Analysis (MEA).

## 1. Introduction

Market opening and deregulation of public monopolies in network industries like transportation, telecommunication and utilities distribution has been the subject of numerous studies since the 1980's, c.f. e.g. Megginson and Netter (2001). The underlying rationale has, among other things, been that promoting competition leads to increased operational efficiency and improved consumer welfare, for instance according to the contestable market hypothesis (Baumol et al. 1982).

In the present paper we consider the organisation of railway operations in 23 European countries during 1995-2001; a period that witnessed a series of reform initiatives from the European Commission (EC) as well as specific national initiatives in some member states that exceeded the EC requirements. Traditionally, railways in Europe have been organised as state monopolies responsible for both infrastructure and services, but the reforms in question have aimed at market openings and the separation of operations and infrastructure management. Therefore, it is of interest to examine the effects of these organisational changes on the operating efficiencies of the railways in order to assess the reforms' effectiveness.

The efficiency of the railways is measured using so-called Multi-directional Efficiency Analysis (e.g. Asmild et al. 2003, Holvad et al. 2004). Multi-directional Efficiency Analysis (MEA), like the more widely used Data Envelopment Analysis (e.g. Charnes et al. 1978) is a non-parametric method capable of measuring the relative performance of production units considering multiple inputs and multiple outputs simultaneously. MEA however, measures

the improvement potential (inefficiency) in each production factor separately, which enables us to investigate the impact of railway reforms on the inefficiencies of specific cost drivers.

A substantial constraint for undertaking benchmarking analyses for the railway sector on a pan-European scale has been the lack of harmonised data between countries. However, as part of an EC sponsored project (*Study of the Financing of and Public Budget Contributions to Railways*) NERA Economic Consulting collected a data set which represents a significant improvement from previous work, as much effort has been put into the preparation of consistent and comparable data. Data from UIC (The International Union of Railways) were used as the starting point, but these were subsequently compared to information provided in the annual reports from the national railway companies, supported by direct requests to the railways (UIC, various years). This process revealed gaps and inconsistencies in the UIC data that were amended using the additional information from the annual reports and the railway companies themselves. Clearly, despite these efforts, some data inconsistencies between the countries may still remain.

We show that reform initiatives improve operating efficiency but potentially differently for different cost drivers. The most robust result is a strongly significant effect of accounting separation on both material and staff costs. Thus, this paper provides clear empirical evidence that accounting separation is important for improving operating efficiency.

The paper is structured as follows: Section 2 provides background information about the railway sector in Europe. Section 3 outlines the methodology used for the performance assessment (MEA). In Section 4 the data used are presented. Efficiency results and explanatory factors are examined in Section 5 and finally Section 6 concludes the paper.

## 2. Motivation

### 2.1 Railway reforms

While the total transport demand in the European Union member states has increased significantly over the last decades, the shares of rail transport of both passengers and freight have decreased. This trend has arguably created economic, social and environmental problems.

The reduced market shares for rail have resulted in financial difficulties for the public monopolies that throughout Europe had in the main been responsible for railways since the end of the Second World War. These monopolies were in general organised as vertically integrated companies with responsibility for both infrastructure management and operations, and often other non-rail transport services such as long-distance coach and ferry services as well. At the same time there has been increased recognition of the need for more sustainable transport, with the rail mode being seen as critical in order to achieve this (European Commission, 2001).

Therefore, railway reforms were initiated in many European countries and since 1991 the reform process has been taken forward through EC legislation aiming to enhance the competitiveness of rail transport. 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). These reforms, which enable a greater role for market forces, are expected to result in improved cost performance and enhanced customer focus (European Commission, 1996). Thereby the reforms should provide a basis for improvements in rail services such that the competitiveness of rail vis-à-vis other modes of transport is enhanced, contributing to sustainable transport as set out in the EC Transport White Paper (European Commission, 2001).

Requirements from the EC concerning separation of infrastructure and operations were initially included in Directive 91/440/EC (European Commission, 1991) where the principle of accounting separation was introduced. Subsequently, Directive 2001/12/EC (European Commission, 2001) provided that independent organisational entities must be specified for transport operations and infrastructure management. This directive allows the member states to achieve this separation through either the organisation of distinct divisions within a single undertaking (the holding company model) or for the infrastructure to be managed by a fully separate entity. Furthermore, according to the directive, member states are required to take measures to ensure that the functions determining equitable and non-discriminatory access to infrastructure are assigned to bodies that do not themselves provide any rail services.

