International Transport Forum

Efficiency in Railway Operations and Infrastructure Management

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Roundtable

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The International Transport Forum

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Executive summary

What we did

Railway efficiency is a challenging concept due to the complexity of providing railway services. This publication examines the question of how to define and effectively measure the performance of railways: What is the proper level of detail at which the analysis should take place? What data needs to be available so that policy makers can benchmark railway performance, evaluate impacts of past interventions and assess the benefits of future initiatives? This report assembles the results of an ITF Roundtable which brought together 25 experts representing rail operators, regulators, transport ministries, sector associations and researchers from 13 countries to discuss how to improve assessments of railway performance.

What we found

Efficiency entails maximising the outputs from a set of inputs (technical efficiency) or creating an optimal mix of inputs to maximise output (allocative efficiency). A single description of efficiency relevant for railway owners/operators, government, users or the regulator is difficult. Operators will define it in terms of access to and cost of infrastructure. Users are interested in availability, reliability or speed. The regulator will measure both technical and allocative efficiency, and will require different information to examine both.

The simplest approach to conceptualise and measure railway efficiency is by deriving key performance indicators (KPIs) from published data. This can be sufficient to develop a simple but balanced scorecard. To monitor performance, both cross-sectional indicators (that compare systems) and time series indicators (that measure change over time) are needed.

Both types of data have to be treated with caution. Cross-sectional data risk comparing systems where outputs or inputs have been delineated differently. Time series indicators suffer from the risk that categorisation of inputs or outputs can change from one year to the next. Data on past performance must therefore be adjusted to reflect change, e.g. organisational set-up or in accounting standards. For cross-sectional benchmarking, the data from different systems must be standardised and normalised.

Measuring the efficiency of a railway system through demand/supply ratios (such as passengers carried per total train kilometres) can also be misleading. Such ratios are influenced by factors like topography, historic evolution, etc., and can be meaningless without adjustment for exogenous factors. The Dutch and British examples demonstrate the difficulties of measuring what constitutes efficiency. Vertical separation of the rail system in the Netherlands in the mid-1990s came with soaring maintenance costs and was perceived as reduced efficiency. Yet most of the cost increase was due to stricter safety rules, more night work and other exogenous factors. Moving to performance-based maintenance contracts brought down maintenance costs over the next ten years.

In the United Kingdom, the rail system underwent full vertical separation around the same time. Costs initially went down as a result of low bids to win regional rail franchises, creating the perception of efficiency gains. Yet several years later, privatisation costs increased sharply as incidents forced a stronger focus on quality, among other things.

The same approach – outsourcing – thus worked in opposite directions in the two countries. In the Netherlands, it proved beneficial to efficiency after a running-in period, while the UK experienced cost savings over the short-term, but ultimately faced very costly accumulated maintenance and investment bill. The difference lies in the way contracting was managed.

Capturing the full complexity of factors determining rail efficiency would require a very large dataset. This is not easily available and would be subject to inherent limitations regarding data quality. It is also not clear how indicators would have to be weighted to capture performance.

Two approaches exist to better capture the complexities of rail performance: Econometric techniques such as Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA). DEA allows carrying out some analysis even without a large dataset of control factors. However, it tends to overstate inefficiencies. Econometric analysis is the better approach where large datasets exist. Panel data is particularly useful in this regard for separating unobserved heterogeneity from inefficiency.

The top-down view offered by econometric modelling will benefit greatly from a bottom-up "engineering narrative" to provide insight into what actually determines performance. It can be further enriched by trying to capture cultural differences between countries – whether organisational changes drive the outcomes and to what extent deeper root causes influence results.

What we recommend

Build on simple indicators for an aggregate analysis of rail performance

A basic aggregate view of railway efficiency can be formed with a small set of cross-section and time series data producing a limited set of KPIs. The data needed is generally collected by railway organisations as a matter of routine. Issues with data availability and the interpretation can be limited. Developing indicators that require large amounts of (not readily available) data can undermine performance monitoring over time, for instance by making it difficult to update those indicators.

Use econometric models to better capture the complexity of rail performance

The inherent complexity of measuring rail efficiency can be addressed through econometric techniques such as Stochastic Frontier Analysis (SFA) or Data Envelopment Analysis (DEA). DEA can carry out some analysis even when a large dataset of control factors is not available, but it tends to overstate inefficiencies. Econometric analysis is therefore to be preferred when large datasets are available.

Develop a narrative of the drivers of rail performance

The top-down view of rail efficiency gained through indicators and econometric analysis will benefit greatly from a bottom-up "engineering narrative". This can provide insights into additional factors that determine performance and help shape the parameters used in the econometric model – for instance, engineering studies can provide insights why an intervention delivers different results in one country compared to another. For instance, unit costs reflect complexity, purpose and usage of the network as much as they give an indication of the efficiency of the maintenance manager.

Invest more into data and indicators related to service quality

Most studies of railway efficiency focus on technical cost efficiency and thus reflect the internal view. But ultimately it is service to the customer that it is important. More effort needs to be invested in providing data and KPIs on the service quality related to how users choose between transport modes, thus linking output measures with input measures more directly.

Chapter 1. Summary of discussions

Introduction

The International Transport Forum (ITF) has produced a series of reports and discussion papers addressing the interrelated issues of railway structure and performance; see for example Beck, Bente and Schilling (2013), Thompson (2013), ECMT (2007) and Thompson (2007). The academic literature on this subject is also significant, with good examples in Mizutani et al. (2014), Nash, Nilsson and Link (2013), van de Velde et al. (2012) and Kirchner (2002, 2004, 2007 and 2011). All of these studies have confronted the question of how to measure the performance, or efficiency, of railways – both in the sense of how one railway compares with others (cross-section) and how railways have changed as a result of policy interventions (time-series). The purpose of the roundtable discussions was to revisit the issue of defining and measuring efficiency at the proper level of detail and with reasonably available data, so that policy makers can benchmark the performance of their railways, evaluate the impact of past changes in railway structure, ownership or regulation and assess the likely outcome of future initiatives. The challenge is inherent in the phrases "proper level of detail" and "reasonably available data".

Efficiency entails maximising the outputs from a set of inputs (technical efficiency) or creating an optimal mix of inputs to maximise output (allocative efficiency). When considering efficiency, one is inclined to think in terms of a single dimension, a single number or a percentage. The railway business is not that simple. Railways come in all shapes and sizes: vertically integrated, vertically separated, public and private, passenger- or freight-dominated or mixed, supported by subsidies or fully self-reliant. The provision of railway services is multidimensional. In economic terms the railway company is a multi-product firm. It is a very capital-intensive business, economies of scale and density can be relevant and some natural monopoly characteristics are present. In most contexts and on most continents, a competitive railway market is not a straightforward concept.

This complexity makes it difficult to produce a description of efficiency that is equally relevant from different viewpoints or to all stakeholders. The answers to questions on railway efficiency will depend on who is asking. Primarily, apart from the owners of rail companies, the questions may come from three main stakeholders:

- the government
- the users of the network (in a vertically separated railway) or the users of railway services
- the economic regulator, if there is one.

In most countries, governments pay large subsidies for railway infrastructure and passenger transport. In these cases, the focus of the government will be on asking whether those subsidies are spent efficiently or how, through higher efficiency, they could be reduced.

Train operators will be interested in efficiency in terms of availability and access costs of railway infrastructure, while the users of railway services will place their stress on punctuality/reliability or speed of transport.

The regulator will pursue both technical and allocative efficiency. This will require different information to examine each aspect. Its focus will include rate setting, user charge price caps, safety and performance in terms of operating and financial indicators.

Against this background, this chapter explores how railway efficiency can be conceptualised and measured at different levels of inquiry and depth, developing the work begun in the paper by Beck, Bente and Schilling (2013).

Is there a simple approach to assessing railway efficiency?

A basic but balanced scorecard

The simplest approach would be to derive key performance indicators (KPIs) from published data. Thompson and Bente (2014) provide an example of what sources and types of publicly available data exist (supplemented by data they have collected themselves). Their sample includes some railways in the European Union, plus the railways of Switzerland, Norway, the People’s Republic of China, the United States, Canada, Japan and Indian Railways.

They propose an approach that can be used to produce some information on railway efficiency in a limited timeframe with limited data. The indicators proposed refer to basic indices of size and scale, and from these parameters basic ratios of efficiency and productivity can be developed (e.g. traffic density, wagon/coach productivity, etc.). Adding a few more data points, one might create a basic but balanced scorecard of railway efficiency that would consist of six types of indicators (Bente and Thompson, 2014):

- system scope
- asset utilisation
- human resource utilisation
- operational performance
- financial performance
- customer-centric service quality.

An example of more detailed KPIs that could be included in each of these fields is presented in Table 1.1.

Table 1.1. A balanced score card for railway efficiency

System scope	Asset utilisation
Passenger service scope Fleet Transport units (pass-km) Train-kilometres Staff Freight service scope Fleet Transport units (tonne-km) Train-kilometres Staff Infrastructure scope Lines Track Stations	Infrastructure assets Train-km/line-km per year Train-km/track-km per year Transport units/line-km per year Transport units/track-km per year Passenger fleet Transport units/unit of fleet per year Kilometres in service/unit of fleet per year Freight fleet Transport units/unit of fleet per year Kilometres in service/unit of fleet per year
Human resources	**Operational performance**
Infrastructure, number of staff in: Operations/traffic management Asset maintenance Network development Total cost of labour by division Passenger service, number of staff in Sales and marketing Operations Asset maintenance Total cost of labour by division Freight service, number of staff Sales and marketing Operations Asset maintenance Total cost of labour by division	Unit cost, infrastructure Asset maintenance (per line/track-km per year) Operational (per line/track-km per year) Unit cost, train operations Passenger service (per train-km) Freight service (per train-km)
Financial performance	**Customer-centric indicators**
Revenue (core, ancillary) Cost (core, ancillary) Asset values (book value, MEV, shadow price) Infrastructure Passenger service Freight service Subsidy (OPEX, CAPEX) (NEW) Investment/capital employed (Re-) Investment/capital employed Indebtedness/EBITDA-ratio Cash-flow from financing activity (depreciation – CAPEX + subsidies-net borrowing)	Modal competitiveness Relative speed between modes Relative performance between modes Relative cost/price between modes Modal split (the points above) subdivided by Freight into business lines (combined/block/…; container/bulk/…) Passenger into: Between agglomerations Cross-country HSR

Source: Bente and Thompson (2014).

Both cross-sectional (comparing systems) and time series (change over time) indices will be required to monitor performance. Time-series analysis makes it possible to compare the performance of a railway system compared to previous years but no matter how well the railway may appear to be performing against itself, it may still be relatively inefficient when compared to other railway companies. Using cross-section (with time-series) one could try to assess whether some railway companies consistently come out on top of the distribution in terms of efficiency over a number of these fields and over time. Both types of data have to be treated with caution. Time series indicators suffer from the risk that the categorisation of inputs or outputs changes from one year to the next, and they can be heavily influenced by major organisational or economic changes, for instance since 2008. Outsourcing services, for example, can have a very large impact on indicators of the efficiency of using human resources. Cross-sectional data similarly risk comparing systems where outputs or inputs have been delineated differently. The limits are addressed more thoroughly in the next section. It is clear that some subjective judgements in the creation and use of these KPIs will have to be made and that an integral part of using such an approach is significant input from railway experts in interpreting the results. A key weakness of the use of KPIs is that different measures will give different results (for example cost per train-km and cost per track-km) and it is not clear which measure should be used.

The outcomes of such an exercise would be subject to multiple caveats, examined in the next section, and would give an observer a first indication of the efficiency of a railway system without explaining why observed efficiency differences arise, a point addressed later in the book.

Caveats to the simple approach to railway efficiency assessment

The simplest benchmarking approach is to compare a railway to its own past performance. Even in this case, however, all things may not be equal. Past data on financial performance may need to be adjusted as a result of organisational changes in the company, changes in accounting standards or policy, inadequate application of accounting standards[1] or external policy decisions,[2] where the State is the owner. There may also be times during which railway investment or maintenance is inadequate, thus storing up problems for the future.

Cross-sectional benchmarking is equally challenging and requires two preparatory processes. The data used from different systems must be standardised and normalised. Standardisation means making sure that the activities or materials compared are alike. Normalisation requires taking account of differences in economies of scale and density. In railways, company size or scale of activity has a substantial impact on the perceived efficiency (most notably asset utilisation).

A rich data set is required to enable standardisation for cross-sectional analysis. Comparison is increasingly compromised by data availability as a result of organisational changes, changes in ownership and integration of railways into larger logistics chains. The UIC Lasting Infrastructure Costs Benchmarking initiative[3] is an excellent example of how to undertake cross-sectional analysis and illustrates how many different factors need to be taken into account before the cost of maintenance and renewals can be examined on comparable grounds. Reported costs across different infrastructure managers have been harmonised under this initiative to account for the complexity of the network, for example in terms of the number of switches per track-km.

Another challenge is the use of demand to supply ratios to compare the output of railways (passengers carried) with inputs (e.g. train-kilometres). In principle in a fully competitive market there should be convergence in these ratios among railways but in practice the demand or output of railway services is dependent on a number of exogenous factors and public policies. Having low traffic levels does not necessarily imply that train operations are inefficient, and vice versa.

For example:

- Heavily subsidised passenger traffic provided in a thin market under public service obligations might yield low passenger numbers per train-kilometre, even though the railway is managed highly efficiently, simply because the market is so small.
- A financially self-sustained, profitable freight railway business relying on high volume, regular freight shipments and under no competitive pressures can still be managed below best-practice efficiency standards.

Bonnafous and Crozet (2014) illustrate how demand/supply ratios can be misinterpreted and how the use of a limited number of indicators can provide a misleading picture without thorough knowledge of the root causes of efficiency. The French rail system, when compared to its peers, seems to be fairly successful in passenger transport. In fact, it ranks first in Europe with 406 million train-kilometres and an average of 227 passengers per train. Other national incumbents like DB in Germany or SBB in Switzerland lie far behind, with 100 and 130 passengers per train, respectively. But when one probes more deeply, it is revealed that this performance is the result of structural differences – in France two-thirds of passenger traffic is carried by the TGV. The high-speed trains have a higher capacity, higher occupancy (due to use of yield management in setting fares) and cover long distances. The illustration suggests how basic structural differences, which are ultimately the result of geography and public (transport) policy decisions, can determine the outcomes of simple efficiency comparisons.

The observed efficiency of a railway system through demand/supply ratios is influenced by factors exogenous to the system (topography, historic evolution, etc.), government policy and endogenous factors, which are dependent on the efforts of management and policy makers. Without adjustment for exogenous factors, KPIs such as “cost per transport unit” may be useless.

Finally, a problem that requires special attention is data availability. Research efforts, especially in the EU, have been hampered by the lack of good quality data. As Thompson and Bente (2014) note, most railways do not see the need for detailed information for internal management purposes or do not think it is in their interest to release such information to permit public comparisons to be made. Given that most railways in the European Union receive substantial financial support from government sources, it is more than questionable to what extent such a practice is acceptable, although it is a well-documented phenomenon in the broader context of state-owned companies, particularly where strong unions have developed (e.g. Salinger, 1984; Rose, 1987; Hendricks, 1977; Savedoff and Spiller, 1999). These authors point to concealing data as a strategy to protect the company’s cash flow. Better information on efficiency might lead to the shedding of excess workforce or the substitution of labour with capital or other changes, which the unions would perceive as a threat to their bargaining power.

The US example illustrates that information can be systematically collected and publicly reported, including from fully private businesses.[4] Moreover, a lot of the collected information is publicly available, while a small part of commercially sensitive information is reserved for regulatory purposes only.

Given the caveats discussed above, a general recommendation in developing “high-level” aggregate analysis, especially when time and resources are limited, is to build on simple indicators, preferably those that the railway organisation already routinely collects. These may simply be unit costs, so long as they are not dependent on external factors[5] and are controllable by management. This should reduce issues with data availability and the interpretation of data.[6] Even in this case, it should be recognised that exogenous factors and the level of demand[7] will influence the outcomes of any comparison, especially the cross-section type. The example in Box 1.1 tries to follow this approach, as much of the information mentioned is in many cases already publicly available. Developing indicators that require large amounts of data that are not readily available can undermine transparency and may be counterproductive for monitoring performance over time, for instance by making it difficult to update those indicators.

The importance of the narrative

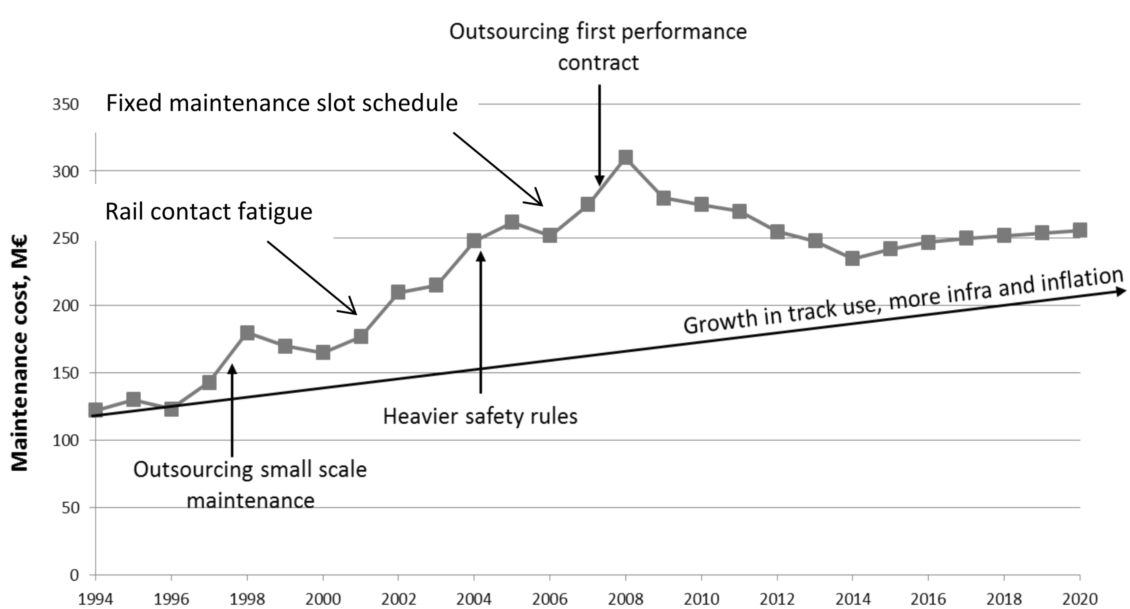
This section looks more closely at the evolution of railway systems in two countries, the Netherlands and Great Britain, in order to illustrate the importance of the context in which a railway operates when assessing the railway's efficiency. In particular, structural reforms and changes in rail policy have affected the railways over recent decades and these changes need to be accounted for.

The evolution of infrastructure costs in the Netherlands

The transformation of the railway sector in the Netherlands started in the 1990s. Full vertical separation occurred in 1995 and by 1998 all network maintenance was outsourced. In 2005, infrastructure maintenance, capacity management and traffic control activities merged to form ProRail BV (Public Limited Liability Company), which became the infrastructure manager in a clear, vertically separated framework.

At first sight, from Figure 1.1, it would appear that vertical separation led to a decrease in the efficiency of the Dutch railway system. Maintenance costs soared over the period 1996-98, and the overall cost of running trains in the country steadily increased from the time of the separation in 1993 (Swier, 2014). However, the main reasons behind the surge in costs are not directly linked to technical inefficiency and outsourcing; changing circumstances including a rapid increase in rail contact fatigue, stricter safety rules, a shift towards night work schedules and an increase in track utilisation are all factors that explain much of the cost increase.