Apart from the separation of infrastructure and operations, further unbundling is also being implemented in the EU member states, including at least accounting separation between passenger and freight operations and between Public Service Obligation (PSO) activities and non-PSO activities. In addition, steps to ensure the independence of essential functions such as capacity allocation, infrastructure charging and licensing are required according to Directive 2001/12/EC (European Commission, 2001).

It should be noted that several variations of both full separation and the holding company model for organisation of railways exist amongst the European countries. For example, although Sweden, Netherlands and Britain all have adopted full separation of infrastructure and operations, in Britain only privately-owned railway undertakings operate on the network whereas in all other countries there is at least one publicly-owned company present in the network. For countries operating according to the holding company model (e.g. Germany, Italy, Switzerland, Poland and Estonia) there are also variations in the organizational set up; in Estonia, for example, the integrated company is majority privately owned, whereas the government is the only shareholder in the other countries. A few countries (France, Czech Republic, Finland and Slovenia) have adopted a structure in between the fully separated and integrated models, where separate entities are established yet some co-ordination between infrastructure and operations is facilitated.

The main advantage of the fully separated model, as opposed to the holding company model, is that non-discriminatory access to the network, required for true market opening, is straightforward due to the lack of links between any railway operator and the infrastructure management. Another possible advantage of full separation is cost transparency which is more difficult to obtain in the holding company model, though accounting separation may at least partly achieve this (cf. e.g. Shires and Preston, 1999). On the other hand, full separation is more likely to result in various forms of coordination problems between the rail operations and the management of the infrastructure as opposed to the holding company model (cf. e.g. Cantos, 2001).

In the following, variables representing various reform initiatives are tested for their influence on railway operating efficiency. The a priori expectations are that especially initiatives

leading to market opening should increase efficiency whereas the net effect on efficiency of the cost transparency and the possible coordination problems resulting from organisational separation is less obvious.

## 2.2 Modelling considerations

There is a substantial body of literature concerning the (levels of) technical and cost efficiency of railway operations, including country comparisons (see e.g. Oum and Yu 1994, and Oum et al. 1999). Only a few studies do, however, consider the effects of regulatory changes on operating efficiency, including Oum and Yu (1994), Gathon and Pestieau (1995), Cantos et al. (1999), Cantos and Maudos (2001), and Friebel et al. (2005). While these studies generally find efficiency improvements from railway reforms, they use different methodological approaches and consider different aspects.

Gathon and Pestieau (1995) decompose efficiency into managerial and regulatory components and argue that deregulation increases efficiency due to management autonomy. Cantos and Maudos (2001) suggest that while productivity increases, the financial performance of the railway companies deteriorate during the period of deregulation. Friebel et al. (2005) pose the argument that the outcome of reforms depends on sequencing and that they should be introduced in a stepwise manner rather than in a combined package. Moreover, they challenge the supposed positive effect of full separation in the specific case of the railway industry.

Oum and Yu (1994) examine the relative efficiency of 19 mainly European railway companies for the period 1978-89 using the non-parametric Data Envelopment Analysis (DEA). In a second stage analysis, Tobit regression is used to provide explanations of the variation in efficiency level. The results indicate that the extent of public subsidies has a

significantly negative effect on efficiency whereas greater managerial autonomy tends to increase efficiency.

DEA is also used by Cantos et al. (1999) who subsequently use Malmquist Indices to investigate productivity changes over time and their decomposition. Their main findings are that productivity improvements are mainly caused by technical change and that technical changes increase with the degree of autonomy and financial independence, where the latter conclusion concurs with that of Gathon and Pestieau (1995) but is based on a multiple output model. While the idea of the decomposition used by Cantos et al. (1999) is relevant, it comes at a cost: Since all cross-period efficiency scores have to be well-defined for calculations of Malmquist Indices, all inputs have to be discretionary in an input oriented model and we argue that an important variable like the network length is naturally non-discretionary. Hence, we do not here use Malmquist Indices. Furthermore, using MEA rather than DEA enables us to analyse the effects of the reforms on specific cost drivers as explained in Section 3 below.

## 3. Multi-directional Efficiency Analysis (MEA)

This section provides a brief description of the MEA methodology; for further details see e.g. Bogetoft and Hougaard (1999), Asmild et al. (2003) and Holvad et al. (2004). We consider here the input oriented version of MEA, since we are concerned with the cost efficiency of railway operations and we furthermore use constant returns to scale models.