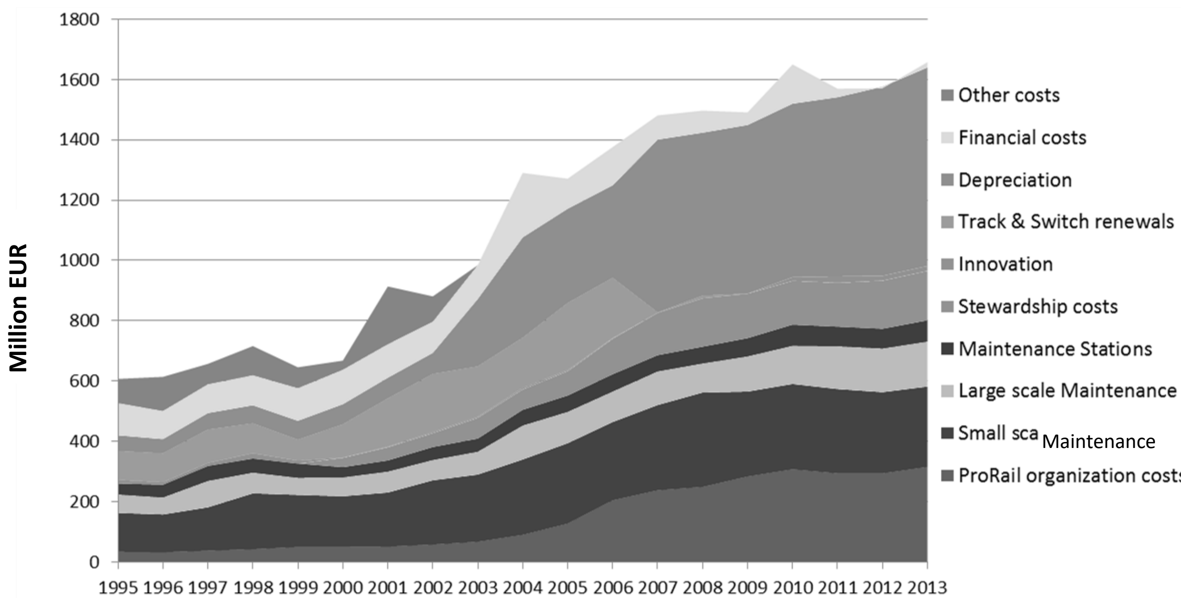
Figure 1.1. Evolution of maintenance costs of the Dutch railway network



Source: adapted from Swier (2012).

In the first ten years after outsourcing, ProRail had input contracts for maintenance. Even though failure rates became lower than before outsourcing, costs did not go down. The performance/price ratio really started to improve after the introduction of powerful performance contracts precisely defining the expected outputs without explicitly prescribing the technical methods of achieving these outputs.[8]

Figure 1.2. Evolution of cost items in infrastructure spending in the Netherlands



Source: Swier (2014).

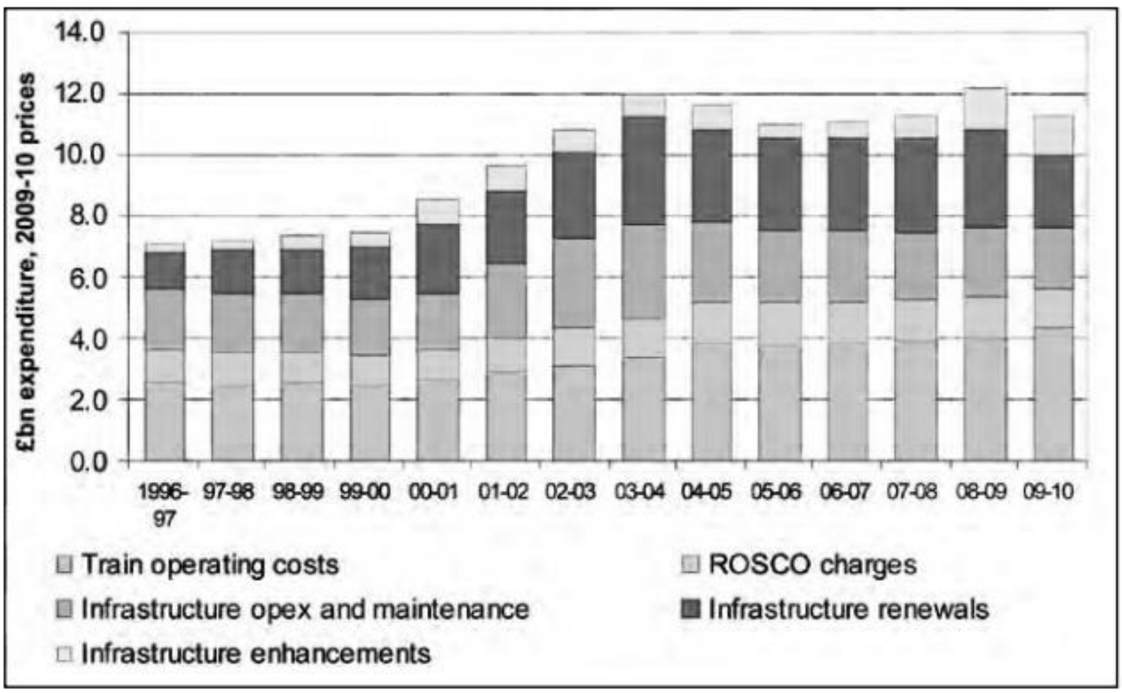
Separation was accompanied by the establishment of more transparent financial reporting rules, with assets depreciated according to replacement value rather than historical cost accounting value, and the inclusion of traffic control and capacity management in the ProRail balance sheet. Arguably, there is a noticeable increase in stewardship costs (such as new monitoring requirements, accounting rules, different charging schedules, etc.) which is partly attributable to separation; however these costs remain small compared to the increase in asset depreciation costs (see Figure 1.2).

When ProRail is compared to infrastructure managers in other countries, a mixed picture emerges. In terms of quality, ProRail fares significantly better than other European railway infrastructure managers, with less rail breaks and track or signal failures, but their maintenance unit costs are higher than the European average (Hansen, Wiggenraad and Wolff, 2013), stressing the need for quality-adjusted metrics.

The cost of the railway system in Great Britain

The British railway system underwent structural changes, including full vertical separation, around the same time as the Netherlands. The Railways Act of 1993 established the privatised framework for British railways, breaking up the historical BR into more than 100 separate companies, the relationships between which were to be set in contracts or through regulatory mechanisms. Infrastructure was taken over by Railtrack, a newly established public sector company whose shares were subsequently sold to the private sector, and train operations were divided among 25 geographical franchises. Maintenance and renewal were subcontracted by Railtrack to several private engineering companies formed by privatising the relevant parts of British Rail. Railtrack went into administration as a result of the derailment of a train near Hatfield in 2001. The accident was caused by a faulty rail. Even though casualties were limited (four deaths), the derailment had major repercussions, as it laid bare the company's ignorance of the condition of its assets. In response, Railtrack imposed speed restrictions over large sections of the network. This resulted in the government compensating the train operating concessions, providing grants for track renewals and allowing the infrastructure company to raise additional debt. Railtrack was replaced and their activities taken over by Network Rail, a not-for-profit company eventually defined as State-owned for national accounting purposes.

Figure 1.3. Expenditure of the British railway system by cost item between 1996 and 2010



Notes: Train operating costs exclude access charges apart from traction electricity. ROSCO – Rolling Stock Leasing Company.

Source: Network Rail regulatory accounts and other sources.

The dynamics of infrastructure spending in Great Britain can be divided into three periods. After privatisation and before the Hatfield incident, maintenance costs went down and total expenditure was stable. This was not only the result of efficiency gains but to a large extent due to less maintenance being carried out by subcontractors, who worked on fixed-cost contracts. Moreover, even if investment rose during this period, experts agree that it was inadequate considering the increase in passenger demand (Nash, 2002). This eventually led to a spiralling of costs after 2001, when Network Rail started making up for the inadequate levels of maintenance and investment under Railtrack and adapted to tougher safety requirements.[9] Substantial inefficiency crept into Network Rail's cost base as the regulatory mechanism was temporarily suspended (see Office of the Rail Regulator, 2003). Since 2004-05, Network Rail, under regulatory pressure, has improved efficiency substantially. Unit costs are still higher than 1996-97 levels and international comparison suggests that costs are still about 30% higher than what could be expected of them (McNulty, 2011). Two main reasons are given in the McNulty report. The first one concerns a lack of outsourcing, Network Rail having taken over all private contractors in 2003, both for safety reasons and to provide better coordination and economies of scale, or at least according to the company. The second reason is the misalignment of incentives as a result of vertical separation. The huge increase in indebtedness to support investment in the years 2001-04 also contributed to sustained higher costs up to 2011, given the cost of financing.

The overall picture for train operating companies (TOCs) is similar. Immediately after privatisation, costs went down as the result of TOC's making low bids to win franchises; franchising was in this regard a success, with passenger numbers increasing and government subsidies decreasing significantly. From 2001 on, TOC costs increased sharply, with 35% unit cost growth from 2000 to 2006 (Smith and Wheat, 2012). This was the result of several factors, including fuel prices, emphasis by franchises on quality (cleanliness, information, etc.) and an above-inflation increase in staff costs. Interestingly, despite this increase, train-operating costs in Great Britain are comparable and even slightly lower than in other European countries (Civity, 2012). Once again, this figure needs to be interpreted looking at the railway context. For instance, the incumbent Dutch operator also has among the lowest unit costs but with much higher traffic density (passenger-kilometre per track-kilometre), thus enabling large economies of density.

Two main conclusions can be drawn from these two case studies. First, unit costs need to be interpreted cautiously. In the case of infrastructure maintenance, unit costs are as much a reflection of the network complexity, purpose and usage as of the efficiency of its maintenance manager. An in-depth knowledge of the "engineering narrative" is required to carry out international comparisons. The same applies to TOCs and overall industry costs, where costs per passenger-kilometre are likely to be more favourable on systems with high track usage rates.

Second, when looking at the evolution of costs for a single country, the broader railway context needs to guide interpretation. For instance, even though the evolution of infrastructure costs is similar between ProRail and Network Rail, the underlying mechanisms are very different. The role of outsourcing has worked in opposite directions in the two countries. In the Dutch case, outsourcing proved beneficial to efficiency after a running-in period of ten years or so, while in the United Kingdom it provided short-term benefits in terms of cost savings, but ended up being very costly due to the accumulated maintenance and investment bill. The difference lies in the way contracting is managed. When applying econometric methods, these elements need to be carefully taken into account.[10] Moreover, not only the costs but also the quality of the railway system needs to be investigated: differences in performance (capacity, functionality, reliability, etc.) often explain cost differences, and if delaying maintenance can result in savings in the short run, it is often not economically justified in the long run.

Taking account of multiple railway efficiency dimensions

If the context plays such a big role in determining efficiency measures as well as their interpretation, to the extent illustrated in the previous section, then a simple approach to railway efficiency will not yield a very accurate image. One could try to expand the set of the observed KPIs. However given the large number of dimensions which affect railway efficiency, a very large dataset would be needed subject to the limitations in data collection highlighted earlier. In addition, the issue of which KPI should receive greater weight is not trivial, and establishing a hierarchy of efficiency measures is challenging.

There are two main approaches to addressing such complexity, as outlined by Smith and Nash (2014): econometric techniques relying on statistical approaches and Data Envelopment Analysis (DEA) based on linear programming. The main advantages of the DEA method over econometric approaches (in terms of handling multiple inputs and outputs and not requiring the specification of a particular functional form) have diminished over time as econometric approaches have evolved. A key advantage of DEA is the possibility to carry out some analysis even when a large dataset of control factors is not available. However the major weaknesses of DEA lie in its inability to take account of random noise, which may lead to inefficiency being overstated, and the lack of statistical tests to provide an objective justification for the exclusion/inclusion of key variables. Econometric analysis is therefore to be preferred when large datasets are available.

Econometric techniques for efficiency measurement rely on three approaches:

- cost functions
- production functions
- distance functions.

The cost function approach assumes cost minimisation in the production process and relates cost to the level of outputs and to input prices. It can deal with multiple outputs, as well as incorporate the treatment of economies of scale and density. It also allows for cost changes over time, for instance resulting from technological progress. It is the only one of the three approaches that accounts for both technical and allocative efficiency. Railway efficiency measurement most commonly relies on cost functions. The relative cost efficiency of transport operators is also the key focus of policy makers and regulators, hence also their reliance on this approach. Another reason for preferring the cost function approach is that data on costs is more reliable.[11] Even though some of the caveats evoked for the simple scorecard approach to railway efficiency remain, one key advantage of the econometric method with costs is that it produces a single efficiency indicator, controlling all the factors that can be modelled in the regression (such as cost changes over time, or some of the differences between countries).

The cost function approach can be extended to allow the relative efficiency of companies to vary through time and allows an estimation of this variation. The extensions are termed SFA (Stochastic[12] Frontier Analysis). As the name suggests, the method is used to construct an efficiency frontier and to estimate the distance of individual observations (railway companies in our case) from the frontier (graphically similar to Data Envelopment Analysis). The approach can be and is used with panel data (cross-section and time-series data).

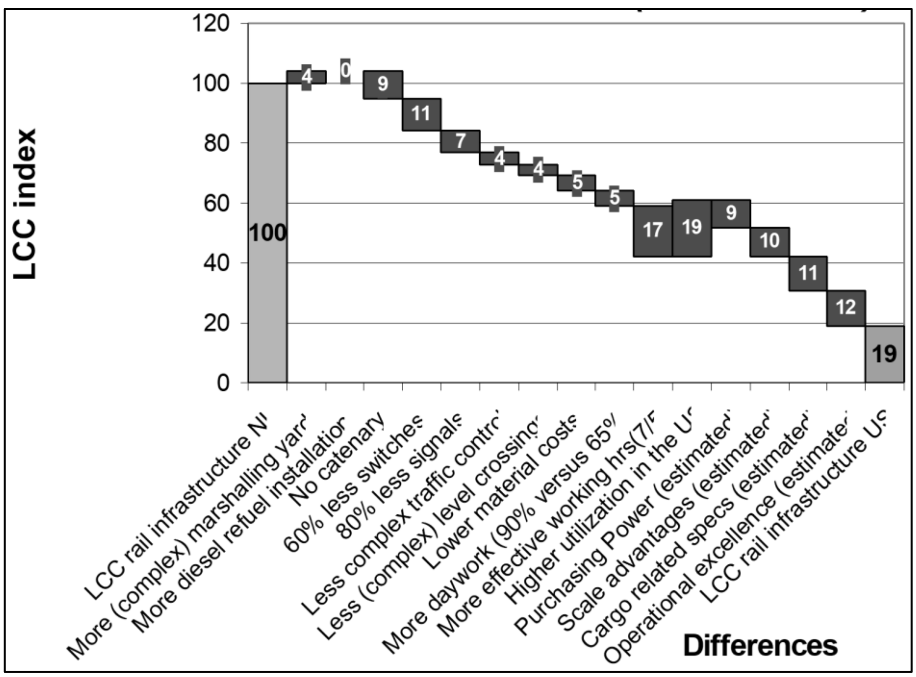
SFA seeks to go beyond the cost function approach by recognising that firms' costs will deviate from the frontier due to random noise (e.g. random events such as bad weather) as well as inefficiency. SFA thus provides a set of assumptions that decompose the residual in the model into two components ("true inefficiency" and "other sources of error"), and therefore obtain a better measure of inefficiency, which disentangles other confounding sources of error.

Econometric approaches do require the choice of an appropriate functional form, but the commonly used Translog function is very flexible and Box-Cox transformations allow the data to dictate the functional form. The choice of distribution for the inefficiency term in stochastic frontier analysis is arbitrary. In the case of SFA, there is a risk that unobserved heterogeneity will be captured as inefficiency. More recent literature cited in and including Smith and Nash (2014), have proposed a number of useful methods to address this issue when panel data is available. In practice, cost functions and increasingly SFA are being used by regulators. Regulators usually apply a number of different methods and approaches to derive an average indicator of efficiency across the methods in order to account for the inherent uncertainty in the data and the modelling process.

Econometric models require a lot of data. Panel data is particularly useful in this regard for separating unobserved heterogeneity from inefficiency. In addition to panel data, regional data within countries is useful to examine within system performance, providing better like-for-like comparisons across countries, improving capturing scale and density effects, and increasing sample sizes.

The econometric modelling approach produces a top-down view of efficiency that would benefit greatly from a bottom-up engineering narrative to provide insight into what determines performance. For instance, in its last review of pricing, the Office of Rail Regulation (ORR) in the United Kingdom commissioned a number of engineering studies to help understand differences in indicators of efficiency between Britain and other countries.

Figure 1.4. Life-cycle cost comparison between the Netherlands and a US railway company



Source: Swier (2014).

In an international comparison exercise with a US railway company, Jan Swier (2014) shows an example of the importance of such an engineering analysis. He found that unit rail infrastructure costs (measured on a life-cycle basis) were as much as five times higher in the Netherlands. This is where another aspect of the narrative comes in: what is the purpose and level of use of the tracks? A precise statistical analysis of these questions for the US railway company and ProRail allowed Swier to establish the cascade diagram in Figure 1.4. Usage and complexity explain 60% of the cost difference. The biggest cost elements in the Netherlands are the large number of switches and signals, as well as the extension of electrified tracks. In contrast, the US company benefits from having dedicated freight traffic and high traffic density in tonne-kilometres with fewer trains.

The policy maker and exogenous efficiency determinants

Exogenous determinants of costs can, as argued in a previous section, be a far greater cause of differences in performance than railway company management. Of the three main stakeholders mentioned in the introduction, the policy maker has the greatest power in determining the exogenous circumstances. The policy maker may not be able to change the topography or the density of settlement of a country but is able to define national transport policy and can choose the structure of the railway company, its ownership and the form of economic regulation. Although it may be debated whether the structure, the ownership and the regulation of the railway company are exogenous factors, this paper considers them as such, as they cannot be decided by the management of the railway company.

The private railways of the United States, Mexico and Canada are vertically integrated companies, competing with other private companies across large areas of land and large markets. These railways are considered to be performing efficiently, but their exogenous (and historical) circumstances are different to other countries, those of Europe for example, where state-owned railway companies still carry most of the traffic.

In the European Union, the dominant mode of private participation, where it has developed, is through exclusive concessions for passenger transport (with competition in the market). Open access freight and more recently passenger train operations (competition in the market / on the track) have gradually expanded since the mid-1990s. The effects of competition on efficiency are not obvious. The EU15 railways do not show a particularly positive picture in terms of traffic growth or modal share. As Thompson and Bente (2014) note, it is possible that the restructuring reforms in the European Union have not been implemented to a sufficient extent to have a significant impact. It is also possible to argue that the outcomes would have been worse without the reforms.

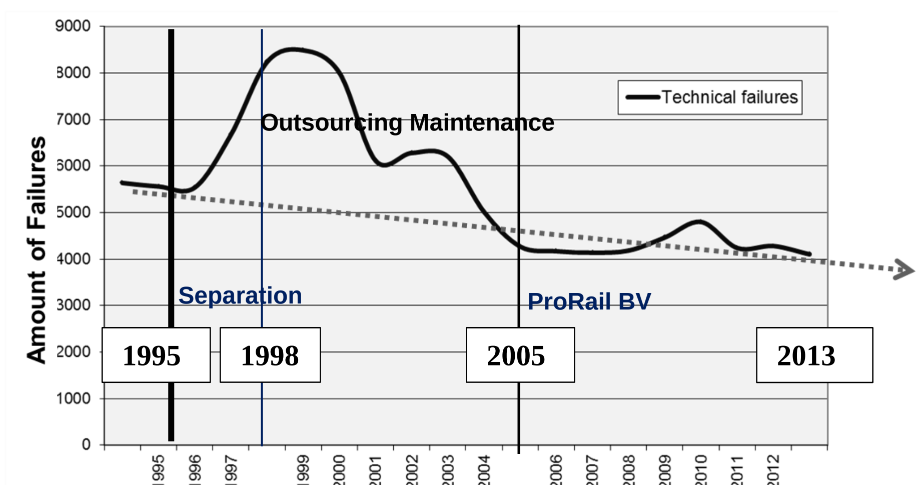
The organisational structure in the case of most railways in the European Union has not substantially changed. In some cases, a restructuring was made from a single company to a holding structure. There are now 14 cases of full vertical and horizontal separation in Europe. Recently, France reintegrated the infrastructure manager, Réseau Ferre de France (RFF), with the national train operator, SNCF, recreating a fully vertically integrated company. Bonnafous and Crozet (2014) note this will lead to further growth of unit costs due to the balance of power being shifted in favour of the company and the unions rather than the public regulatory authority. It will also likely undo any advances in infrastructure management efficiency achieved through devolving the infrastructure management role to RFF.

The United Kingdom is the most analysed case of railway privatisation and vertical separation in the EU. The process of the privatisation of the original British Rail was marked by a steep learning curve on the part of the infrastructure manager and the regulator. Smith and Nash (2014), in their literature review, show that not everything in the United Kingdom went “according to plan”. The events that led to the bankruptcy of the infrastructure manager and its administration resulted in a major loss of efficiency, from which they have not yet recovered. In freight transport, privatisation effects were overridden by exogenous developments in the economy and especially the structure and geography/distance of coal transport.[13] In passenger transport, the growth of traffic can be attributed to exogenous developments in the economy for the most part. The cost of operations in passenger franchising increased, partly due to inadequate franchise size and overlap. These developments contrast with other countries like Germany and Sweden, where savings of 10% to 30% are reported as a result of the introduction of competitive tendering for exclusive concessions for passenger services.

Vertical separation adds transaction costs for coordination and internal accounting and negotiation, although the exact magnitude of these costs is debated. The McNulty study (2011) noted that the major issue of vertical separation in the United Kingdom was not the transaction costs but rather a misalignment of incentives between the operators and infrastructure manager, which increased the cost of the latter from 2% to 20%. The most comprehensive study to date, EVES-Rail (van de Velde, 2012), concluded that the vertically separated model works less well on intensely used networks and provides the perhaps counter-intuitive result that vertical separation reduces costs on less intensely used networks. Likewise, Mizutani and Uranishi (2013) find that while horizontal separation unequivocally reduces costs, vertical integration only reduces costs for densely trafficked railways; the explanation is that transaction costs caused by vertical separation will be much greater in densely trafficked networks than in less densely trafficked ones.

But the study also provides no evidence that the introduction of competition had any effect on cost. The analysis is subject to data issues and did not take account of some factors that may be important (e.g. differences in declared and effective economic regulation). Finally, the EVES study gathers data from a large sample of Asian and European railways so its results only reflect average behaviour. It is not able to explain some of the finer changes that have been observed, for instance in the Netherlands, where vertical separation first introduced a disturbance in the system with a worsening of performance before a net improvement became evident (Figure 1.5).

Figure 1.5. Example of technical failure performance of ProRail before and after vertical separation



Source: Swier (2014).

Given this discussion, a further element that could be added to exogenous performance drivers might be cultural differences between countries. This leads to further pertinent questions. To what extent do the changes in organisation and ownership drive the outcomes and to what extent are there deeper root causes that influence the results – is there a confounding problem? If this is the case, what can really be said about railway efficiency, structure and ownership of railways in the European Union or elsewhere?

Clearly, such questions do not imply that no progress has been made in our understanding of the problem, but a lack of good quality data is a major obstacle to informing policy.

Conclusion

Railway efficiency is a challenging concept due to the complexity of the production process in the railway business.

A basic view of railway efficiency can be formed with a small set of cross-section and time series data producing a limited set of KPIs. Railways generally produce this data as needed for internal management, but it is not publicly available in every jurisdiction. A basic responsibility of government is to require companies to report key data, with collection and publication co-ordinated either by companies and their associations or by government. Railway experts will inevitably be required for interpretation of the results, but large deviations from efficient operation should be evident. For some of the key management and policy purposes the set of basic indicators identified in Box 1.1 will be sufficient.

For monitoring efficient use of public subsidies and regulating monopolistic infrastructure managers and exclusive train operating concessions, more sophisticated econometric techniques will need to be employed. These have much greater data requirements but are essential to developing meaningful benchmarking outputs.

With both basic indicators and econometric analysis, a narrative of exogenous and endogenous drivers of railway performance will need to be developed in order to contribute to a fuller understanding of differences. The narrative includes the key functions of the railway network (whether it carries mixed traffic or is dominated by one traffic type), the topographical characteristics of the country, historical policy decisions and other elements outside of the scope of influence of the company's management. Interpretation of any kind of efficiency analysis results without taking account of the narrative will lead to misinformed decisions.

Along with econometric analysis, bottom-up engineering analysis can be employed to develop the narrative in sufficient detail to shape the parameters used in the econometric functions modelled. Bottom-up analysis can also shed light on whether the parameter estimates in a model make sense. When benchmarking the performance of several countries, the use of KPI requires detailed harmonisation of data, as exemplified by the UIC study. There is a link between this harmonisation process and statistical methods: both are trying to take account of factors before reaching an efficiency judgement. Further, econometric approaches could even inform the harmonisation process as it informs on the factors that need to be controlled for.

As the brief review of the current state of the art in railway efficiency assessment revealed, both the simple and econometric approaches are data intensive and suffer from problems with data availability and quality. While there are positive exceptions in data collection and availability, inadequate data explains why questions with regard to railway efficiency often remain very much open. The problem is not that it is unclear what data should be collected. In the United States, both accounting regulations for private companies and data reporting requirements imposed by the regulator, the Surface Transportation Board, make most of the data required for construction of a "balanced scorecard" publicly available. US and Canadian data reporting requirements provide a model for the data needed for regulation of vertically integrated freight-dominated railways elsewhere.

In Europe, good quality studies have been undertaken, in terms of data quality and common terms of reference, in a number of EU research projects on railway infrastructure expenditure (e.g. the RailCalc and GRACE projects). However, data is not collected routinely or, when it is, it is only made public after it is has been processed to mask the identity of individual railways, as the UIC is constrained to do by its member companies. Such practice is at odds with the substantial share of public money involved in the operating of national railways.

Much work by regulators and supranational organisations will be required to ensure collection of consistent data across countries. European data collection and dissemination could be greatly improved if a regulatory body, such as the European Railway Agency, were mandated to specify data to be reported by every railway, requiring annual production and publication. A small number of national regulators already do this and the annual network statements of some railways provide a wealth of information. The European Commission is also currently improving the Rail Market Monitoring Report, which it produces biannually for all Member States. When maintenance and construction is outsourced, the necessary information is available in the contracts and invoices. While respecting subsidiarity and confidentiality, the specification of a common set of information to be produced for all the railways would be extremely useful for comparing performance.

Finally, most studies of railway efficiency are focused on technical cost efficiency. Performance on costs reflects the inside view, but what is ultimately important is service to the customer. More effort needs to be invested in providing data and KPIs on the service quality related to how users choose between transport modes, thus linking output measures with input measures more directly.

Notes

1 Nash and Smith (2014) cite examples where no depreciation or interest is entered into the accounts for assets that have been purchased with grants.

2 E.g. prior to privatisation, the state might decide to treat railway infrastructure as a strategic asset and remove it from the balance sheets of the railway infrastructure manager. This would, at least in part, change its borrowing capacity against its assets and influence all future business activity.

3 Information on the initiative is available here: http://www.uic.org/com/uic-e-news/367/article/15-year-report-on-infrastructure?page=thickbox_enews.

4 The railway companies face charges in case of reporting inaccurate data. The incentive for accurate reporting is enforced through the fact that such data are often used in court proceedings with shippers or the regulator and are subject to intense scrutiny.

5 For example, if the infrastructure manager is state owned and subsidised, it is the decision of the state how much money it wants to make available for maintenance or renewals so these costs are outside of the direct control of the infrastructure manager.

6 However, care should be taken when comparing different railway companies or countries because unit costs depend on economy of scale and density, which need to be controlled for.

7 Whether demand for rail services should be treated as wholly exogenous is a complex question. On the one hand, derived demand from economic activity can be treated exogenously and rail systems with similar levels of demand can be more appropriately compared. On the other hand, demand growth can be an internalised management objective for railway companies, as exemplified by net cost contracts in a franchising system.

8 One of the biggest challenges when writing these performance contracts, especially those related to daily maintenance, is to set out outputs that guarantee track quality in the long-term and prevent sub-contractors from opportunistically reducing costs by only carrying out short-term maintenance.

9 The strengthening of safety requirements resulted from the public outrage over the Hatfield incident. However, it is now argued (Evans, 2007) that safety statistics had not deteriorated. The very high level of maintenance required after the incident rather stemmed from the fact that Railtrack did not know the state of their network and could thus not direct maintenance to the portions of the network that required it most.

10 As noted by Nash and Smith (2014), vertical separation or outsourcing "is not a dummy variable in the regression" i.e. a variable, which can take the value one or zero (e.g. there is or is not vertical separation).

11 Getting comparable data may be difficult, for instance for financial costs, but at least cost data does not suffer from the problem of outsourcing.

12 "Stochastic" refers to something than can be estimated statistically but cannot be precisely predicted.

13 With the closing of the coal mines in the UK, coal power plants had to shift to imported coal. That meant that more than half of the increase in tonne-kilometres in rail freight could be explained by the increased length of coal hauls from the ports to the coal power plants.

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Chapter 2. What is rail efficiency and how can it be changed?

Defining efficiency in a general sense

In the abstract, what we mean by "efficiency" or productivity (we will use these terms essentially interchangeably) is maximising the outputs from a set of inputs or maximising the ratio of inputs/outputs. Efficiency is not a stand-alone concept, however; efficiency is always dependent on a comparative context. We need to know how a given performance compares with others.

Defining and measuring efficiency or productivity in the railway context is a complex problem because:

- Size and scale matter. Large railways and highly dense railways have a potential advantage in efficiency because some parts of railway operations are subject to returns to scale, at least over the range below the very largest systems.
- The mix of services matters. Most measures of productivity appear to show that passenger service is less "productive" than freight. That is, a passenger-km tends to require more resources to produce than a tonne-km: after all, many countries operate 10 000 tonnes (or greater) unit freight trains while passenger trains carrying more than 1 000 passengers are rare (see Mumbai commuter trains, however). Moreover, freight is generally considered to be "commercial" and market-driven, and managers have an opportunity to set reasonably clear management objectives. Passenger services are typically justified by social as well as financial performance, leading to political involvement and mixed, even contradictory management objectives.

Evaluating railway efficiency therefore requires a number of different types of indices relating to scale, asset productivity (including labour), financial indices (revenue-cost) and economic measures that include social costs and social benefits. No single index can ever be dispositive. Instead, we will need to look at a collection of indices to see which railways tend to fall at the bottom of the pack and which tend to rise to the top.

The complexity of measures makes it important to have two types of indices: cross-section (comparing railway systems at a single point in time) and time series (change over time). There can well be reasons for a lower ranking on various cross-sectional indices, especially when some railways are forced by the government to provide large quantities of politically driven regional or commuter services (whether or not compensated by public service obligation payments), or where regulation suppresses tariffs and harms financial performance. Even where a plausible case can be made for lower comparative performance, however, adverse changes over time are harder to explain.

Indicators available from published data

Indicators of efficiency or productivity can be developed at many different levels. The objective of this chapter is to identify indicators that can be developed from publicly available data[1]. We recognise that some measures would require much more detailed information, such as a comparison of the costs of DB versus Network Rail in maintaining a kilometre of electrified line with comparable traffic levels. Unfortunately, information at these detailed levels is either not collected or not reported publicly.[2] Annex 2.A2 contains a detailed discussion of the sources of data used in this paper. The dataset developed covers the period 1970 to 2011 (in some cases later) for time series purposes and furnishes a complete cross-sectional set for 2011. The data set includes all EU railways (separated between the EU15 and EU10) along with Switzerland and Norway. In addition, for comparison we include China, the United States (Class I freight railways and Amtrak), Canada (freight railways and VIA), Japan and, in some cases, Indian Railways (IR).

The basic indices of size and scale are as follows (see Table 2.A1.1 for a key to the countries, railways and groupings employed in this analysis and Table 2.A1.2 for summary data):

- Passenger data: passengers carried,[3] passenger-kms, gross tonne-kms for passenger trains, passenger train-kms, coaches, DMUs, and EMUs
- Freight data: tonnes carried, tonne-kms moved, gross tonne-kms of freight moved, freight train-kms and freight wagons[4]
- Common or joint assets: locomotives, labour, kilometres of line
- Financial and economic performance: total operating cost; total operating revenue, passenger revenue, freight revenue.

Ratios of efficiency and productivity developed from the measures above:

- Average trip length for passengers (passenger-kms/passengers) and average length of haul for freight (tonne-kms/tonnes). Table 2.A1.3.
- Passenger share of Traffic Units (TU): passenger-kms/(passenger-kms + tonne-kms). Table 2.A1.4.
- Passenger share of gross tonne-kms: passenger GT-km/(passenger GT-kms + freight GT-kms). Table 2.A1.4.
- Passenger share of train-kms: passenger train-kms/(passenger train-kms + freight train-kms). Table 2.A1.4.
- Traffic density: TU/line kms, gross tonne-kms/line kms and train-kms/line kms. Table 2.A1.5.
- Coach productivity: passenger-kms/(coaches+ DMUs+EMUs). Table 2.A1.6.
- Wagon productivity: tonne-kms/wagon. Table 2.A1.6.
- Locomotive usage: TU/(locomotives + MU factor)[5] Table 2.A1.6.
- Labour productivity: TU/employees, gross tonne-kms/employees and train-kms/employees. Table 2.A1.7.
- Operating ratio: operating cost/operating revenue. This is a commonly used measure of financial performance and an indication of the railway's ability to cover its financial obligations.[6] Table 2.A1.8.
- Average revenue per passenger-km and per tonne-km. These are measures of the railway's average tariffs and give an indication of the railway's cost levels combined with government subsidy policy. These measures show performance from the customer's point of view – how much do I have to pay? In addition, they give a good indication of the railway's charges compared with competing modes. These measures are presented in constant 2011 Purchasing

Power Parity (PPP) adjusted international dollars. This involves several revenue conversions: 1) into constant local currency (which requires conversion from local currency to Euros in those countries joining the Euro); 2) into USD at 2011 conversion rates; and 3) into PPP USD. Although this chain of conversions clearly introduces potential errors at every stage, we believe it is interesting because it furnishes a general comparison of amounts that users actually pay in various countries and especially because it shows the impact (if any) on railway users of the various reform programmes. Table 2.A1.9.

- Market shares for passenger and freight from OECD data of freight and passenger traffic for all modes since 1970. This is the best available measure of how the railway has performed in competition with highway, water and air traffic and is a measure of the impact of reforms on the railway's competitive position. Table 2.A1.10.

Initial rankings based on cross-sectional comparisons and initial discussion of time-series data

The data available are far too extensive for a detailed review of every railway. Instead, we can briefly summarise the highlights of the basic performance indices illustrated in Tables 2.A1.1-2.A1.10.

Table 2.A1.1 provides a listing of all railway entities on which at least partial data have been collected and shows how the tables distinguish among EU15, EU10 (and Croatia), Norway and Switzerland, and all other railways. It also provides the railway abbreviations that are used throughout this paper.

Table 2.A1.2 shows employees (labour force), line kms, passenger-kms and tonne-kms. There are some railways, notably China, US Class I freight, Indian Railways and Japanese railways that are immense industrial undertakings by any measure. SNCF, DB AG, PKP, FS and the UK rail system appear at the upper end of the ranges as well. By comparison, many of the EU's smaller railways are 1/1 000 (or less) the size of the largest railways. Although there have been studies arguing that returns to scale in railways taper off beyond a certain size (and some of the largest appear to be at or beyond this point), there is little question that many of the smaller railways will inherently be on the less efficient end of the scale. This has to be considered when assessing their performance.

Table 2.A1.3 shows the average trip distance for passengers and the average length of haul for freight. Railways with a longer average trip are in a different market segment than those with mostly short trips. CR, Amtrak and VIA, for example, operate numerous long-haul trains with sleepers and diners and, for Amtrak and VIA, are partly in the cruise business and partly compete with air travel. A critical characteristic of most of the EU railways is their very short average length of passenger trips, which means that they operate mostly short intercity trips or commuter services. At these trip lengths, auto and bus are the main alternatives. Somewhat the same phenomenon shows up even more strongly in freight, where US Class I, CR, Canada and IR operate with lengths of haul long enough to fully capture the economic advantages of long-haul, heavy loading freight traffic. By comparison, most of the EU railways are constrained to operate at lengths of haul where trucking becomes more competitive. We highlight here that there is a real possibility that the EU lengths of rail freight haulage (and passengers to a lesser extent) may be distorted to appear lower than they actually are by double-counting of the tonnes handled when traffic crosses national borders.[7] This also highlights the need for better origin-to-destination rail traffic data in addition to that reported by the individual railways.[8]

Table 2.A1.4 shows the role of passenger traffic in the total traffic of each railway, first as a percentage of Traffic Units (the sum of passenger-kms plus tonne-kms), then as a percentage of gross tonne-kms and

then as a percentage of train-kms – three different aspects of rail service. Traffic Units give a basic picture of the relative markets the railway serves, gross tonne-kms gives at least an indication of the relative maintenance burden imposed by each type of service, and train-kms gives a rough picture of the relative usage of line capacity, which is the basic limitation on the ability of the railway to provide service. By these measures, the EU15 railways tend to be passenger-dominant, the EU10 railways less so. Japan is highly passenger-dominant and the US, Canada and CR are freight-dominant. It is also significant to note that the passenger share of train-kms tends to be higher than TU or gross tonne-km, indicating that measures of efficiency of system use should look at all three measures in order to account for services, wear and tear in the system, and usage of capacity.

Table 2.A1.5 then looks at measures of line traffic density according to TU/km, gross tonne-kms/km and train-kms/km. It is interesting that CR and US Class I tend to rank higher by the first two measures, whereas the EU railways rank higher by the third. We could say that the US Class I railways, for example, are more efficient at using their tracks to move volumes of freight, but the EU railways are more efficient at moving trains carrying passengers. From another viewpoint, we could argue that the focus in the European Union on using line capacity to emphasise train-kms may well limit the ability of the systems to move freight that requires fewer train-kms but can interfere with passenger trains because of the speed difference between freight and passenger trains.

Table 2.A1.6 provides a series of measures of the productivity of rolling stock. The measure for coaches is passenger-km/coaches including MU coaches. Wagon productivity is shown as tonne-km/wagon fleet. Locomotive productivity is TU/locomotives plus an adjusted number of MUs to reflect the fact that MUs provide tractive effort. The adjustment factor used divides the number of MUs by six: we recognise this as, at best, an approximation. In fact, while the coach measure pertains only to passenger service and the wagon measure pertains only to freight, making them both reasonably separable, the locomotive measure necessarily includes both services (except for railways that provide only freight or only passenger service) since locomotives are often used interchangeably. Once again, in terms of locomotive usage intensity, the major freight railways tend to predominate. IR, CR, SBB and Japan stand well above the rest in coach productivity.

Table 2.A1.7 shows output per employee as measured by TU/employee, gross tonne-kms/employee and train-kms/employee. The US Class I and Canadian freight railways stand far above the pack in TU and gross tonne-kms per employee, but are in the middle of the pack for train-kms/employee. This reflects the same difference in focus where, in order to reduce labour costs, the United States and Canada run fewer, but long and heavy trains whereas the EU systems run higher frequencies of shorter trains primarily because passengers place a higher value on service frequency than do freight shippers.

Table 2.A1.8 shows the operating ratio, which is the ratio of total operating costs (excluding costs of debt and equity) to total operating revenues and is a basic measure of financial performance. Railways running an operating ratio above approximately 85% are much less likely to cover their total costs and will require increasing outside support as the ratio becomes higher – they are financially "inefficient" (though they may be economically efficient if they are rendering a social service at low cost and with adequate compensation). By definition, an operating ratio above 100% means that the railway cannot survive without outside assistance. The critical observation is how few railways even approach being self-sufficient financially. This may be well within the fiscal boundaries established by governments, but it does ensure that railways are enmeshed in the annual politics of public finance: note, for example, that the US Class I railways are profitable (operating ratio of 73.2%) whereas Amtrak (operating ratio of 150.2%) is dependent on public finance. It is also interesting to see that the operating ratios of RHK (900%) and BV/Trafikverket (250%) reflect the stated policies of the Finnish and Swedish governments to

collect only marginal costs of infrastructure provision from users. By comparison, an estimate of the operating ratio for DB Netz is 86.9%, reflecting the stated goal of the government to collect the full cost of operations from users. The reported operating ratio of RFF (78.7%) is also surprisingly low, and perhaps explains the complaints of SNCF that access charges were too high. It will be interesting to see what happens to this ratio when RFF is re-merged with the SNCF parent company. The Annual Reports of Network Rail stated an operating ratio of 64.5%, which would again reflect a policy of collecting full cost from users. We emphasise, however, that these measures are particularly sensitive to accounting issues and to transparent accounting (or lack thereof) for public support.