Let $N$ be the set of observed production units, here railways in 23 European countries each year from 1995 to 2001. Let unit $j \in N$ use $m$ inputs $x_{ij}$, $i = 1,\ldots, m$, to produce $s$ outputs $y_{rj}$, $r = 1,\ldots, s$. We further subdivide the inputs into discretionary and non-discretionary inputs to be denoted by $x_{ij}^{D}$ ($i = 1,\ldots,k$) and $x_{ij}^{N}$ ($i = k+1,\ldots,m$) respectively. The mathematical programs

used to calculate the relative input specific MEA-inefficiencies for a given unit ($x_0, y_0$) can now be determined as follows: First, the ideal reference point for ($x_0, y_0$) is found by solving the $k$ linear programs $i = 1, \ldots, k$ (one for each discretionary input dimension):

$$
\begin{aligned}
\min \quad & \theta_{i0} \\
st. \quad & \sum_j \lambda_j x_{ij}^D \le \theta_{i0} \\
& \sum_j \lambda_j x_{(-i)j}^D \le x_{(-i)0}^D \qquad -i = 1,\ldots,i-1,i+1,\ldots,k \\
& \sum_j \lambda_j x_{ij}^N \le x_{i0}^N \qquad i = k+1,\ldots,m \\
& \sum_j \lambda_j y_{rj} \ge y_{r0} \qquad r = 1,\ldots,s \\
& \lambda_j \ge 0 \qquad \forall j
\end{aligned}
\qquad \text{(eq. 1)}
$$

where the notation (-$i$) denotes all input dimensions except dimension $i$.

Letting ($\lambda^*, \theta^*_{i0}$) be the solutions to the above programs for $i=1, \ldots, k$, the ideal reference plan for ($x_0, y_0$) is given by ($\theta^*_{10}, \ldots, \theta^*_{k0}$). Consider next the following linear programming problem for ($x_0, y_0$):

$$
\begin{aligned}
\max \quad & \beta \\
st. \quad & \sum_j \lambda_j x_{ij}^D \le x_{i0}^D - \beta\left(x_{i0}^D - \theta_{i0}^*\right) \qquad i = 1,\ldots,k \\
& \sum_j \lambda_j x_{ij}^N \le x_{i0}^N \qquad i = k+1,\ldots,m \\
& \sum_j \lambda_j y_{rj} \ge y_{r0} \qquad r = 1,\ldots,s \\
& \lambda_j \ge 0 \qquad \forall j
\end{aligned}
\qquad \text{(eq. 2)}
$$

The solution ($\lambda^*, \beta^*_0$) to this program can be used to determine the benchmark selection for ($x_0, y_0$) and thereby the $k$-dimensional vector of relative (discretionary) input specific MEA-inefficiencies for unit ($x_0, y_0$) becomes:

$$\left( \frac{\beta_0^*(x_{i0}^D - \theta_i^*)}{x_{i0}^D} \right)_{i=1,\ldots,k}, \qquad \text{(eq. 3)}$$

where all elements in the vectors are constrained between 0 and 1.

## 4. Data and model

The data used for the analysis of railway efficiencies and the impacts of reforms were collected as part of an EU sponsored project undertaken by NERA Economic Consulting. Railway statistics for all current EU Member States plus Norway and Switzerland are available for the period 1995 – 2001 (NERA, 2004). The NERA data set represents a substantial effort towards ensuring data comparability between the countries as mentioned in the introduction.

The data cover activity and resource indicators (e.g. passenger kilometres, tonne-kilometres, traffic units, staff and length of lines) as well as data from the income statements (e.g. revenue, costs and public budget contributions) and balance sheets (e.g. capital, reserves and debt). All monetary figures are reported in real euros (2001 prices). Data provided for each country concern the main state railway organisation with the exception of Britain where the data are aggregated from different private rail companies as the whole rail sector was privatised in 1993. For those countries where the industry is vertically separated regarding infrastructure and operations, separate data are available for the railway undertaking and the infrastructure manager and further information is also provided which combine the data for the two organisations whilst netting out financial flows between them.

### 4.1 Definition of data used for efficiency analysis

Based on the NERA data set, a core analytical model for the efficiency analysis will be specified below. This model draws on specifications from earlier studies of railway efficiency

(e.g. Oum and Yu, 1994) and considers the main inputs and outputs involved in railway production.

Since one of the main goals of the reform initiatives is to create cost-consciousness in the railway systems, the analytical models include the two main cost components: *Labour* and *material* costs. Furthermore, *network length* is included as an indicator of capacity, but since it is not a decision parameter (in the short run at least) it is incorporated as a non-discretionary input variable.

Looking at the output side, requirements for public service obligation activities means that physical production rather than revenues become relevant. The models therefore include *passenger* and *freight* train-kilometres as the two output variables. The exact definitions of the input and output variables are given below.

Even though we consider a panel data set we have chosen to pool the data for the different years into one combined data set and thus all efficiencies are measured relative to one common frontier. If the years had been considered separately, the annual results could have been compared using Malmquist indices. However, as mentioned previously, the presence of a non-discretionary variable in our modelling framework makes this approach infeasible. Nevertheless, measuring all efficiencies relative to the same (pooled) frontier rather than annual frontiers ensures that efficiencies can be compared directly. Furthermore it should be noted that the subsequent analysis of the effects of reform initiatives consider *changes* in rather than *levels* of inefficiencies, and therefore it is of little importance whether the estimated benchmarks are actually attainable for the individual observations.

To sum up, the core analytical model comprises the following input and output variables from the NERA data set:

- Outputs:
  - Passenger train-kilometres (in thousands): The number of kilometres travelled by passenger trains.
  - Freight train-kilometres (in thousands): The number of kilometres travelled by freight trains.
- Discretionary Inputs:
  - Staff costs (in million euros): Following UIC's guidelines, total staff costs comprise all staff remuneration, railways' contributions towards family allowances, safety, social welfare, staff training, contributions to pension funds, and pensions paid directly by the railways after deduction of contributions by active staff.
  - Material purchases and external charges (in million euros): Material costs consist of most operating costs which are not staff costs. Typically it includes operating costs incurred when constructing assets as well as maintenance costs, energy costs and rolling stock leasing costs.
- Non-discretionary Input:
  - Network length. The network length refers to the length of lines in kilometres available for train service irrespective of the number of parallel tracks.

## 4.2 Reform characteristics

The performance results from the core model specified above are in a second stage analysis related to the organisational structure for railways in the different countries. The analysis considers dummy variables for the following reform characteristics:

- **Accounting Separation**: Indicating whether or not infrastructure and services are separated on an accounting basis.
- **Complete Separation**: Indicating whether or not infrastructure and services are institutionally separated.
- **Independent Management**: Indicating whether or not legislation is transposed that assures independent management from the government of railway companies.
- **Competitive Tendering for Passenger Services**: Indicating whether or not competitive tendering is used to procure (some or all) passenger railway services.
- **Market Opening Freight Transport**: Indicating whether or not legislation is transposed that allows entry of competitors and competition has developed to a significant extent.

Information concerning these reform characteristics for each country and for each year were established using materials from different sources, including Driessen et al. (2006) and Nash and Rivera-Trujillo (2004).

### 4.3 Final data set for efficiency analysis

For our core model with the inputs and outputs specified above, complete data were available for most countries except for Bulgaria, Latvia, Lithuania and Romania. These countries are therefore excluded from the analysis, resulting in 28 observations (4 countries x 7 years) being removed from the original data set. Furthermore, individual observations from some

countries had to be discarded due to either missing data points for one or more of the variables in certain years or in a few cases because variable values for a given year were out of line with the values for all other years for that country. This concerned the following 5 observations that were subsequently also discarded from the data set: Great Britain for 1995 due to very high staff costs in that year compared to all the other years; Netherlands for 2000 and 2001 due to missing data for freight train kilometres; Switzerland for 1998 as a result of a single very high value for material purchases and external charges compared to both the period before and after that year and Czech Republic for 1995 caused by a very high value for material purchases and external charges. The final data set for the efficiency analysis therefore comprises 156 observations (compared to the 189 original observations including all countries and years). For countries that operate a vertically separated railway system, the observations are combined data for both infrastructure manager and railway undertaking. This choice of data definition facilitates comparisons between railway systems that are vertically separated and those that are vertically integrated.