Table 2.A1.9 shows the most important index of efficiency from the point of view of the customer prices charged. In Table 2.A1.9, we have converted average revenues per passenger-km and per tonne-km into 2011 USD at Purchasing Power Parity (PPP). Because this involves conversion of currencies, first into constant terms, then into a common currency and then into PPP terms, it is clearly subject to a range of error. With this acknowledged, it is interesting to see that the average passenger tariffs of many EU railways are well into the range of low-cost airlines as well as costs of auto operation, which does not bode well for competition except in congested urban environments. Similarly, many of the EU railways charge average freight tariffs that are roughly comparable to trucking costs and thus subject to intense competition. Extremely low passenger tariffs on some railways (IR) reflect a desire to use freight income to pay for passenger losses caused by politically suppressed passenger fares.

Table 2.A1.10 shows the market share (percentage of passenger-km) of rail transport in the passenger sector in competition with autos and buses. It also shows the rail market share (percentage of tonne-km) in relation to the entire surface transport market (trucks, water and pipeline) and then the rail market share compared to trucks alone. In a direct sense, this is not so much a measure of rail efficiency as it is a measure of the result of rail efficiency (or lack thereof) in the overall market. An inefficient railway will perform poorly; an efficient railway has a chance to perform well. We argue that the competition of rail versus trucks is probably the best measure of rail's performance in the transport markets. As this table shows, rail plays a very different role in some countries than in others. For example, rail plays practically no role in US and Canadian intercity passenger transport but is predominant in Japan.

Because the amount of information to be presented would be too large, we selected a few indicators and a few countries to display a sample of the time-series information that is available. We show only the years 1970, 1975, 1980, 1985, 1990, 1995, 2000 and 2005-2011 (interim years are available in the underlying database). We select France (SNCF), Germany (DB through 1995 and DB AG for 1995-2011), and the United Kingdom (old BR before 1995, ATOC, UK freight and Network Rail afterward): these railways together account for about 60% of all EU15 railway traffic. We show the Czech Republic (CD) and Poland (PKP), as these represent about 60% of traffic in the EU10 and because the data available are not complicated by changes in corporate structure. We also show the US, Japan and Switzerland (SBB) to represent railway activity outside the EU. We use 1980 and 1995 as base years: 1980 is a point in the development of the European Union when railways began to be affected by the overall economic changes and is the year before deregulation in the United States; 1995 is close to the beginning of the European Commission's attempts to restructure the EU railways.

Table 2.A1.11 gives an overall picture of how railway traffic has developed over time. Notable from this table is the fact that rail passenger traffic grew faster in the United Kingdom than for SNCF and DB, especially after 1995. UK freight traffic also grew faster. Rail traffic has been shrinking in the EU10 and had, at best, stabilised by 2011. Swiss traffic trends essentially mirrored those of the EU15, while Japanese passenger and freight traffic were stagnant or slowly shrinking. US passenger traffic grew slowly while freight traffic grew strongly, especially from the base in 1980.

Table 2.A1.12 shows the evolution in operating ratios and labour productivity (using TU/employee). There is a mild improvement in operating ratio in most countries, with a marked improvement in US Class I freight railways and in Japan. With this said, it is interesting to note the difference between the US Class I railways (73%) and Amtrak (150%). Labour productivity improved in all countries, with the greatest growth rate in the US Class I freight railroads, United Kingdom and Japan.

Table 2.A1.13 shows the side of the railways that the consumer sees, i.e. average tariffs. There was an apparent trend upward in average passenger tariffs in every country from 1980 and in all but one (Japan) from 1995. Average freight rates were stable or trending downward in most countries; but only in the US Class I railroads do they appear to be well below competitive trucking rates. We stress again here that the calculation of average rail tariffs is inherently an approximation because of all of the conversions involved. We do believe that they are usefully indicative both as to levels and changes over time, but they do need to be viewed with some caution.

Table 2.A1.14 shows the evolution in market shares in passenger and freight markets. The rail passenger share of the EU15 railways (~7%) has changed little since 1980 and 1995 whereas the rail passenger share in the EU10 countries has rapidly fallen to EU15 levels. Rail passenger traffic has an insignificant share in the United States and that has not changed.[9] Japanese rail passenger shares have been stable at a level much higher than the EU, while Swiss rail passenger shares have grown slightly and are about twice the EU levels. The picture for rail freight is quite different: EU15 rail freight shares have fallen since 1980 but have remained stable since 1995. EU10 rail freight shares have fallen dramatically since 1980 and 1995, though they may now be stabilising at a level slightly above that of the EU15. Interestingly, the Swiss rail freight market share is much higher than in the EU, though it has fallen somewhat since 1980 and 1995. The US rail freight market share has stabilised since 1980, though it was falling rapidly before then (it was 78% in 1950 and 67% in 1960).

At this point, we can answer the first issue posed in this chapter. Yes, there are measures of efficiency or productivity that can be developed from publicly available data. The measures we have developed do give an overall picture of the performance of the selected railways both in cross-section (2011) and over time (1970 to 2011). It is possible from these measures to identify the more efficient railways: China in both freight and passenger; US and Canadian Class I railways in freight; and Japan for passenger service. Within Europe, SBB seems to measure up quite well while the EU15 and EU10 railways present a mixed picture. It would also be possible to use the data developed to assess the efficiency of a specified railway and track its progression over time, if that were desired.

With this said, these measures could be greatly improved in the European Union by having a regulatory body that could specify the data to be reported by every railway, verify its accuracy and require its production annually.[10] It is possible that many of the gaps identified in the database could be filled by reference to Annual Reports or other national documents, but there is no single point of reference for complete and consistent reports.

In fact, the EU data gaps and consistency problems underline an important challenge in measuring and comparing railway efficiency – most railways either do not see the need for detailed information for internal management purposes or do not think it is in their interest to release such information to permit public comparisons to be made. For example, as mentioned earlier, the data in “Railway Efficiency,” (Beck, Bente and Schilling, 2013) conceals the identity of the railways in the comparison, significantly vitiating the use of the results. This has long been the practice of the UIC in making comparisons of relative performance of its members. Under what circumstances should public entities, supported by public funding, be allowed to conceal information that would facilitate public analysis and evaluation of their performance? This will be a point to consider in the analysis of the interaction among ownership, structure and performance measurement discussed below. It is also a critical point in assessing whether the European Commission's railway objectives – transparent accounting for infrastructure to ensure fair access and financial stability of the infrastructure agency, accompanied by separated accounts for passenger and rail services – can ever be met.

We argue that the information that the Commission would need to ensure implementation of its Directives with respect to financial transparency of infrastructure, passenger and freight operations simply does not yet exist, and should be added to the task of a designated authority. In addition, one important piece of information – where do passengers and freight shipments *actually originate and terminate?* – is not yet available in the European Union and awaits collection of passenger ticket and waybill information. The same issues were described in more detail in "Railway Accounts for Effective Regulation" (Thompson, 2007).[11] The data collected and reported by the US Surface Transportation Board (STB), including "Analysis of Class I Railroads" and "Public Use Carload Waybill Statistics", would be a useful model for EU agencies to consider.

How can efficiency be changed?

It is all very well and good to define and measure efficiency (however approximately) but the effort expended in defining, collecting and reporting data will have no payoff if there is nothing that can be done to change railway performance.[12] Fortunately, if railways are willing, and the political will exists, efficiency can be changed.

One way to change efficiency, much favoured by traditional, engineering-dominated railway managements, is increased investment (increasing capital intensity). One of the arguments in favour of added investment – making up for deferred maintenance – can well have some justification, although it sometimes simply reflects neglect of a facility that lost its economic role long ago and should be taken out of service. Where legitimate deferred-maintenance needs exist, good management (and good public policy) will deal with it. Another argument – replacing old with new without regard to payoff – tends to appear when the railway does not face any commercial objectives. In either case, this chapter does not look at increased investment alone, although we acknowledge its role in improving efficiency when a good financial or economic case can be made, especially when the success of a new structure depends on a fresh start from years of past investment neglect.

We instead look at various structural or organisational innovations that have aimed at changing the underlying objectives or incentives faced by railway management, and use the time series data in outlining those changes that seemed to have "worked" and those that have not been as successful.

In general terms, we can identify changes in structure, ownership and incentives, though these can be combined and can work together:

- Structural change means movement along the spectrum that begins with monolithic form (all assets owned by the railway and all services provided by the railway). The Ministry of Railways in China has long been an example of a monolith. China recently separated China Railways (CR) from a newly-created Ministry of Railways, leaving Indian Railways (IR) as the only remaining major railway that is still fully monolithic. There are railway structures where the dominant operator is in control of infrastructure while other operators are tenants on the infrastructure and pay for access (either marginal costs or a negotiated fee). This can include either competing operations in the same market (freight trackage rights on a freight operator's lines, which covers 27% of US freight lines) or non-competing operators (passenger) on freight lines (Amtrak and

VIA) or, indeed, freight operators on passenger lines (JR Freight). The United States, Canada and Japan are examples where the dominant operator controls the infrastructure and tenants pay for access. The complete form of structural change is full vertical separation, with an infrastructure provider offering neutral access to all operators, in accord with published access charges. The EU Commission's Directives have been aimed at creating vertical separation of infrastructure but the process has been fragmented, inconsistent across member countries and, in many cases, remains incomplete.

- Ownership change means movement along the range from fully public to fully private. US and Canadian freight railways are now fully private, though the Canadian National (CN) was only privatised in 1995 and Conrail was privatised in 1987. Amtrak is a publicly-owned corporation. The old Japanese National Railway was broken up (structural change) and the three largest passenger operators privatised in 1987. Most EU railways remain fully public, but the private sector is increasingly being allowed to provide some operating services, both in the passenger and freight markets. The United Kingdom was, at one time, an extreme case of virtually complete privatisation, but that has evolved back into a public/private balance.
- Changes in incentives ("rules of the game") include situations in which the management of the railway is given more freedom to operate commercially and is given objectives that include at least some degree of risk for cost control or net revenue maximisation, or both. Management contracting is a starting point, but the process can extend through gross cost or even net cost franchising.[13] In the US context, deregulation completely changed the ability of freight railways to work directly with shippers to set rates and services that met shipper needs without interference from the regulator.

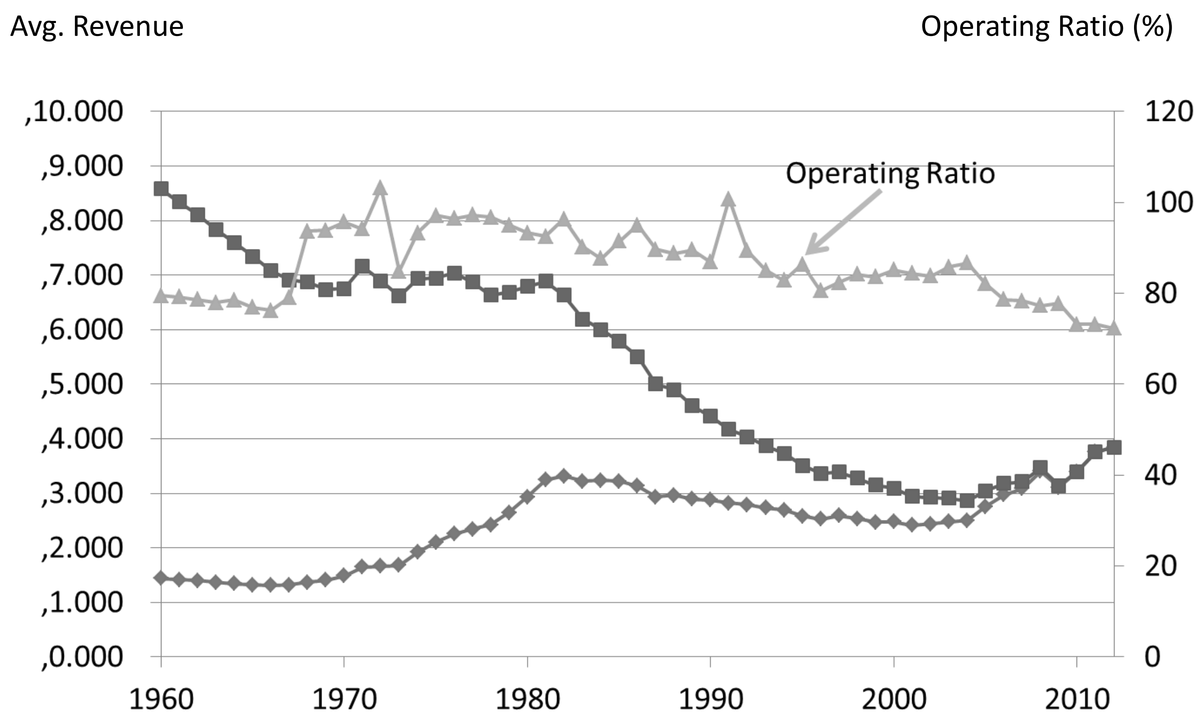
Did any of these changes work?

The reform process in the United States actually comprised three parts: (1) formation of Amtrak in 1972, in order to free the private freight railroads of the burden of passenger deficits (and, in the minds of some, to free passenger service from the indifference of freight company management); (2) combining the bankrupt freight railroads in the mid-west and north-east part of the country into one entity, refinancing and rebuilding it, and subsequently re-privatising it in 1987; and (3) deregulation in 1980 (the Staggers Act). As Tables 2.A1.11 and 2.A1.12, and Figure 2.1 show, these reforms were highly successful in stabilising market share, lowering rates, increasing traffic and improving essentially all indices of efficiency.[14] The comparison with changes in Amtrak is interesting. Amtrak rates went up (Table 2.A1.13), service grew slowly (Table 2.A1.11) and productivity was stagnant (Table 2.A1.12). Operating ratios improved for freight and were stagnant (and high for Amtrak). With this said, the essential purpose of Amtrak – to save the freight railways that were staggering under the burden of passenger deficits – was achieved.

In Canada, privatisation of CN produced a change in the relative productivity of CN with CP (Canadian Pacific, always private), though the shift was not dramatic. In sum, however, Canadian rail freight rates declined steadily both before and after CN privatisation, while labour productivity improved rapidly. Operating ratios also improved after 1995. Comparing Figure 2.2 with Figure 2.1, it is also apparent that the Canadian experience was at least partly driven by deregulation of the US freight railways, with which the Canadian railways both compete and co-operate.[15] VIA offers the same comparison with the Canadian freight railways as Amtrak does with the Class I US freight railroads: VIA's labour productivity is low (Table 2.A1.7) and is little changed since establishment in 1980. VIA's operating ratio (185.5 – see

Table 2.A1.8) is high, although its average tariffs are well below Amtrak and are about the EU average, but for a very different traffic mix (see Table 2.A1.3, where VIA has the third longest average length of trip, reflecting the importance of long-haul trains).

Figure 2.1. US Class I Railroads operating ratio (%) and all commodity average revenue/tonne-mile

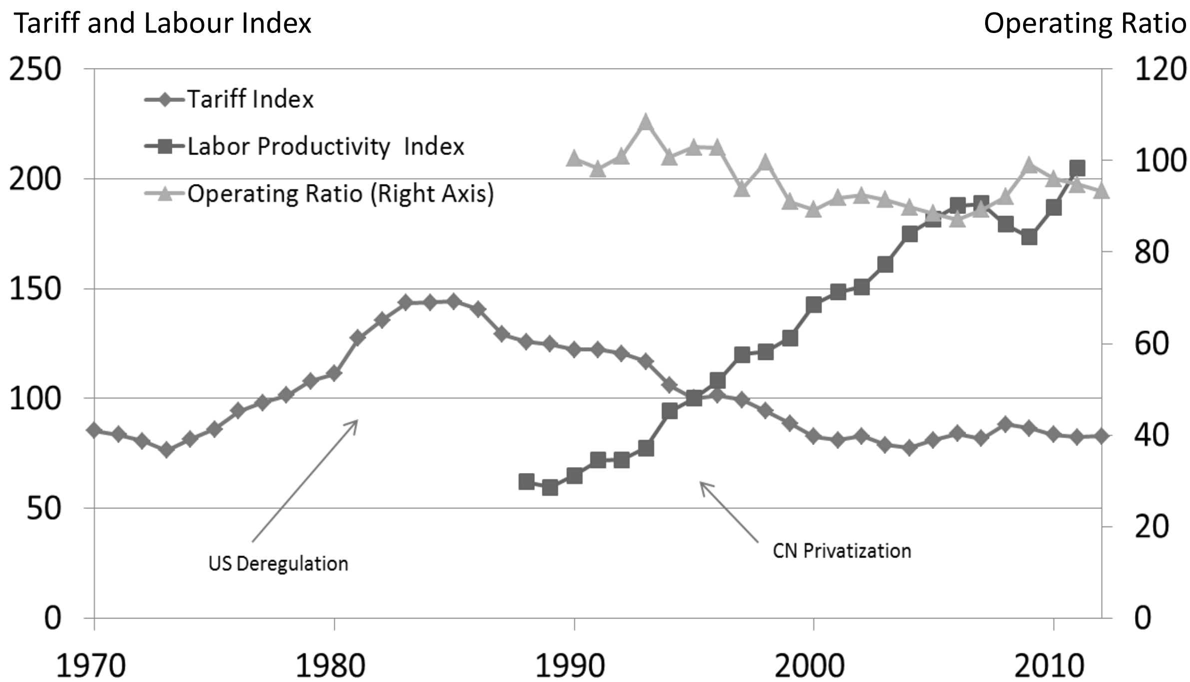


Note: US cents/tonne-mile

Source: Analysis of Class I Railroads and US Bureau of Economic Analysis (GDP Deflator).

In brief, the Japanese reforms involved breaking up the old, monolithic Japanese National Railways (JNR) into six new passenger companies and a freight company that operates much like a "freight Amtrak", i.e. it pays access charges and uses the narrow-gauge lines of the passenger companies (the high-speed lines – Shinkansen – are standard gauge and are not used for freight). The three large passenger companies (JR East, JR West and JR Central) were subsequently privatised by sale of their stock. An explicit goal of the reform was to break the control of the unions over the politically oriented management. As Figure 2.3 shows, the reforms were highly successful in improving labour productivity and the operating ratio for the system.[16] This was accomplished while tariffs were held stable (Table 2.A1.13) and total traffic actually remained almost the same over the last twenty years. Performance of JR Freight is harder to pinpoint. What is clear is that traffic has declined while tariffs have been held stable, roughly at EU levels. In perspective, however, JR Freight has faced a problem similar to that of Amtrak: as the traffic of the dominant operator has grown there is less room for the tenant. This has caused Amtrak's on-time performance to plummet and has restricted JR Freight's ability to handle its traffic. It is probably a risk inherent to dominant/tenant schemes (or, arguably, where some operators have closer linkage to infrastructure management than other operators).