Table 1, 2 and 3 below show descriptive statistics for the input and output variables across the whole data set, mean values for the input and output variables for each country and the status of the various reform variables for each country respectively.

| | | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Inputs** | Material purchases and external charges (million €) | 1 380.19 | 2 336.2 | 35.8 | 10 774.3 |
| | Staff costs (million €) | 1 752.55 | 2 568.5 | 30.9 | 12 348.6 |
| | Network length* (km) | 8 970.30 | 9 984.0 | 274 | 41 573.0 |
| **Outputs** | Passenger train-kilometres (1000 km) | 121 275.90 | 161 262.8 | 2 714 | 729 900 |
| | Freight train-kilometres (1000 km) | 39 131.95 | 51 804.6 | 1 048 | 226 900 |

Table 1. Descriptive statistics of input and output variables.

* denotes a non-discretionary input variable

| Country | Material purchases and ext. charges | Staff costs | Network length * | Passenger Train-kilometres | Freight Train-kilometres |
|---|---|---|---|---|---|
| Austria | 788.9 | 2 095.9 | 5 650.4 | 86 742.0 | 44 331.0 |
| Belgium | 781.6 | 2 342.1 | 3 425.3 | 74 331.3 | 17 827.1 |
| Czech republic | 498.9 | 608.9 | 9 411.5 | 98 166.7 | 43 581.8 |
| Denmark | 451.0 | 560.9 | 2 259.7 | 53 385.7 | 6 665.6 |
| Estonia | 58.5 | 34.0 | 982.3 | 4 061.6 | 4 136.6 |
| Finland | 365.8 | 375.0 | 5 856.0 | 26 763.1 | 16 696.1 |
| France | 4 155.9 | 7 349.2 | 31 104.1 | 351 000.1 | 151 273.0 |
| Germany | 10 481.7 | 10 226.8 | 38 422.9 | 689 688.1 | 212 449.7 |
| Great Britain | 5 109.6 | 2 537.6 | 16 655.7 | 400 814.0 | 50 179.6 |
| Greece | 69.8 | 276.8 | 2 401.6 | 15 378.9 | 1 564.1 |
| Hungary | 329.5 | 376.7 | 7 665.3 | 74 794.6 | 16 932.1 |
| Ireland | 126.0 | 149.4 | 1 932.6 | 11 104.4 | 4 199.6 |
| Italy | 2 379.9 | 5 344.6 | 16 062.1 | 253 808.6 | 63 938.4 |
| Luxembourg | 142.0 | 170.4 | 274.1 | 6 063.0 | 1 193.1 |
| Netherlands | 1 762.3 | 1 073.7 | 2 804.2 | 113 867.8 | 7 204.7 |
| Norway | 460.8 | 458.6 | 4 086.7 | 26 646.1 | 9 144.0 |
| Poland | 985.9 | 1 507.6 | 22 865.4 | 168 875.6 | 100 922.9 |
| Portugal | 215.9 | 269.6 | 2 920.0 | 32 232.7 | 7 930.5 |
| Slovakia | 305.7 | 284.1 | 3 664.9 | 37 176.1 | 21 823.1 |
| Slovenia | 115.6 | 143.2 | 1 205.1 | 11 077.9 | 7 315.9 |
| Spain | 833.6 | 1 076.3 | 12 300.0 | 126 206.3 | 39 330.9 |
| Sweden | 865.4 | 829.7 | 9 966.6 | 63 776.3 | 35 833.4 |
| Switzerland | 908.7 | 2 008.9 | 2 936.5 | 94 004.0 | 26 907.0 |

Table 2. Mean values across years for the input and output values for each country.

* denotes a non-discretionary input variable

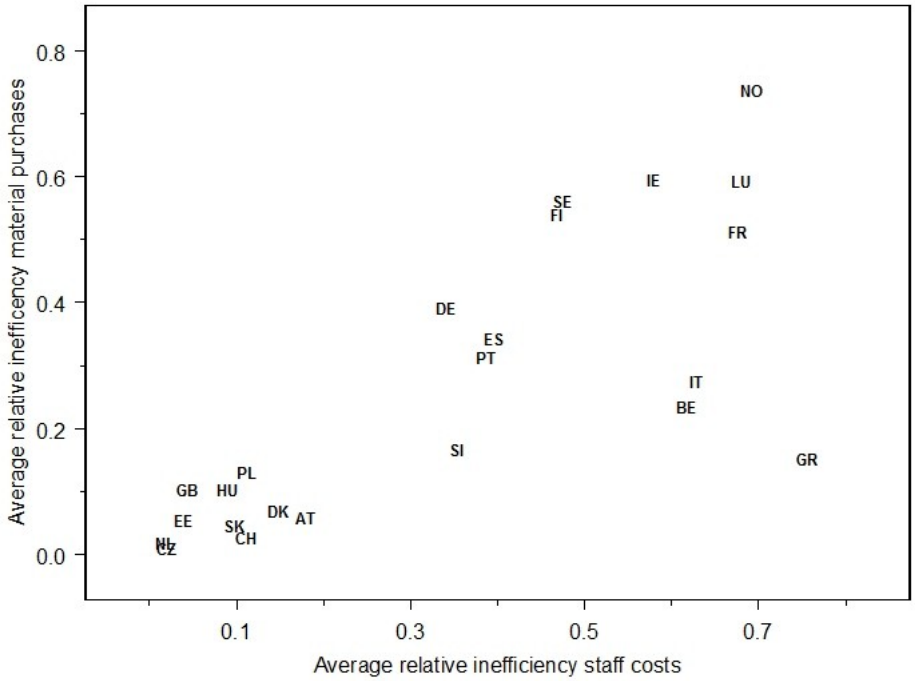
| Country | Accounting separation | Complete separation | Independent management | Passenger tendering | Market opening freight |
|---|---|---|---|---|---|
| Austria | Full | Not | Full | Not | Not |
| Belgium | Full | Not | Full | Not | Not |
| Czech | Full | Not | Not | Not | Full+ |
| Denmark | From 1997 | From 1997 | From 1999 | From 2001 | From 1999 |
| Estonia | Not | Not | From 1997 | Not | From 1999 |
| Finland | Full | Full | Not | Not | Not |
| France | Full | From 1997 | From 1997 | Not | Not |
| Germany | Full | Not | Full | From 1996 | Full |
| Great Britain | Full | Full | Full | Full | Full+ |
| Greece | Not | Not | Not | Not | Not |
| Hungary | Not | Not | Full | Not | Not |
| Ireland | From 1996 | Not | Full | Not | Not |
| Italy | From 1998 | Not | Full | Not | From 2001 |
| Luxembourg | Full | Not | Not | Not | Not |
| Netherlands | Full | Not | Full | From 1999 | From 1998+ |
| Norway | From 1997 | From 1999 | From 1997 | Not | Not |
| Poland | From 1999 | Not | From 2001 | Not | From 2000 |
| Portugal | From 1997 | From 1997 | From 1997 | From 1999 | Not |
| Slovakia | From 1997 | Not | Not | Not | From 1998 |
| Slovenia | From 1999 | Not | Not | Not | Not |
| Spain | From 1997 | Not | Full | Not | Not |
| Sweden | Full | Full | Full | Full | From 1996 |
| Switzerland | From 1998 | Not | Full | Not | From 1999 |

Table 3. Outline of the onset of various reforms for each country. 'Full' means that the reforms were implemented before 1995 and 'Not' means that reforms are still not implemented in 2001.

+ denotes that the data series is incomplete

## 5. Results

The averages across the study period of the annual relative MEA inefficiencies for each country are shown in Figure 1 below, where the figure concern inefficiencies in material purchases and staff costs respectively.




It appears that there is a positive relationship between the inefficiencies on the two input variables, but generally with higher relative inefficiency on staff costs. Looking at the individual countries shows that the early reformer Great Britain is one of the countries with low inefficiency on especially staff costs. Other countries with overall low inefficiencies are Switzerland, Netherlands, Czech Republic, Estonia and Slovakia, which may be caused by economies of density as well as relatively low wage levels in Eastern European countries. Furthermore, especially the Czech Republic and Netherlands have shown substantial reform progression. A bit surprising is the high inefficiency for other early reformers like Germany and Sweden. For Germany, the relatively poor cost performance is probably caused by restructuring following the integration of the East and West German railways. And for Sweden, the poor performance may be explained by low population density and relatively

high wages[1]. These factors may also partly explain the high inefficiencies in other countries such as Belgium, Finland, France, Greece, Ireland, Italy[2], Luxembourg, Norway and Spain. But all these countries, and in particular Spain, Ireland and Greece, are also countries that have been slow in initiating reforms.

While many earlier studies have compared railway efficiencies in different countries we here, however, specifically focus on the *changes* in inefficiencies in individual countries as they relate to the implementation of reforms. Since there are big differences in the *levels* of inefficiency between countries, it is necessary to account for country effects when testing for the effects of the various reform initiates described in Section 4 above. The influence of the various railway reforms on the changes in inefficiencies on staff and material costs are analysed by use of ordinary multivariate analysis of variances controlling for country effects. Wilks' lambda is used for simultaneous analysis of influence on the potential cost reductions, while marginal analyses are performed using standard t-tests.