Figure 2.2. Canadian Freight Railways
(Tariff index and labour productivity index, 1995=100)



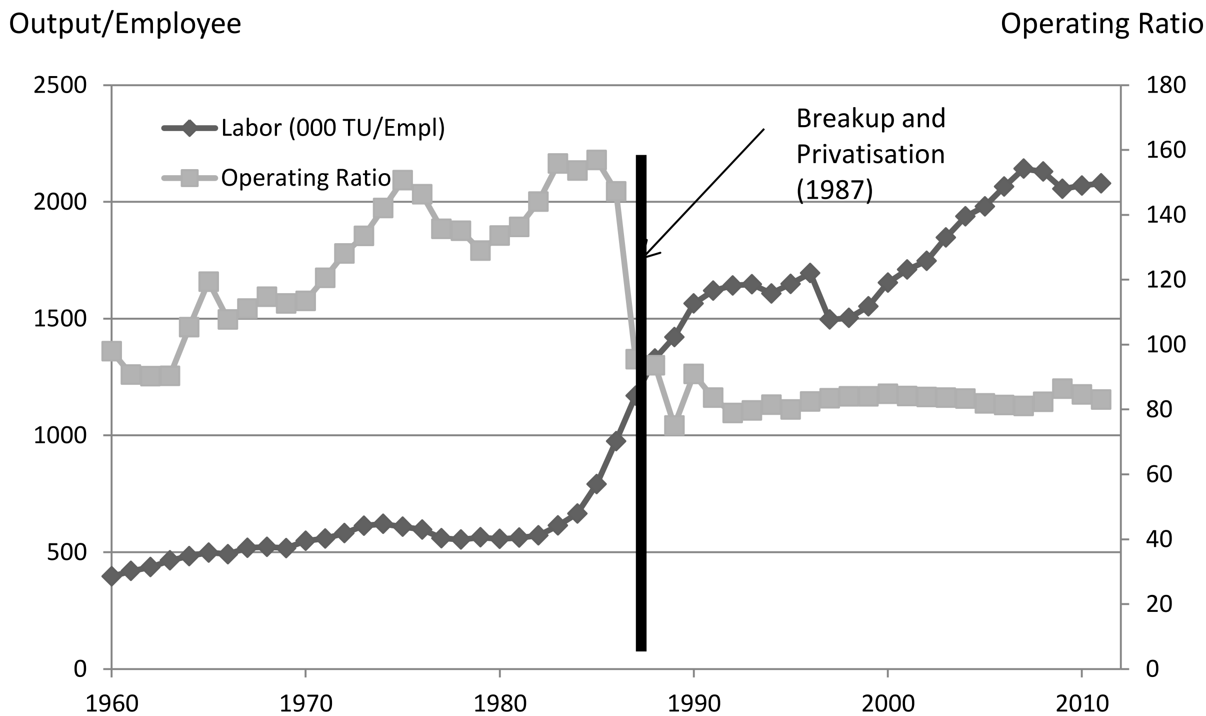
Source: Railway Association of Canada.

Experience in the European Union is much more complex to assess. In overall terms the Rail Liberalisation studies by Kirchner[17] suggest that the Commission's structural reforms have gradually been implemented, though the degree differs among members, as Table 2.A1.15 shows. Although the indices are arguable on a number of grounds and are, in any case, only partly objective, Kirchner argues that the market is now more liberal and that the degree of competition has increased.

Table 2.A1.15 does indicate that the Liberalisation Index as computed by Kirchner had improved over the time period (2002, 2004, 2007 and 2011) studies. This appears to have been much more applicable to freight service than passengers, probably because the interaction between public support and passenger service is stronger than in freight. Governments find it hard to allow competition for their supported services, though this has changed in some countries.

It is also significant that Kirchner divided his index into three parts: LEX (legal change); ACCESS (whether the infrastructure agency actually allowed access to take place in accordance with the new laws); and COM (a measure of the actual degree of competition that emerged). Looking at the COM index on Table 2.A1.15, even by 2011 there was only one country (United Kingdom) that had an "advanced" COM index, and only four (Germany, the Netherlands, Denmark and Estonia) that were considered "on schedule". It is also interesting that DB AG owns the major freight carriers in Germany, the Netherlands and Denmark (and in the United Kingdom), so the apparent degree of freight competition in these countries may be less than indicated. Estonia essentially exchanges traffic only with Russia (its Baltic connections are either "delayed" or "pending departure"), so competition would be of limited value.

Figure 2.3. Changes at JNR at privatisation
(operating ratio (%) and labour productivity)



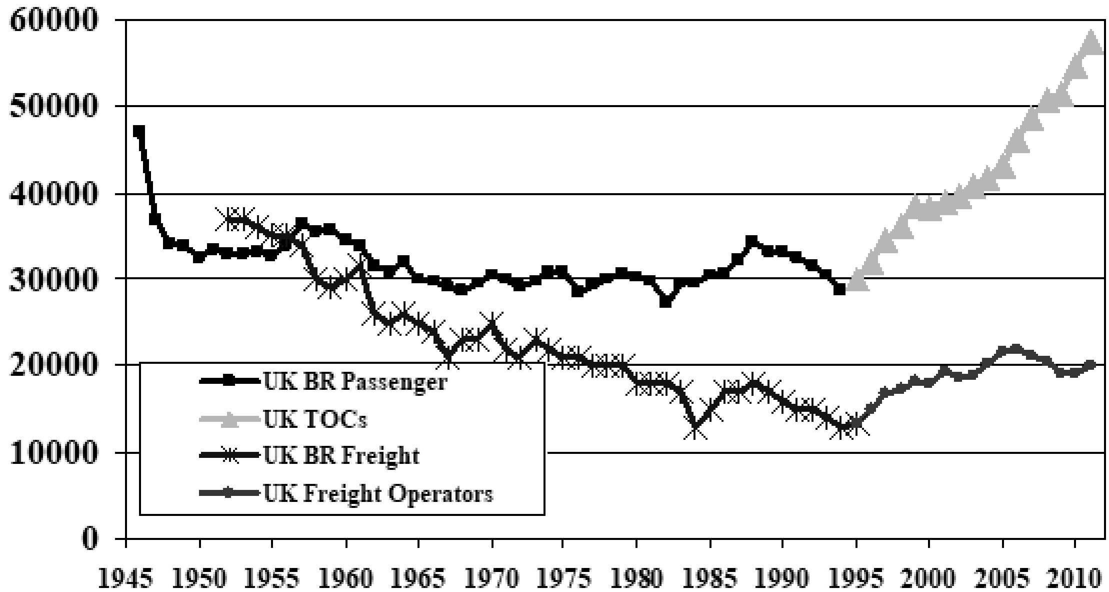
Source: Author’s analysis and UIC Railway Time Series, 1970-2000.

The relatively slow development of intra-rail competition, combined with the slower pace of liberalisation in the passenger sector, should alert us to have lower expectations for the impacts of the EU reforms, especially in countries slower to adopt the reforms. This effect can be multiplied by the fact that a country might well be aggressive in its reforms, only to see the impact muted by slow change in the countries to which it connects.

This overall picture of a slow pace of reform in the EU railways, developed by Kirchner, is supported by the results in Tables 2.A1.11 and 2.A1.14. The EU15 railways do not demonstrate a particularly dynamic performance, either measured by freight or passenger traffic growth or by market share. We acknowledge that the outcome could have (we argue would have) been worse without reform, but it is not possible to contend that the reforms have had (to date, at least) anything like the positive impact of the reforms in the United States, Canada and Japan. It is also possible to argue (as the Kirchner indices suggest) that the restructuring reforms have not actually been implemented yet to the degree necessary to have an impact on efficiency.

The picture for the EU10 railways (and Croatia) is even harder to assess, partly because they are more recent members and, more important, because they were subjected to the wrenching transition from central planning to market structure, which would have had a devastating impact on both passenger and freight traffic no matter what changes in structure had occurred. With this said, it is at least interesting to point out that new, private freight operating companies are already carrying nearly 25% of freight traffic in Bulgaria and are carrying about 50% of the freight traffic in Romania. Clearly, this would not have happened without vertical separation. It will be interesting to see if these companies eventually operate at higher levels of productivity and efficiency.

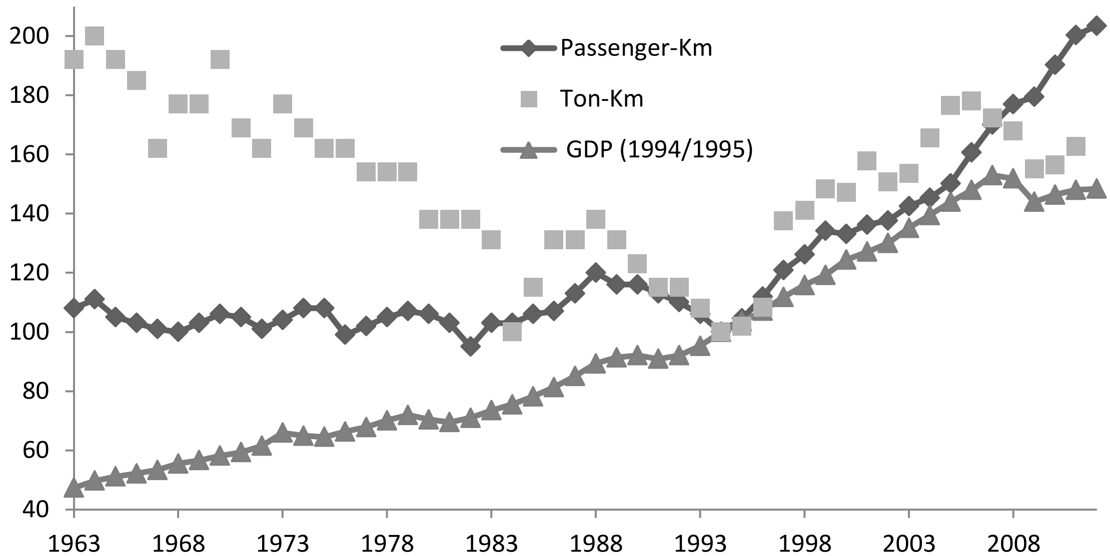
Figure 2.4. Rail traffic in the United Kingdom
(per 000 000 passenger-km and tonne-km)



Source: SRA, WDI, UIC, ORR.

It is difficult to use the efficiency indices to draw any clear conclusions about the performance of DB AG and SNCF. They are both in the upper middle of the pack in size and outputs. Despite the emphasis on developing HSR services, SNCF has an average passenger trip of only 79 km, while DB AG is even shorter, at 40 km, suggesting that the efficiency of both is heavily influenced by the economics of short-haul passenger service. Well over 70% of SNCF's traffic output is passenger service, while DB AG's passenger service ratio is in the high 40% range. In operations, though, 89% of SNCF's train-km are passengers, as are 75% of DB's operations: both railways are clearly using most of their capacity for passenger service and (as with the US and Japanese cases) when one service dominates, the others suffer for lack of priority access to capacity. Both are in the middle of the pack as to line traffic density, with DB AG slightly above SNCF. SNCF appears to make somewhat better use of its rolling stock fleet, though neither is at the top of the productivity rankings. However measured, the labour productivity of SNCF is lower than DB AG, although the productivity measures for both SNCF and DB AG (especially) are probably reduced by the inclusion of non-rail employees in the totals.[18] SNCF reported a better operating ratio than DB AG in 2011, but this would not have been true in most of the earlier years reported. DB's average passenger fare is about 30% higher than SNCF, but its average freight tariff is about 10% lower than SNCF. SNCF's market share is higher than DB AG for passengers but lower for freight. SNCF's passenger traffic has grown slightly faster than DB AG's, but SNCF's performance in the freight market has been very poor, worse than DB AG and actually worse than the EU10 countries. DB AG's improvement in labour productivity has been significantly better than SNCF, but neither did as well in this index as any of the other railways listed in Table 2.A1.12 (except Amtrak). Passenger tariffs on both SNCF and DB AG are higher than in 1990, by 50% for SNCF and 34% for DB AG. By comparison, both saw a significant reduction in freight tariffs since 1990.

Figure 2.5. UK passenger-km, tonne-km and GDP
(Index 1994=100, GDP index constant GBP 1994-1995)



Source: SRA and UK Treasury.

It has been shown that vertical separation adds some costs of co-ordination and reporting as well as internal accounting and negotiation, although the exact degree of the added costs is around 5% or so.[19] The counter question – have these costs produced offsetting benefits? – for example, through added competition that reduces tariffs (as in the United States), certainly has an apparent answer: "no" for passengers and "mixed" for freight. Essentially, every EU15 and EU10 railway has the same or higher passenger tariffs as in 2000 or 1995. There is no discernible pattern in average freight tariffs, with some higher and some lower in 2011 than in 1995 or 2000.

The United Kingdom presents a significantly different picture. Although we defer to the paper by Nash et al. (2013) to survey the UK case in more detail, Figures 2.4 and 2.5 give a useful picture in comparison with other EU experiences. As shown in Figure 2.4, both passenger service and freight service reacted strongly to the restructuring, with passenger service reaching levels not seen since the end of World War II. In fact, as Table 2.A1.11 shows, passenger service in the United Kingdom grew faster since the restructuring in 1995 than either SNCF or DB AG, and far faster than the EU15 average. The same is true for freight in the United Kingdom. The United Kingdom's rail market shares for both passenger and freight increased faster than the EU15 average, while the average passenger tariff has been nearly stable in constant terms.

There has been spirited debate in the economics academic community as to whether the positive UK rail results have been due to privatisation or to restructuring, or were primarily driven by strong GDP growth. This is an argument that cannot be resolved, but Figure 2.5 clearly shows that *something positive* happened upon reform: it would be very difficult to attribute all of the change to growth in the economy.

Conclusion

No simple attempt to measure railway system efficiency can be expected to provide meaningful answers, both because of the ambiguity and inherent challenge in defining what is meant by the term "efficiency" and because the structural complexity of rail organisations and the heterogeneity of railway services and offerings limits the value of any single index. Differing perceptions and purposes for attempts to measure efficiency will therefore require appropriate, tailored approaches.

Among the various purposes for measuring efficiency, the following need to be distinguished in particular:

- a government's interest in determining or monitoring the overall performance of its railway system, e.g. with respect to value for money, modal competitiveness, operational cost efficiency or financial viability
- a government's policy analysis, to define and review the success of railway restructuring or market organisation initiatives
- an audit of railway management performance (be it in a domestic or an international context)
- an intergovernmental policy evaluation and benchmarking effort.

There are fundamental practical issues about efficiency measurement that need to be resolved before more high-level conceptual questions can effectively be addressed, including:

- Robust, internationally comparable reporting standards do not exist (note that while mandatory standards apply in the United States and Canada, Europe has nothing close to a homogeneous format). On a global scale, the UIC has the "best available" database, which could nevertheless be improved. However, the UIC's data may be at risk of losing quality and coverage.
- Transparency – Railways frequently resist reporting data to their governments, even when (and this appears to be the "default option" in Europe) substantial amounts of taxpayers' money is deployed to fund infrastructure and "public-service obligations".
- Off-balance-sheet items – Subsidies paid to railway systems are in many cases very substantial, but are not clearly reported. They typically come through one, or a combination of, the following: infrastructure investment grants, passenger tariff surrogates and operations support, as well as special-purpose vehicles for "legacy staff" obligations. Such items are often not included in railway balance sheets and official reports, and these off-balance-sheet items can have a strongly distorting effect on financial "efficiency" measurements.
- Last but not least, definitions of parameters, be they rather of a technical/operational, service performance or financial nature, often lack clarity and uniformity, which is a prerequisite for valid international comparisons.

As a consequence, and to the frustration of many industry observers, cross-sectional measurements of railway "efficiency" are often more subject to distortion and misunderstandings than meets the eye in the first place. This fact imposes a significant caveat on any interpretation of face-value comparative measurements. With this is mind, time-series evaluations can strongly buttress comparisons of how individual railways have developed over time and provide far greater reliability for interpretation. Even so, discontinuities in reporting or the organisational set-up of railways over time can also be a source of ambiguity (albeit less critical than in the case of cross-sectional comparisons).

From a "good public corporate governance" perspective, full reporting, including "shadow assets" and financial flows to special-purpose vehicles, should be the norm. This is essential to provide full accountability to the public on the deployment of funds and to inform policy makers responsibly.

Acknowledgment of the above-mentioned limitations on data availability, quality and meaning leads to a cautious note on the use of econometric models to describe railway efficiency, for a number of reasons:

- Inconsistency of input data, including unclear definitions.
- Structural scarcity of data ("no big data") due to small and unstable samples of observed/observable railways systems, with inevitably inadequate sample sizes for statistical evaluations.
- An inability of econometric models to discriminate between "good" or "poor" corporate governance and management, which in practice can have an overriding impact on actual railway efficiency.
- Most railway systems in the world show signs of protracted under-investment, especially in infrastructure, because "pro-forma" statements of steady-state investment requirements (i.e. future cash flows to be set aside) are rarely reported accurately. As a result, such backlogs often go undetected, leading to a real risk of a mis-assessment of the condition of infrastructure or other long-lived assets.

Qualified and informed judgment is always required in conjunction with even the best available and most sophisticated supporting efficiency measurement analyses. As a high-level common denominator (an entry point) to measuring railway "efficiency", a balanced scorecard approach should be used that allows for some standardisation and is broad enough to cover different aspects and measuring purposes in a 360-degree manner. A "Balanced Railway Efficiency Scorecard" (BRESC) should at least contain the following elements on a first-tier level (each and all open for greater in-depth analysis):

- scope of the railway system
- asset utilisation of infrastructure and fleet
- human resource deployment
- operational performance
- financials
- customer-centric performance (i.e. performance in the market).

Railways are very asset-intensive systems, and economic analysis shows that under real-life conditions, asset utilisation, which is highly disparate for different systems around the world, has a major impact on overall system profitability or "efficiency". To a very large extent, asset utilisation is a result of historically developed networks with vastly different traffic density, coupled with above-rail operations that are more or less focused on sufficiently high demand services (where "demand" can have both a political as well as a market dimension). It is immediately and demonstrably clear that such disparate "operating conditions" affect railways' economics by orders of magnitude: asset utilisation is therefore a structural determinant for a system's (in)ability to make profits or losses.

No other single factor is more important for economic railway efficiency than asset utilisation. Hence, from an efficiency measurement purpose standpoint, it is vitally important to separate the impact of those parameters that are primarily imposed by governments and other political stakeholders from those that are a good "proxy" for the performance of railway management.

A good and highly aggregate efficiency measurement from an overall perspective is railway market share ("modal share"); however, in cases where public subsidies are applied to provide services (the norm in Europe), subsidies can literally buy market share: thus, market share and system funding provisions need to be understood in close connection. As a direct result, efficiency measurements of a railway system may not suffice to describe the performance of railway management due to the overriding impact of economic "legacy factors" – parameters, such as politics, which are exogenous to railway management.

Good proxies for direct management performance are the normalised full cost per train-kilometre in above-rail operations and the normalised full cost of maintaining and operating a unit piece of network infrastructure (e.g. a kilometre of line or track) in infrastructure management organisations. Various other dedicated or sometimes more global analyses exist to measure management performance in infrastructure and above-rail operations, many of them in confidential or anonymous form, but it is not always clear that proper distinctions are made between what management can influence and what is provided by "system legacy". More work is needed if the effort to measure railway "efficiency" is to be promoted further.

Last but not least, almost all of the global railway efficiency measuring work is devoted to technical/operational and financial aspects, and the customer perspective (which one could arguably consider the ultimate measure of efficiency) appears to be a neglected area. Market-level questions to be analysed are, for instance: how efficient is the travel or shipment solution offered by a railway in the eyes of the passenger or the shipper? Or, "how competitive is the price of using a railway service as compared to other modes?" From a government perspective, this also means addressing aspects of public welfare.

There is reason to assume that the customer perspective has been neglected so far because it poses a challenge to describe and measure; however, this should not be an excuse not to attempt it (note that emerging "big-data" applications may represent breakthrough opportunities to capture customer-centric information).

Looking at the data and indices per se, it is clear that the policy and structural changes in the United States, Canada and Japan worked in almost all dimensions, and one can strongly argue that the changes would not have occurred without the reforms.

It is far beyond the scope of this paper to review all of the EU railways individually. The experience in the European Union is much more complex because most services at base are social rather than commercial, legitimately increasing the role of government, and there is no good annual reporting on the value of social benefits and costs generated by the railways.[20] The result has been a much less clear definition of objectives and incentives along with unstable, often inadequate financial support, reflecting the vicissitudes of annual public budgeting. Attempts to change the situation have been impeded by political resistance from unions and other interest groups and, in many cases, a complete lack of transparency of the actual performance ("efficiency") of the railway, which has made scrutiny by the public, including the academic sector, impossible. We also have to deal with the null hypothesis – what would have happened without reform? – though SNCF performance may give an indication. It is also possible to argue that DB AG has resisted the actual implementation of most of the significant aspects of the EU's reform objectives, at least with respect to railway structure in Germany.