Table 4 below shows the estimated effects (on the inefficiencies) of the selected reform characteristics and the significance probabilities from the above mentioned test statistics.

1. The issue of relative wages will be analysed specifically in section 5.2 below.

2. It should be noted, that Italy in recent years has made substantial progress towards market opening, but the effect is not evident within the current study period.

| Grouping Variable (and counts) | Input direction | Estimate of effect (std.error) | t-test, p value | Wilks' Lambda, p-value |
|---|---|---|---|---|
| Accounting separation (with=110,without=46) | Material purchases and ext. charges | -0.0462 (0.0175) | p=0.009** | p=0.011* |
| | Staff costs | -0.0591 (0.0206) | p=0.005** | |
| Complete separation (with=39, without=117) | Material purchases and ext. charges | -0.0436 (0.0260) | p=0.096 | p=0.215 |
| | Staff costs | -0.0470 (0.0308) | p=0.130 | |
| Independent management (with=97, without=59) | Material purchases and ext. charges | -0.0552 (0.0234) | p=0.020* | p=0.067 |
| | Staff costs | -0.0447 (0.0280) | p=0.113 | |
| Passenger tendering (with=24, without=132) | Material purchases and ext. charges | -0.0688 (0.0329) | p=0.039* | p=0.098 |
| | Staff costs | -0.0714 (0.0391) | p=0.070 | |
| Market opening freight (with=43, without=113) | Material purchases and ext. charges | -0.0280 (0.0206) | p=0.177 | p=0.052 |
| | Staff costs | -0.0589 (0.0240) | p=0.016* | |

Table 4. Test statistics and estimates for the effect on inefficiencies of reforms, calculated in a linear model controlling for country effects.

P values for Wilks' Lambda are calculated in the corresponding exact F(2,131) distribution.
Significance on 5% and 1% level are indicated by * and ** respectively.

The immediate observation from the results in Table 4 is that all coefficients are negative, which means that all reform initiatives reduce the cost inefficiency, i.e. improve the cost efficiency of operations both in terms of material purchases and staff costs. However, only some of the coefficients are significant: Accounting separation (for both inputs), independent management (for materials), passenger tendering (for materials) and market opening freight (for staff).

Accounting separation is clearly highly significant – and for both cost drivers. Thus it appears that the cost transparency resulting from the accounting separation is important for improving the cost efficiency. It should be noted, however, that complete separation (full organisational disintegration of railway operations and infrastructure management) obviously implies

accounting separation. But since complete separation is not significant, there is no empirical evidence about whether complete separation results in additional benefits above and beyond the significant positive impact of accounting separation alone.

Independent management (for materials) is also significant, confirming the expectation that giving the railway companies more independence from state control has a positive influence on performance. That independent management is only significant for material costs, and not for staff costs, may be explained by management being less constrained in terms of implementing changes regarding materials acquisition and utilization as opposed to the staff costs where the scope for changes may be more limited, at least in the short run, due to contractual factors etc. (although it should be noted that the results for staff cost improvement have the expected sign).

Passenger tendering shows a weakly significant positive effect on material costs. This effect is only based on data from four countries (see Table 3) and, therefore, the generality of the result is questionable. Again, the effect is only significant for material cost, which also in this case is likely to be caused by more management flexibility regarding material costs than staff. Indeed, it is likely that the constraints regarding staff are even stronger concerning passenger transport due to e.g. political attention to ensure sufficient passenger assistance and comfort, less use of subcontracting and hence more staff employed as civil servants. It should be noticed that several countries (e.g. Denmark and the Netherlands) introduced competitive tendering for parts of the passenger services towards the end of the study period for which the effects may only emerge in the subsequent years.

In the case of market opening for freight, it is the effect on staff costs that is significant but not on material costs. As noted above staff expenditure is relatively easier to change when it comes to freight rather than passenger transport. Indeed, one of the main aims of the reforms was to improve efficiency by increasing the competitive pressure on railway companies especially on the freight market.