It seems clear that the UK Government overshot its target by smashing the old BR and privatising it completely at the outset – but gradual reform since 1995 has produced a system that certainly seems better than the old BR. In France, the attempts to reform (without actually doing so) have clearly not been very productive. RFF never fully emerged from SNCF control, and recombining them into a new agency will mostly have the effect of turning back the clock. The DB AG holding company approach produced a conflict of interest between DB Netz and the operators with regard to potential entrants, a conflict that will remain until DB Netz is truly separated.

Notes

1 Unless otherwise specifically indicated, *all data are expressed in metric terms* – tonnes and kilometres. Unless otherwise specified, tonnes mean net tonnes.

2 The International Union of Railways (UIC) sponsored a series of studies on the relative efficiency of track maintenance among a number of railways. Unfortunately, the identity of the railways in the dataset was concealed, depriving outside analysts of the ability to put the relative performance of each railway into context. This also deprived governments of the ability to assess the performance of their own railways and to decide whether the public was getting value for money. Beck et al. (2012) suffer from the same "confidentiality" restrictions. An explicit objective of this study is to rely only on data sets that are publicly available.

3 We highlight the fact that there can well be double-counting of passengers carried and freight tonnes carried, since the same passenger (or tonne) can cross a railway border more than once and be counted each time. Passenger-km and tonne-km are not subject to double-counting. Given that the average trip length of most EU railways is quite short, this issue may not be as significant for passengers as for freight.

4 Numbers of freight wagons are also affected in countries where there are significant numbers of lessor- or shipper-owned wagons that do not appear as railway-owned assets. For example, only one-third of US freight wagons are owned by railways.

5 Measuring locomotive productivity is complicated by the presence of DMUs (Diesel Multiple Unit) and EMUs (Electrical Multiple Unit) that have their own tractive effort. We attempt to correct for this by calculating effective locomotives, by dividing DMU or EMU numbers by a factor that represents the average length of a DMU or EMU train. We acknowledge that this is, at best, an approximation. Of course, on freight-only railways or railways without MUs this is not a problem.

6 The operating ratio includes depreciation and amortisation but excludes payments to acquire and compensate sources of capital.

7 This could be corrected if railways distinguished between tonnes originated as opposed to total tonnes handled and tonnes originated off-line and terminated off-line.

8 A similar problem appeared in the US Carload Waybill Statistics in the early years of waybill reporting, because each railway in a multiple railway shipment could report the same tonnage. This has since been corrected. See McCullough and Thompson (2012) for a detailed discussion of the issue.

9 This is, to some extent, the result of exclusion of the traffic of US commuter railways (which is included in the EU, Swiss and Japanese results). US commuter railways carry slightly more passenger-km than Amtrak, so the United States' share would double, but still remain below 1% if auto traffic is included.

10 For railways, this requirement might also be met by encouraging all railway service providers, including infrastructure entities, to complete the existing data requirements of the UIC.

11 See also "Workshop Report – Measuring Investment in Transport Infrastructure", ITF, Paris, France, 9 and 10 February 2012, where exactly the same data issues arise.

12 Indeed, the experience of the authors suggests that railway management often resists collecting information, and especially reporting it, on the grounds that they cannot do anything with the results anyway. Of course, it could also be because they are concerned that better information might support efforts to change the rules of the game they face (or in fact change them). As a rule of thumb, public ownership and management under political control seem to be antithetical to collection of transparent information, even where the information is for public use. To be fair, private corporations also try to restrict public reporting but, as the STB example demonstrates (Office of Rail Regulation [ORR] in the UK is a demonstration of restrictions on passenger information), these objections can be overcome. Moreover, private corporations are not usually spending public money and, when they are, they are required to report in greater detail.

13 See ECMT (2007) for a discussion of gross cost and net cost franchising.

14 See McCullough and Thompson (2012) for a detailed discussion of the impact of the Staggers Act on US rail freight tariffs and on the profitability of the Class I Railroads. Basically, rates went down and profits went up because productivity increased even more rapidly, especially as a result of contract tariffs.

15 A recent OECD report (ITF, 2014) showed that changes in the structure and ownership of the Mexican railways had a similar effect.

16 The operating ratios shown are actually for the entire system, and are lowered by the performance of the three smaller railways and the freight company (JR Freight). The operating ratio for the three larger companies by themselves would be more favourable.

17 Kirchner (2011), but also 2002, 2004 and 2007.

18 The SNCF would be raised by about 25% and DB nearly doubled if non-rail employees were excluded from the productivity measures. Unfortunately, though the data exist to do this separation in later years, the information is not available for earlier years.

19 See e.g. Nash et al. (2013).

20 This information could be added to other reporting requirements, at least in a prescribed, approximate form.

Annex 2.A1. Tables

Table 2.A1.1. Sample key

Country	Railway name and date of inception
EU-15	
Austria	GKB
	ÖBB
Belgium	SNCB/NMBS
Denmark	DSB
	BDK (1997)
Finland	VR
	RHK/FTA (1995)
France	SNCF
	RFF (1997)
	Veolia
DB Germany	Prior to reunification
DR Germany	Prior to reunification
Germany	DBAG (1994)
Greece	OSE
Ireland	CIE
Italy	FNM
	FS
Luxembourg	CFL
	CFL Cargo (2007)
Netherlands	NS
	Pro Rail (1998)
Portugal	CP
	CP Carga
	REFER (1997)
Spain	RENFE
	ADIF (2005)
	Euskotren
	FEVE
	FGC
Sweden	SJ
	Green Cargo (2002))
	BV/Trafikverket (1988)
United Kingdom	BR
	ATOC (1995)
	Freight (1995)
	Railtrack/NR (1995)
	NIR

Country	Railway name and date of inception
EU-10 + Croatia	
Bulgaria	BDZ
	BDZP
	BDZ Cargo
	NRIC (2003)
	BRC
	Bulmarket
Czech Republic	CD (2003)
	SZDC (2003)
Slovakia	ZSSK
	ZSSK Cargo
	ZSR (2002)
Former Czech.	CSD (End 1992)
Estonia	EVR
Hungary	Floyd
	Gysev
	MAV
	MAV Cargo (2006)
	MAV Start (2007)
Latvia	LDZ
Lithuania	LG
Poland	PKP
Romania	CFR
	CFR Calatori (2006)
	CFR MARFA (2006)
	CFR SA (2006)
	GFR
	Servtrans
	TFG
	Unifertrans
Slovenia	SZ
Croatia	HZ
Other Railways	
United States	Class I
	Amtrak (1972)
Canada	Freight
	VIA (1980)
China	CR
Japan	All
India	IR
Norway and Switzerland	
Norway	NSB
	Cargonet (2002)
	JBV (1996)
Switzerland	BLS
	BLS Cargo
	SBB/CFF/FFS

Table 2.A1.2. Basic Indicators of size and scale of railway operations

EU15	*EU10*	CH/NO	All Other

Railway	Employees	Railway	Line Km	Railway	Pax Km	Railway	Tonne-Km
CR	2 051 100	US Class I	153 249	IR	978 508	CR	2 562 635
IR	1 328 000	CR	66 041	CR	815 699	US Class I	2 526 444
US Class I	158 623	IR	64 460	Japan	245 612	IR	625 723
SNCF	139 501	Canada Frt	52 002	**SNCF**	86 094	Canada Frt	372 264
DBAG	137 482	Amtrak	37 000	**DBAG**	77 567	**DBAG**	111 980
Japan	127 900	**DBAG**	33 570	**ATOC**	57 500	***PKP***	37 189
PKP	100 942	**RFF**	29 616	**FS**	39 368	**Green Cargo**	*24 000*
FS	76 417	Japan	20 131	**RENFE**	21 398	**SNCF**	23 241
ATOC	49 405	***PKP***	19 725	SBB/CFF/FFS	17 156	Japan	20 256
ÖBB	45 352	**FS**	16 726	**NS**	16 808	**UK Freight**	*20 000*
MAV	37 034	**Network Rail**	15 759	***PKP***	15 740	**ÖBB**	16 890
SNCB/NMBS	36 453	**ADIF**	13 945	**SNCB/NMBS**	10 848	***LDZ***	16 550
Network Rail	34 130	*VIA*	13 490	Amtrak	10 331	***LG***	15 088
Canada Frt	33 106	***CFR***	10 777	**ÖBB**	10 300	***CD***	12 123
CD	31 846	**BV/Trafik.**	10 014	**DSB**	10 102	**FS**	11 547
SBB/CFF/FFS	28 586	***SZDC***	9 470	***CD***	6 635	**VR**	9 395
CFR SA	23 951	***MAV***	7 387	**SJ**	6 381	***MAV Cargo***	*8 000*
Amtrak	20 047	**RHK/FTA**	5 944	***MAV Start***	5 561	SBB/CFF/FFS	7 656
ZSR	15 820	**ÖBB**	4 826	***CFR Calatori***	4 814	**RENFE**	7 564
CFR Calatori	14 269	JBV	4 154	**VR**	3 882	***ZSSK Cargo***	7 290
RENFE	13 955	***NRIC***	4 072	**CP**	3 750	***CFR MARFA***	6 658
NRIC	13 825	***ZSR***	3 624	NSB	2 663	**SNCB/NMBS**	*5 500*
ADIF	13 433	**SNCB/NMBS**	*3 578*	***ZSSK***	2 413	**NS**	*5 000*
HZ	12 468	SBB/CFF/FFS	3 040	***BDZ***	2 068	***EVR***	*5 000*
LDZ	11 665	**Pro Rail**	*2 886*	**CIE**	1 638	***GFR***	4 805
SZDC	11 631	**REFER**	2 794	***HZ***	1 486	***SZ***	3 584
BDZ	10 637	***HZ***	2 722	VIA	1 369	Cargonet	*3 000*
LG	10 505	**OSE**	2 534	**OSE**	*1 300*	***BDZ***	2 497
CFR MARFA	9 145	**BDK**	*2 130*	**FNM**	*1 100*	***HZ***	2 438
VR	8 967	**CIE**	1 919	BLS	865	**CP Carga**	2 064
SZ	8 886	***LDZ***	1 864	**FGC**	821	**DSB**	*1 800*
ZSSK Cargo	8 701	***LG***	1 767	***SZ***	773	BLS Cargo	1 104
DSB	8 084	***SZ***	1 209	***LG***	389	***Servtrans***	781
NS	7 653	**FEVE**	1 192	**CFL**	349	***Gysev***	775
BV/Trafik.	6 758	***EVR***	792	**Euskotren**	279	***BRC***	671
ZSSK	4 862	BLS	430	***EVR***	243	***CFR SA***	614
CIE	4 198	**FNM**	*318*	***Gysev***	200	**OSE**	*500*
Pro Rail	3 954	***Gysev***	284	**FEVE**	183	**FEVE**	388
JBV	3 600	**CFL**	275	***LDZ***	84	***Unifertrans***	362
OSE	3 262	**FGC**	270			**CFL Cargo**	*200*
REFER	3 237	**Euskotren**	226			***Bulmarket***	123
Green Cargo	*3 200*					**CIE**	105
NSB	3 183					**FGC**	49
CP	3 132						
CFL	3 077						
SJ	3 037						
VIA	2 899						
BLS	2 722						
GFR	2 603						
FNM	*2 200*						
BDK	*2 000*						
FEVE	1 957						
EVR	1 796						
Gysev	1 354						
RFF	1 353						
FGC	1 298						
Euskotren	863						
Servtrans	792						
CP Carga	665						
Unifertrans	*270*						
BRC	253						
TFG	130						
RHK/FTA	120						
Bulmarket	80						
BLS Cargo	79						

Table 2.A1.3. Average length of haul in km

EU15	EU10	CH/NO	All Other
Railway	Passenger	Railway	Freight
CR	529	US Class I	1 477
Amtrak	355	Canada Frt	1 199
VIA	331	CR	805
LDZ	250	IR	679
SJ	205	Japan	654
IR	128	CFR SA	483
CFR Calatori	90	RENFE	437
OSE	87	GFR	392
PKP	85	SNCF	371
LG	84	Green Cargo	353
SNCF	79	BRC	324
FS	75	DBAG	318
BDZ	71	LG	288
VR	57	LDZ	279
NS	54	FS	276
ZSSK	53	VR	270
NSB	52	PKP	265
EVR	51	Bulmarket	259
MAV Start	50	DSB	240
ÖBB	49	BLS Cargo	237
SZ	49	Unifertrans	237
SBB/CFF/FFS	49	CP Carga	226
SNCB/NMBS	47	Freight	222
DSB	46	SZ	220
RENFE	46	BDZ	215
CIE	44	Servtrans	207
Gysev	41	HZ	207
DBAG	40	EVR	200
CD	40	MAV Cargo	200
ATOC	39	ÖBB	199
HZ	30	ZSSK Cargo	194
CP	30	Floyd	190
Japan	28	CD	182
FEVE	21	CFR MARFA	181
CFL	19	CIE	172
BLS	17	SBB/CFF/FFS	163
Euskotren	11	OSE	147
FGC	10	FEVE	142
		Gysev	141
		SNCB/NMBS	138
		FGC	63
		CFL Cargo	32

Note: Data from 2011.

Table 2.A1.4. Passenger shares (%) measured by traffic units, gross tonne-kms and train-kms

EU15	EU10	CH/NO	All Other		
	% of TU		% of Gross Tonne-Km		% of Train-Km
ZSSK	100	CIE	100	DSB	100
MAV Start	100	FNM	100	NS	100
Amtrak	100	NS	100	ZSSK	100
VIA	100	NIR	100	MAV Start	100
NSB	100	ZSSK	100	Amtrak	100
Euskotren	100	MAV Start	100	VIA	100
FGC	94	VIA	100	Euskotren	100
CIE	94	NSB	100	FGC	98
Japan	92	Euskotren	98	CIE	98
DSB	85	FGC	93	Japan	92
SNCF	79	Japan	81	SNCB/NMBS	89
FS	77	SNCF	73	CFL	89
NS	77	RENFE	70	SNCF	89
ATOC	74	SNCB/NMBS	67	RENFE	88
RENFE	74	CP	62	FEVE	88
OSE	72	SBB/CFF/FFS	61	FS	88
SBB/CFF/FFS	69	CFL	59	OSE	87
SNCB/NMBS	66	FEVE	49	SBB/CFF/FFS	83
CP	64	BDZ	46	CP	82
CFL	64	SJ	46	CD	82
IR	61	CD	43	BDZ	75
BLS	44	Gysev	42	HZ	75
DBAG	41	DBAG	42	DBAG	75
BDZ	39	HZ	35	CFR Calatori	74
ÖBB	38	IR	35	Gysev	74
HZ	38	VR	35	BLS	73
CD	35	CFR Calatori	34	VR	70
FEVE	32	ATOC	33	PKP	69
PKP	30	ÖBB	32	ÖBB	69
VR	29	BLS	31	IR	64
CFR Calatori	28	PKP	24	SZ	60
CR	24	SZ	19	CR	44
SJ	21	CR	17	EVR	38
Gysev	21	LG	4	LG	36
SZ	18	EVR	4	Servtrans	15
EVR	5	LDZ	1	US Class I	7
LG	3	Canada Frt	1	LDZ	6
LDZ	1				
US Class I	1				

Table 2.A1.5. Measures of line traffic density

EU15	EU10	CH/NO	All Other		
	TU/Km (000)		Gross T-Km/Km (000)		Train-Km/Km
CR	51 155	CR	72 238	SBB/CFF/FFS	45 663
IR	24 887	US Class I	29 585	NS	39 369
US Class I	16 553	IR	24 356	FGC	38 007
Japan	13 207	SBB/CFF/FFS	24 342	Japan	37 355
LDZ	8 924	EVR	17 249	BLS	37 072
LG	8 759	LG	16 365	CFL	32 724
SBB/CFF/FFS	8 162	LDZ	15 510	UK	32 631
NS	7 556	Japan	13 853	CR	30 817
Canada Frt	7 185	ÖBB	13 749	FNM	28 346
EVR	6 620	Canada Frt	12 930	ÖBB	28 212
DBAG	5 646	DBAG	11 703	DSB	27 809
ÖBB	5 634	NS	11 499	DBAG	25 772
DSB	5 588	SNCB/NMBS	10 900	SNCB/NMBS	24 427
UK	4 918	CFL	8 844	Euskotren	23 367
SNCB/NMBS	4 569	BLS	6 977	Gysev	18 824
SNCF	3 692	SNCF	6 970	FS	16 474
SZ	3 604	Gysev	6 810	SZ	16 443
FNM	3 459	SZ	6 699	SNCF	15 659
Gysev	3 433	ZSSK	5 832	CD	15 598
FGC	3 222	FNM	5 346	IR	14 629
FS	3 044	FGC	5 293	RENFE	13 087
PKP	2 683	PKP	5 289	MAV	12 574
ZSSK	2 677	VR	4 937	CP	12 554
VR	2 234	CD	4 784	ZSSK	11 591
CP	2 081	RENFE	4 545	HZ	9 102
RENFE	2 077	UK	3 996	CIE	9 051
BLS	2 012	CP	3 761	LG	8 671
CFL	1 996	CFR	3 495	PKP	8 645
CD	1 981	MAV	3 374	VR	8 592
MAV	1 836	Euskotren	3 133	EVR	8 415
CFR	1 616	HZ	2 868	FEVE	8 270
HZ	1 442	BDZ	2 289	OSE	8 208
BDZ	1 316	FS	1 495	BDZ	7 737
Euskotren	1 235	CIE	1 407	CFR	7 578
CIE	908	FEVE	1 102	LDZ	5 293
OSE	710	Amtrak	1 047	US Class I	4 491
FEVE	479	OSE	1 026	Amtrak	1 629
Amtrak	279	JBV	849	VIA	785
VIA	101	VIA	321	Canada Frt	204

Note: Data from 2011.

Table 2.A1.6. Measures of productivity of rolling stock

EU15	*EU10*	CH/NO	All Other

Railway	Passenger-Km/Coach + MUs	Railway	Tonne-Km/Wagon	Railway	TU/Locomotive + adjusted Mus*
IR	223 404	*Gysev*	8 424	IR	178 950
CR	60 049	Canada Frt *	5 429	CR	172 449
SBB/CFF/FFS	47 132	CR	3 983	Japan	159 473
Japan	44 820	Green Cargo	3 429	Canada Frt	134 780
SJ	35 450	IR	3 276	SJ	104 038
CFR Calatori	20 227	*LDZ*	2 702	US Class I	102 161
DSB	18 434	Japan	2 328	DSB	83 231
BDZ	14 563	*BRC*	2 207	*LDZ*	82 347
FS	14 399	US Class I	2 005	Green Cargo	76 190
SNCF	14 170	*GFR*	1 848	*MAV Start*	75 489
HZ	13 759	*EVR*	1 677	*EVR*	69 907
VR	11 155	*LG*	1 634	*LG*	58 294
Gysev	11 111	SNCF	1 144	RENFE	56 566
Amtrak	8 777	*SZ*	1 141	NS	55 942
CP	8 601	DBAG	1 049	CP Carga	46 909
ÖBB	7 768	ÖBB	958	NSB	40 146
PKP	7 301	SBB/CFF/FFS	925	FGC	29 326
SNCB/NMBS	7 251	VR	907	ATOC	28 975
LG	6 707	*MAV Cargo*	727	SNCF	28 931
ZSSK	6 557	CP Carga	651	DBAG	27 558
MAV Start	6 277	*Unifertrans*	635	VR	26 741
OSE	5 078	RENFE	613	*BRC*	25 808
CFL	4 847	*PKP*	571	SNCB/NMBS	25 438
CD	4 570	*Bulmarket*	542	*Floyd*	24 300
EVR	4 500	*BDZ*	514	*SZ*	23 962
FGC	3 873	SNCB/NMBS	500	BLS Cargo	22 080
BLS	3 794	*Servtrans*	485	CP	21 887
DBAG	3 778	*CD*	444	*Gysev*	21 429
NS	3 560	FS	405	*GFR*	21 167
ATOC	2 677	*HZ*	402	ÖBB	20 711
CIE	2 452	FEVE	340	FS	18 742
FNM	2 444	FGC	239	CIE	18 220
NSB	2 245	CIE	209	SBB/CFF/FFS	17 791
VIA	1 720	*CFR MARFA*	167	*PKP*	16 133
SZ	1 528	OSE	158	*HZ*	15 812
Euskotren	1 125	CFL Cargo	51	*Unifertrans*	12 067
LDZ	420	Euskotren	3	FNM	11 640
				FEVE	10 774
				BDZ	10 666
				CD	10 451
				ZSSK Cargo	10 353
				ZSSK	9 923
				OSE	9 262
				VIA	9 229
				CFL	9 184
				Euskotren	9 152
				Bulmarket	8 786
				CFR MARFA	7 671
				BLS	7 588
				CFR Calatori	5 762
				CFL Cargo	3 448

* Canada's apparent high productivity may be due to exclusion of non-railway owned wagons.

Note: Data from 2011.

Table 2.A1.7. Indicators of output per employee

EU15	EU10	CH/NO	All Other

Railway	TU/ Employee (000)	Railway	GT-Km/ Employee (000)	Railway	Train-Km/ Employee
US Class I	15 927	US Class I	28 339	NS	14 846
Canada Frt	11 245	Canada Frt	20 179	SJ	13 303
Green Cargo	7 500	Green Cargo	7 813	RENFE	13 078
Floyd	3 857	EVR	7 606	ATOC	10 408
CP Carga	3 104	SJ	6 915	CP Carga	9 335
EVR	2 919	CP Carga	6 027	CP	9 217
NS	2 850	BRC	4 593	NSB	8 840
BRC	2 652	RENFE	4 541	NIR	7 931
SJ	2 101	NS	4 336	FGC	7 906
Japan	2 079	Floyd	3 857	DSB	7 327
RENFE	2 075	VR	3 272	OSE	6 376
GFR	1 846	GFR	3 069	ZSSK	6 319
CR	1 647	DBAG **	2 857	DBAG **	6 292
Bulmarket	1 538	LG	2 753	Floyd	6 222
VR	1 481	SBB/CFF/FFS	2 589	Euskotren	6 119
LG	1 473	Unifertrans	2 574	Japan	5 880
DSB	1 472	LDZ	2 478	SBB/CFF/FFS	5 868
LDZ	1 426	CR	2 326	BLS	5 856
DBAG **	1 378	Japan	2 180	VR	5 695
Unifertrans	1 341	CP	2 075	FEVE	5 037
IR	1 208	NSB	2 007	US Class I	5 007
CP	1 197	Servtrans	1 948	CD	4 638
ATOC	1 164	Amtrak	1 932	CFR Calatori	4 260
Servtrans	986	ZSSK Cargo	1 682	CIE	4 137
SBB/CFF/FFS	868	CFR MARFA	1 607	FNM	4 097
ZSSK Cargo	838	Bulmarket	1 538	Gysev	3 948
NSB	837	VIA	1 494	BRC	3 806
SNCF *	784	SNCF *	1 480	EVR	3 711
CFR MARFA	728	ÖBB	1 463	VIA	3 652
Gysev	720	Gysev	1 428	FS	3 606
FGC	670	CD	1 423	SNCF *	3 326
FS	666	ZSSK	1 337	Bulmarket	3 225
ÖBB	600	NIR	1 213	Amtrak	3 007
CD	589	IR	1 182	ÖBB	3 002
OSE	552	BLS	1 102	BDZ	2 847
PKP	524	FGC	1 101	GFR	2 471
Amtrak	515	SNCB/NMBS	1 070	SNCB/NMBS	2 398
FNM	500	PKP	1 033	SZ	2 237
ZSSK	496	JBV	980	Servtrans	2 091
SZ	490	SZ	911	HZ	1 987
VIA	472	CFR Calatori	893	Unifertrans	1 922
SNCB/NMBS	448	Euskotren	820	PKP	1 689
BDZ	429	OSE	797	LG	1 459
CIE	415	FNM	773	CFR MARFA	1 370
NIR	354	BDZ	755	ZSSK Cargo	1 297
CFR Calatori	337	FEVE	671	CR	992
Euskotren	323	CIE	643	LDZ	846
BLS	318	HZ	626	IR	710
HZ	315	ATOC	425		
FEVE	292	FS	327		
CFR SA	26				

* SNCF adjusted for non-rail employees (1.079)

** DB AG adjusted for non-rail employees (2.053)

Note: Data from 2011.

Table 2.A1.8. Operating Ratios (%)

EU15	***EU10***
CH/NO	**All Other**
Railway	**Operating Ratio***
RHK/FTA	900.0
OSE	553.6
FEVE	442.5
BV/Trafik.	250.0
VIA	185.5
FGC	171.3
Amtrak	150.2
CP Carga	143.5
REFER	143.4
CP	136.0
CFR SA	131.4
SNCB/NMBS	120.0
Servtrans	114.0
NRIC	112.9
BDZ Cargo	109.5
MAV Cargo	108.0
MAV	105.6
CFR MARFA	105.1
ZSR	105.0
HZ	104.1
ADIF	103.9
CIE	103.0
Green Cargo	103.0
JBV	103.0
DSB	101.3
ZSSK	100.3
PKP	100.2
NSB	99.7
SZ	99.6
SJ	99.2
CFR Calatori	98.8
BLS	98.3
VR	98.1
CD	97.4
ZSSK Cargo	95.4
DBAG	95.0
Canada Frt	94.8
SBB/CFF/FFS	93.4
Pro Rail	93.0
LDZ	92.8
FS	92.7
NS	92.5
GKB	91.8
SZDC	91.2
ÖBB	90.5
RENFE	90.3
Unifertrans	90.0
SNCF	89.3
LG	88.5
DBAG **	86.9
Japan	83.1
RFF	78.7
CFL	76.4
US Class I	73.2
Gysev	69.9
EVR	69.0
Network Rail ***	64.5

* Operating Ratio is defined as Operating Expenses/ Operating Revenues (%). Operating Expenses include Depreciation and Amortization, but exclude costs of capital (principal and interest on debt and equity.

** Estimated from DB Annual Reports. See, e.g. 2010 Annual Report at pg 60

*** Taken from Network Rail Annual Report. See pg 1 of 14 of 2010/2011 Annual Report.

Table 2.A1.9. Average revenues expressed as constant 2011 US PPP $ per passenger-km or per tonne-km

EU15	EU10	CH/NO	All Other
Railway	**Average Passenger Revenue/ Passenger-Km**	**Railway**	**Average Freight Revenue/ Tonne-Km**
CFL	0.7520	Unifertrans	0.1593
LDZ	0.3979	ÖBB	0.1501
CFR Calatori	0.2950	Gysev	0.1357
Amtrak	0.2899	BLS Cargo	0.1224
DBAG	0.2560	CIE	0.1087
Gysev	0.2453	CFR MARFA	0.1077
NS	0.2240	FS	0.1056
SNCB/NMBS	0.2063	FGC	0.1035
ÖBB	0.2041	GFR	0.1029
CIE	0.1997	Servtrans	0.1020
SNCF	0.1931	BDZ	0.0975
ATOC	0.1878	CD	0.0842
FS	0.1682	SBB/CFF/FFS	0.0830
VIA	0.1647	DBAG *	0.0825
BLS	0.1552	BRC	0.0817
NIR	0.1525	PKP	0.0813
Japan	0.1502	IR	0.0760
SBB/CFF/FFS	0.1456	SNCB/NMBS	0.0682
LG	0.1396	SNCF	0.0626
VR	0.1375	LG	0.0609
HZ	0.1338	Japan	0.0573
SZ	0.1329	SZ	0.0566
NSB	0.1155	ZSSK Cargo	0.0558
MAV Start	0.1084	FEVE	0.0458
RENFE	0.1076	VR	0.0435
SJ	0.1044	LDZ	0.0417
FGC	0.1019	CP Carga	0.0362
PKP	0.0955	RENFE	0.0347
FEVE	0.0831	US Class I	0.0257
Euskotren	0.0818	Canada Frt	0.0236
CD	0.0810	CR	0.0232
CP	0.0720	EVR	0.0142
BDZ	0.0604	HZ	0.0100
DSB	0.0590		
ZSSK	0.0483		
CR **	0.0469		
IR	0.0201		

* The UIC data for DB AG freight Revenues are probably contaminated by trucking revenues generated by Schenker The average revenue shown here is taken from data for the DB AG rail freight business group as shown in the DB AG Annual Report for 2011.

** Estimated from 2008

Table 2.A1.10. Rail market shares for passengers and freight

Country	Rail Passenger Share (% Pass-Km) of Rail, Bus and Auto Traffic	Country	Rail Share (% Tonne-Km) of Truck Barge and Pipeline Traffic	Country	Rail Share (% Tonne-Km) of Rail and Truck Traffic Only
Austria		Austria	34.9	Austria	41.6
Belgium	7.4	Belgium	13.7	Belgium	16.8
Denmark	9.2	Denmark	14.6	Denmark	17.9
Finland	5.0	Finland	25.8	Finland	25.9
France	9.3	France	14.4	France	16.1
Germany (DBAG)	8.1	Germany (DBAG)	22.3	Germany (DBAG)	25.9
Greece	3.8	Greece	1.7	Greece	1.7
Ireland		Ireland	1.0	Ireland	1.0
Italy	5.6	Italy	7.8	Italy	8.3
Luxembourg		Luxembourg	2.9	Luxembourg	3.0
Netherlands	10.7	Netherlands	6.8	Netherlands	15.1
Portugal		Portugal	15.0	Portugal	15.3
Spain	5.5	Spain	3.6	Spain	3.7
Sweden	8.8	Sweden	40.6	Sweden	40.6
UK	7.4	UK	11.3	UK	12.0
EU 15	7.0	EU 15	15.4	EU 15	17.5
Bulgaria	17.5	Bulgaria	12.5	Bulgaria	13.4
Czech Rep.	8.2	Czech	19.9	Czech	20.7
Slovakia	7.2	Slovak	21.0	Slovak	21.5
Estonia	9.9	Estonia	48.8	Estonia	48.8
Hungary	10.2	Hungary	17.9	Hungary	20.9
Latvia	27.2	Latvia	59.5	Latvia	63.8
Lithuania	1.2	Lithuania	40.6	Lithuania	41.2
Poland	5.2	Poland	18.1	Poland	19.7
Romania	30.1	Romania	27.6	Romania	35.8
Slovenia	2.7	Slovenia	63.3	Slovenia	63.3
EU 10	7.3	EU 10	23.8	EU 10	25.9
Croatia	32.1	Croatia	18.0	Croatia	21.5
Norway	4.6	Norway	15.0	Norway	17.2
Switzerland	17.5	Switzerland	39.4	Switzerland	39.7
US	0.2	US	32.3	US	39.0
Canada	0.3	Canada	44.4	Canada	64.6
China	36.4	China	26.8	China	36.4
Japan	84.2	Japan	7.9	Japan	7.9
India	14.1	India	33.2	India	35.6

* Note: This is taken from OECD website data

Table 2.A1.11. Development of railway traffic over time

Total Passenger-Km		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	CAGR 1980 to 2011 (%)	CAGR 1995 to 2011 (%)
France	SNCF	40 979	50 696	54 660	62 070	63 761	55 311	69 571	76 559	79 483	81 487	86 664	85 697	84 860	86 094	2.2	4.1
Germany	DBAG*	62 362	66 177	63 637	65 157	61 024	70 334	74 015	72 497	74 738	74 677	76 929	75 579	77 221	77 567	0.9	0.9
UK	BR/ATOC/Frt	30 409	30 256	31 704	30 256	33 191	30 000	38 200	43 100	46 100	48 800	50 800	51 500	54 600	57 500	2.9	6.1
EU-		219 183	244 950	250 263	258 071	269 593	273 724	298 945	299 741	313 374	315 847	334 435	344 443	344 800	349 668	1.6	2.3
Czech Rep	CD						8 023	7 266	6 631	6 887	6 855	6 759	6 462	6 553	6 635	na	-1.7
Poland	PKP	36 891	42 819	46 324	51 978	50 373	20 960	19 706	16 742	16 971	17 081	17 958	16 454	15 715	15 740	-5.0	-2.6
EU-		101 034	109 558	119 213	133 724	131 326	68 520	54 290	47 105	47 674	46 339	46 165	40 264	38 871	38 920	-5.2	-5.0
US	Amtrak		6 031	7 637	8 042	9 769	8 924	8 970	8 660	8 706	9 309	9 943	9 476	9 518	10 331	1.4	1.3
Japan	Japan	189 726	215 289	193 143	197 463	237 551	248 993	240 657	245 957	249 029	255 201	253 555	244 235	244 591	245 612	1.2	-0.1
Switzerland	SBB/CFF/FFS	8 168	7 984	9 167	9 381	11 049	11 712	12 835	13 830	14 267	15 132	16 142	16 182	16 868	17 156	3.0	3.5

Freight Tonne-Km (000,000)		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	CAGR 1980 to 2011 (%)	CAGR 1995 to 2011 (%)
France	SNCF	67 586	63 473	68 815	55 121	50 667	48 136	55 352	40 701	40 924	40 634	35 932	26 482	22 840	23 241	-5.0	-6.4
Germany	DBAG *	109 963	103 114	118 988	120 493	101 166	69 442	76 815	81 722	88 407	92 077	91 178	72 257	80 378	111 980	-0.3	4.4
UK	BR/ATOC/Frt	24 550	20 960	17 640	16 047	15 986	12 537	18 090	21 700	21 880	21 180	20 630	19 060	19 230	20 000	0.6	4.3
EU-		387 140	361 684	404 831	393 535	354 582	219 743	249 703	237 664	253 120	251 712	246 595	178 880	183 365	240 223	-2.5	0.8
Czech Rep	CD						22 634	17 220	14 385	16 364	16 972	15 951	12 616	11 921	12 123	na	-5.5
Poland	PKP	98 233	127 505	132 576	118 863	81 776	68 206	54 015	45 438	42 651	43 548	39 200	29 941	34 327	37 189	-5.9	-5.4
EU-		267 495	330 140	350 849	340 652	253 261	168 657	144 489	140 046	138 913	140 534	131 839	96 287	98 572	122 353	-4.9	-2.9
US	Class I	1 117 386	1 101 962	1 342 598	1 281 274	1 510 629	1 907 610	2 141 768	2 478 477	2 588 741	2 586 767	2 596 542	2 256 650	2 470 556	2 526 444	3.1	2.6
Japan	Japan	61 482	46 030	36 961	21 383	26 803	24 747	21 800	22 632	23 014	23 166	22 100	20 432	20 255	20 256	-2.8	-1.8
Switzerland	SBB/CFF/FFS	6 592	5 139	7 385	7 049	8 303	8 156	10 658	8 571	8 439	13 368	12 531	4 181	7 778	7 656	0.2	-0.6

* Before 1993, this is the sum of DB and DR.

Table 2.A1.12. Evolution of operating ratio and TU/employee over time

Operating Ratio %		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
France	SNCF	100	105	104	113	107	107	98	96	96	96	96	100	93	89
	RFF	-	-	-	-	-	-	-	95	95	101	104	78	77	79
Germany	DBAG *	109	122	114	111	117	99	98	95	93	92	93	94	95	95
UK	BR	88	97	103	100	102	92	-	-	-	-	-	-	-	-
Czech Rep	CD	-	-	-	-	-	110	109	102	101	100	111	101	102	97
Poland	PKP	113	131	103	91	91	102	116	112	105	101	110	111	106	100
United States	Class I	96	97	93	91	87	86	85	82	79	78	77	78	73	73
	Amtrak	-	210	238	198	154	180	-	156	147	146	142	-	153	150
Japan	Japan	114	151	134	157	91	80	85	82	61	81	82	86	85	83
	SBB/CFF/FFS	100	127	122	107	100	99	95	101	95	97	94	93	94	93

TU/Employee		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	CAGR 1980 to 2011 (%)	CAGR 1995 to 2011 (%)
France	SNCF **	358	405	485	484	566	571	713	704	739	758	774	717	707	727	1.9	2.2
Germany	DBAG **	261	269	323	348	339	474	832	700	712	721	700	616	658	671	3.5	3.2
UK	BR/ATOC	200	202	204	260	363	333						1 037	1 099	1 164	8.6	12.1
Czech Rep	CD						297	284	322	395	420	467	490	505	589	na	6.4
Poland	PKP	375	475	492	452	393	371	403	487	474	491	470	410	470	524	0.3	3.2
US	Class I	1 973	2 259	2 929	4 244	6 980	10 135	12 721	15 258	15 448	15 470	15 790	14 856	16 268	15 927	8.4	4.2
US	Amtrak		685	357	364	407	374	350	450	467	490	518	493	480	515	1.8	2.9
Japan	Japan	546	608	556	791	1 364	1 422	1 654	1 981	2 065	2 142	2 130	2 055	2 070	2 079	6.5	3.5
Switzerland	SBB/CFF/FFS	363	321	431	443	513	593	831	863	891	1 125	1 126	798	876	868	3.4	3.5

* Prior to 1995, DB AG is the older DB

** Both SNCF and DB AG are affected by the presence of a large number of non-rail employees, which cannot be corrected for 1980 and 1995. If later years include a higher percentage of non-rail than earlier years, then TU/Employee will look too low, and productivity growth will also look too low.

Table 2.A1.13. Evolution of railway average tariffs

Average Passenger Revenue/Passenger-Km Expressed in 2011 PPP International Dollars

		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
France	**SNCF**	0.0478	0.0611	0.0877	0.1257	0.1249	0.1090	0.1234	0.1767	0.1761	0.1764	0.1793	0.1905	0.1908	0.1931
Germany	**DBAG ****	0.1079	0.1673	0.2015	0.1993	0.1906	0.1808	0.1852	0.2167	0.2080	0.2043	0.2045	0.2193	0.2266	0.2560
UK	**BR/ATOC**	0.0332	0.0483	0.0947	0.1238	0.1479	0.1661	0.1609	0.1591	0.1615	0.1635	0.1715	0.1842	0.1832	0.1878
Czech Rep	***CD***						0.0419	0.0749	0.0768	0.0750	0.0754	0.0722	0.0827	0.0808	0.0810
Poland	***PKP***					0.0041	0.0558	0.0687	0.1004	0.1032	0.0855	0.0882	0.1051	0.0997	0.0955
US	Amtrak		0.1174	0.1389	0.1451	0.1602	0.1510	0.1705	0.2171	0.2340	0.2505	0.2935	0.2791	0.2790	0.2899
Japan	All	0.1265	-	0.2164	-	-	0.1739	0.1682	0.1580	0.1553	0.1518	0.1522	0.1573	0.1502	0.1502
Switzerland	SBB/CFF/FFS	0.1107	0.1355	0.1428	0.2244	0.1304	0.1356	0.1158	0.1569	0.1247	0.2016	0.1969	0.1589	0.1449	0.1456

Average Freight Revenue/Tonne-Km Expressed in 2011 PPP International Dollars

		1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
France	**SNCF**	0.0458	0.0584	0.0758	0.1116	0.0942	0.0792	0.0528	0.0569	0.0546	0.0544	0.0584	0.0646	0.0642	0.0626	
Germany	**DBAG****	0.1372	0.1755	0.1610	0.1513	0.1161	0.0900	0.0601		0.0471	0.0475	0.0536	0.0535	0.0544	0.0564	0.0587
UK	**BR/Frt**	0.0356	0.0538	0.1075	0.1094	0.1161	na	na	na	na	na	na	na	na	na	
Czech Rep	***CD (2003)***						0.0988	0.1336	0.1062	0.0910	0.0845	0.0819	0.0751	0.0946	0.0842	
Poland	***PKP***					0.0232	0.0724	0.0825	0.0835	0.0839	0.0803	0.0846	0.0854	0.0810	0.0813	
United States	Class I	0.0342	0.0416	0.0458	0.0413	0.0306	0.0243	0.0185	0.0190	0.0200	0.0207	0.0232	0.0213	0.0232	0.0257	0.0263
Japan	All	0.1193	0.1229	0.1718	-	-	0.0800	0.0674	0.0575	0.0565	0.0557	0.0564	0.0600	0.0573	-	
Switzerland	SBB/CFF/FFS	0.2121	0.2823	0.2235	0.2111	0.1574	0.1279	0.0925	0.0954	0.0949	0.0753	0.0780	-	0.0883	0.0830	

** Before 1995, this uses the old DB data (DR not included). Freight rates are recalculated from DB Annual Reports to remove apparent Schenker distortion.