### 5.2 Results on East-West differences

It is obvious that two different modes of operation existed especially before the reforms began, namely in Eastern and Western Europe respectively. Generally the former communist countries in Eastern Europe (Czech Republic, Estonia, Hungary, Poland, Slovakia and Slovenia) have been characterised by lower (labour) productivity but also by lower wage levels. This is also apparent in the current dataset, where considering the ratio of staff costs to staff numbers clearly divides the countries in Eastern and Western Europe into two distinct groups. Therefore, one would expect that considering staff numbers instead of staff costs would change the ranking of countries based on efficiency scores[3]. Indeed, for the current data set countries like Estonia and Slovakia show considerably more inefficiency when using staff numbers rather than costs whereas countries such as Spain and Sweden do considerably better. These changes are likely to be explained by differences in wage levels.

Because of the two distinct modes one might question whether the reforms have the same effects in Eastern and Western Europe. Still controlling for country effects, it turns out that there is a slight difference in the effect of market opening for freight on staff cost inefficiency

3. Note also that when changing the model such that staff numbers are used instead of staff costs (ceteris paribus) all previously significant effects of reform variables remain significant and point in the same direction (i.e. reducing cost inefficiency). Furthermore, additional effects become significant.

in Eastern and Western Europe, (p=0.050). The estimated effects and standard deviations are -0.0097 (0.0274) for Eastern Europe and -0.0964 (0.0342) for Western Europe, meaning that staff cost inefficiencies are reduced more in the Western part of Europe than in the Eastern part when introducing market opening for freight. Similar analyses of the other reform variables results in insignificant differences between the two parts of Europe. Effects of complete separation and passenger tendering were not obtainable (estimable) in the Eastern European countries, and consequently comparison with Western countries was not possible.

## 6. Conclusion

A main finding in the current study is that all the reform initiatives have negative impacts on the *in*efficiencies on both material and staff costs, i.e. they improve operating efficiency. Not all of these effects are significant however. This may in part be caused by the fact that for some of the reforms initiatives the available data contains too few occurrences of the introduction of the initiative (like in the case of passenger tendering and complete separation), which reduces the strengths of the statistical tests.

Generally, we observe that more effects are significant for material costs than for staff costs. A possible explanation for this finding is that management has more flexibility for adjusting the acquisition and utilization of materials rather than staff, as the latter is limited by contractual obligations etc. Note that whether the reforms affect the two input factors differently can be directly analysed using the framework of MEA, whereas using e.g. DEA would not enable such a distinction.

The most robust result is the strongly significant effect of accounting separation on both material and staff costs. Thus, this paper provides empirical evidence that accounting separation is important for improving operating efficiency. The strength of the result is increased by the fact that many countries implemented this particular initiative during the study period such that the data set enables a strong statistical test for the effect of this reform on the efficiencies. As more data becomes available in the future concerning the introduction of more reforms in specific countries, it will become possible to obtain a clearer picture of the effects of those initiatives as well. In particular, additional observations will enable tests for interaction effects between reform variables such that e.g. East-West differences can be tested.

By using the MEA methodology we are, however, still able to obtain significant results given the current data availability, since MEA disaggregates the efficiencies on the various cost drivers. As a consequence we are able to detect significant efficiency improvements on at least one of the two input factors for most reform initiatives.

Input specific efficiency scores can also be obtained using subvector Data Envelopment Analysis (see e.g. Färe et al. 1994), but while subvector DEA considers each input dimension separately (ceteris paribus) the MEA methodology estimates the input inefficiency in each dimension simultaneously and thereby utilizes the available information on input trade-offs as given by the shape of the production frontier. Furthermore, we have here introduced non-discretionary variables into the MEA framework.

While our methodological approach has enabled a more detailed investigation of the effects of the reforms on specific cost drivers, the overall picture is in line with previous studies (cf.

Section 2) in that the reform initiatives have positive impacts on operating efficiency. The literature to date, however, provides no clear conclusion regarding the net benefits of complete separation, yet this model is recommended by the EC (European Commission 2001).

We have here shown that there is a clear positive effect on operating efficiencies of the cost transparency following from accounting separation. But whether there is an additional benefit of complete separation, or whether the potential coordination problems outweigh the benefits, remains an unanswered question. It is, however, important to note that these two reform initiatives should be investigated separately, because otherwise the known positive effect of accounting separation is likely to be confounded in the effect of complete separation. A formal test of the specific additional effect of complete separation (over accounting separation) requires more observations from countries moving from accounting separation alone to complete separation (like France in 1997 and Norway in 1999).

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