Table 2.A1.14. Evolution of railway market shares

Rail Market Share (% Passenger-Km) of Rail, Auto and Bus Passenger Traffic

	1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
France	11.0	11.2	10.0	10.5	8.8	7.0	8.1	8.3	8.6	8.7	9.3	9.2	9.1	9.3
Germany	8.8	7.7	7.1	7.4	6.3	7.4	7.7	7.6	7.7	7.7	8.0	7.9	8.0	8.1
UK	8.1	7.5	6.7	6.0	5.1	4.3	5.4	5.7	5.9	6.3	6.6	6.7	7.1	7.4
EU 15	10.4	9.5	8.5	8.1	7.0	6.6	6.9	7.0	7.2	7.3	7.6	7.9	7.8	7.0
Czech Republic						10.9	9.1	7.9	8.0	7.8	7.7	7.4	8.1	8.2
Poland	55.9	48.3	48.5	36.1	30.6	12.7	9.8	7.3	6.9	6.8	6.3	5.7	5.3	5.2
EU 10	50.1	40.1	35.8	32.6	29.1	16.2	12.3	9.0	8.6	8.3	7.8	7.3	7.0	7.3
US	0.4	0.1	0.1	0.1	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Japan	50.4	47.3	42.2	40.3	31.2	30.4	28.8	29.5	30.1	30.6	30.9	30.4		
Switzerland	16.9	14.2	12.9	12.3	14.8	14.4	13.6	16.1	16.4	16.9	17.0	17.3	17.5	17.5

Rail Market Share (% Net Tonne-Km) of Rail Plus Truck Traffic

	1970	1975	1980	1985	1990	1995	2000	2005	2006	2007	2008	2009	2010	2011
France	50.5	42.1	39.8	39.1	30.2	22.9	23.1	17.0	17.2	17.1	17.1	16.2	14.7	16.1
Germany	47.5	36.1	33.9	32.3	37.8	22.9	21.6	23.5	24.5	25.0	25.3	23.8	25.5	25.9
UK	22.4	18.6	16.2	13.7	10.7	8.3	10.5	11.4	11.6	10.9	11.5	12.0	10.8	12.0
EU 15	32.2	23.6	21.5	20.5	20.3	15.4	15.6	14.3	15.2	15.2	15.4	14.3	14.8	15.4
Czech Republic						44.9	30.9	25.5	23.9	25.3	23.3	22.2	21.0	20.7
Poland	86.3	79.9	75.2	76.7	67.5	57.1	41.9	29.4	28.2	25.4	23.0	18.5	18.5	19.7
EU 10	78.4	74.4	69.3	69.4	63.8	48.0	40.0	29.0	27.5	26.0	24.8	22.1	22.4	23.8
United States*	65.1	62.5	62.7	59.5	59.7	59.9	56.4	57.5	59.0	58.0	54.8	54.5		
Japan	31.7	26.6	17.3	9.6	9.0	7.9	6.6	6.4	6.3	6.2	6.0	5.8	7.7	7.9
Switzerland	59.0	52.7	53.2	47.8	44.0	42.2	44.9	42.6	43.3	41.3	41.5	38.4	39.4	39.7

* US calculated on different basis using AAR statistics for rail versus intercity truck only. OECD does not provide similar data for other countries.

Table 2.A1.15. Rail Liberalisation Index for EU railways

>800	Advanced
600 to 800	On Schedule
300 to 600	Delayed
<300	Pending Departure
	No data

LEX, ACCESS and COM Details

	Overall Liberalization				2007		2011		LEX				ACCESS				COM			
Country	2002	2004	2007	2011	Frt.	Pass.	Frt.	Pass.	2002	2004	2007	2011	2002	2004	2007	2011	2002	2004	2007	2011
UK	805	781	827	865	848	798	862	852	960	940	969	980	740	715	791	837	780	580	793	866
DE	760	728	826	842	844	809	875	814	840	750	905	935	840	720	807	819	520	505	555	615
SE	760	729	825	872	908	742	896	855	800	680	857	960	760	760	817	850	720	510	633	577
NL	720	695	809	817	887	732	884	779	760	670	865	887	820	710	795	799	460	455	509	680
AT	430	579	788	806	852	727	873	761	680	530	819	895	410	600	781	784	240	232	349	575
DK	720	693	788	825	811	757	851	808	860	790	821	925	770	650	780	800	480	390	498	655
CH	650	677	757	741	848	662	850	680	600	605	670	678	770	710	778	756	440	495	459	509
PL		549	739	737	786	692	826	699		600	783	803		530	728	720		175	490	518
CZ		549	738	738	798	679	783	705		530	839	786		560	713	726		215	279	422
RO			722	726	797	650	834	650			822	783			697	711			440	487
PT	380	668	707	737	797	619	847	676	700	820	829	884	290	605	676	701	220	190	200	434
SK		458	700	738	756	643	793	702		535	853	857		430	662	708		260	381	381
NO	390	589	698	729	836	574	861	652	580	570	777	769	410	595	679	719	140	135	274	482
EE		257	691	729	727	667	781	701		380	728	840		205	680	702		245	704	629
LT		222	684	592	744	624	703	530		260	820	730		210	650	558		165	184	120
IT	560	688	676	737	734	617	809	706	660	740	819	795	680	670	640	722	240	225	293	470
SI		326	665	672	743	585	799	590		550	622	655		230	675	676		120	153	337
BG			652	718	761	557	806	668			722	839			635	688			241	421
LV		516	650	587	733	576	747	500		580	683	780		485	642	539		225	313	411
BE	395	461	649	753	780	518	881	663	380	425	740	820	500	475	626	737	180	180	201	424
HU		366	637	658	740	533	780	592		485	731	822		320	613	616		125	275	522
FI	410	542	636	672	732	540	753	661	620	640	732	729	440	505	612	657	160	140	145	156
ES	195	148	630	583	785	486	770	485	300	250	711	701	180	105	610	554	140	110	151	333
LU	280	467	581	585	688	474	742	508	520	530	551	669	220	440	588	564	152	120	115	104
FR	340	305	574	612	727	431	772	521	340	360	595	650	430	280	568	602	152	130	178	334
GR	210	162	559	592	690	429	698	559	260	305	619	859	240	100	544	525	100	100	133	136
IE	295	149	333	467	458	206	603	399	520	180	332	414	280	130	338	481	100	100	115	120
Sample	17	25	27	27	27	27	27	27	17	25	27	27	17	25	27	27	17	25	27	27
EU 15	484	520	681	718	769	592	808	670	613	574	744	807	507	498	665	695	310	264	325	432
EU 10	-	405	688	690	759	621	785	634	-	490	760	790	-	371	670	664	-	191	346	425
EU 25		480	683	706	765	604	799	655		545	751	800		454	667	683		239	333	429
2011 pg				12			66	67				52				59				63
2007 pg.		32	57		71	78					59				64				68	
2004 pg										27				29				3		
2002 pg	5								7				9				11			

Note: 2002 Indices were visually estimated from graphs. Numbers shown were then calculated by multiplying the original numbers by 4, 2 and 4 respectively.

Source: Rail Liberalization Index report of indicated year

Annex 2.A2. Data sources

The good news with railway data – as opposed to trucking, air and water transport data – is that railways probably report more information in more detail than other modes. Depending on the country and the railway (and the year) it is possible to collect all the data used in this chapter along with even more detailed data on types of service, commodities, etc. The bad news is that data taken from different sources purporting to represent the same thing (passenger-km in a particular year) are not always (or even often) consistent. In addition, not all railways report all data in any given year and some railways do not bother to report at all. In some cases, restructuring has meant that most information is lost on those parts of the railway that are established separately (Green Cargo and UK freight operators). The net result is that most of the apparently precise information in rail data sets has to be taken with a grain of salt and that there is a real need for governments and the European Union to take action to improve the quality and amount of rail data reported to the public. Thompson (2007) discusses this issue in more detail.

The basic source of EU railway information is the International Union of Railways (UIC). This includes "Railway Time-Series Data 1970-2000", "Railway Time-Series Data 2008" (the electronic form was used) and various issues of the *International Railway Statistics* for 2002 through 2011. Some of these data were manually transcribed, which may have introduced errors attributable only to the authors and not the UIC.

The source of US data for Class I freight railways is "Analysis of Class I Railroads", as published by the Surface Transportation Board (STB). This report has existed essentially in its current form in an unbroken series since the beginning of the 20th century. We have also used the "Public Use Carload Waybill Sample", with added calculations of variable costs at the two-digit Standard Transportation Commodity Code (STCC) level, as furnished by the STB and processed by the Association of American Railroads (AAR). In some cases, we have used data from "Railroad Facts", a statistical compendium of Class I freight railroad activity, published by the AAR. Amtrak data were taken from various Amtrak statistical reports, notably the "Monthly Performance Report" for September of various years that contain annual fiscal year data, along with various Amtrak Annual Reports.

Canadian data were taken from various issues of *Railway Trends*, published by the Railway Association of Canada (RAC) and data taken from Statistics Canada as processed by the RAC.

UK data are taken from UIC reports and from various editions of *National Rail Trends Yearbook*, published by the Office of the Rail Regulator.

Chinese data are taken from *China Railways Facts*, 2008 edition, published by the Statistics Centre of the Ministry of Railways, along with updated figures provided to us by the Ministry.

Data on tonne-kms and passenger-kms used for calculation of market shares were taken from the OECD website. Data on inflation indices, currency values and PPP conversion factors are taken from the World Bank's "World Development Indicators", which generally cover all countries over the period 1960 to the present. For reasons of space and brevity, we have not included the full set of 33 Excel spreadsheets covering 81 railway entities (26 existing or former countries) over 41 years. These are available on request from the authors (lou.thompson@gmail.com). The tables presented are extracted from these supporting spreadsheets.

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Chapter 3. Efficiency indicators of railways in France

Introduction

France is a key player in the European rail system, far outstripping all other countries in high-speed rail travel, with 53 billion passenger-kilometres travelled in 2013. Because of the size of this market segment, France is the European country with the greatest number of passenger-kilometres per year (92.4 billion in 2013). In terms of freight, France lies in third place in Europe, with 32 billion tonne-kilometres, behind Germany and Poland (with, respectively, 112 and 40 billion tonne-kilometres in 2013). These figures should be seen in light of French public policy for rail in the last several years.

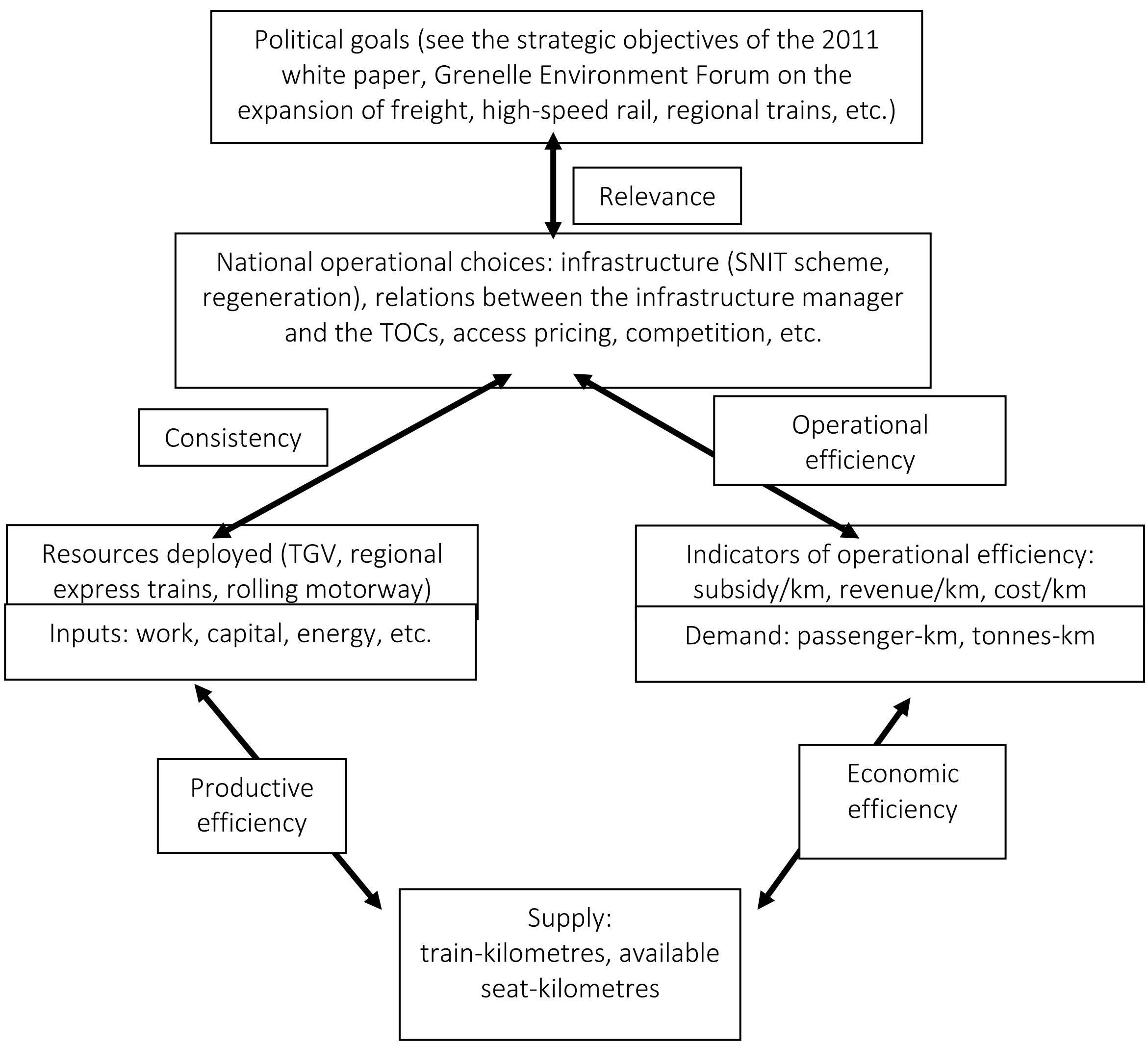
- The success of the TGV is undeniable (Crozet, 2013). Work started in September 1975 on the first high-speed rail (HSR) line, between Paris and Lyon, and it was inaugurated in September 1981. New high-speed lines were opened in 1989 (towards the south-west), in 1993 (towards the north), etc. The high-speed network now covers 2 033 km, and will reach over 2 700 km in 2017 with the opening of the four lines currently being built.
- The regionalisation of intercity and local services was tested in 1997 and fully deployed in the early 2000s. Since then, TERs (regional express trains) have seen traffic rise steeply (50% between 2000 and 2013), as have services in the Ile-de-France region (25%), to a lesser extent.
- Rail freight has been far less successful. The French network carried 55 billion t-km in 2001, but this figure scarcely reached 32 billion t-km in 2013. This weak performance contrasts sharply with the ambitious public policy of the last fifteen years. The Grenelle Environment Forum (2007-2010) oversaw the deployment of a costly freight plan that was no more effective than its predecessors.

The main reason for exploring the differing trends of these three segments of the rail economy is to highlight the fact that, in France and elsewhere, there exists more than one rail market. Performance needs to be measured by type of activity, especially since the theory of network goods (Katz and Shapiro, 1987) and EU Directive 1991/440/EEC showed that infrastructure management should be considered separately from the operation of trains. Regardless of its level of independence from rail operators, the infrastructure manager is now a central player in rail performance. In the second part of this chapter, we will therefore examine infrastructure performance and, since this is a highly capital-intensive activity, the efficiency of capital.

Investment in infrastructure, especially rail infrastructure, largely falls to the public authorities. Even more than in other network industries, in rail the government plays a central role. With the exception of a handful of lines, rail infrastructure in Europe consists of state-owned monopolies. As a legacy of prior decades of integrated monopoly, a country’s main rail operator is also generally owned by the State. Even today, in France, the SNCF has a virtual monopoly over passenger traffic and receives subsidies for its various missions that total EUR 9 billion. Its revenues in France come to EUR 23 billion. When the EUR 4.2 billion paid in annual subsidies to the infrastructure manager is taken into account, total rail subsidies amount to EUR 13.2 billion.[1]

Given this ubiquity of the State, we cannot restrict our examination to the private sector. Neither the train operating companies (TOCs) nor the infrastructure manager are in the standard situation for business activities in which strategic decisions are taken by the shareholders according to the profitability of invested capital. By no means do all rail transport services constitute business activities. A large part of the rail passenger transport offering comes under the public service obligations defined by the EU regulation of that name. It is not appropriate, therefore, to talk about performance or efficiency in unqualified terms. As shown in Figure 3.1, we need to define indicators that distinguish between relevance, consistency and different kinds of efficiencies.

Figure 3.1. Relevance, consistency and efficiency of rail transport



The top section of the figure shows two key ideas: relevance and consistency.

- *Relevance* is about political goals and the operational objectives linked thereto. In 2009, the French parliament passed a national transport infrastructure bill (SNIT) which will see the creation of 4 000 km of new high-speed rail lines by 2030. A committee of parliamentarians and experts (Duron, 2013) subsequently stressed the need to prioritise network maintenance and investment in capacity in rail hubs. Extending the high-speed rail network may require large amounts of public money, as pointed out by the Court of Auditors in 2014. Committing funds to these projects could be considered injudicious at a time when the government is scarcely managing to reduce the deficit.
- *Consistency* compares resources deployed, in the widest possible sense, to operational objectives. Until recently, France made money available to achieve its goals: generous subsidies for regional express trains, expansion of the high-speed network, freight subsidies, funds for the rolling motorway, etc. But worsening public finances have thrown the issue of consistency into sharper relief. In 2013, the transport ministry announced the phasing out of rail freight subsidies. After abandoning the proposed national truck road user charge, it is struggling to find the funding required for the expansion of regional express services and still does not know how it will pay for the new high-speed lines that ministers keep promising (Bordeaux-Toulouse, Montpellier-Perpignan). This creeping inconsistency raises questions about the relevance of the objectives.

This chapter, therefore, remains mindful of this context in which the question of the relevance and consistency of public policy is raised time and again. With this in mind, we will, in the next section, examine the different ways to assess the efficiency of rail transport services. And in the section that follows it, we will turn to the efficiency of infrastructure management.

Efficiency of rail transport services

The lower section of Figure 3.1 shows two main kinds of efficiency. A third is shown to the top right. It is worth examining in detail the reasons why we need to distinguish among them, beginning with economic efficiency.

- Economic efficiency compares technical outputs (train-kilometres) to economic outputs such as passenger-kilometres and tonne-kilometres. A good level of productive output can be associated with poor economic efficiency if supply exceeds demand. Occupancy rates are the critical factor: when occupancy rates are high, economic outputs can be directly compared to technical inputs such as capital and work.
- Productive efficiency is based on traditional economic calculations of productivity and looks at the activity’s most basic ratio of output to input. Outputs can be either train-kilometres or available seat-kilometres. Inputs can be the quantity of work or capital, measured with a greater or lesser degree of complexity, resulting in the calculation of basic or far more sophisticated indicators such as production frontiers.
- Operational efficiency is the standpoint of the public authorities who subsidise rail transport services. The rather simplistic question is this: is it worth it? If the trains are full but costs or subsidies per passenger-kilometre are very high, is the community getting value for money? This idea has been much explored in the United Kingdom, and can be applied to France with a little international benchmarking.

This section will examine each of these three categories. Using a few simple indicators, we will see that the French rail system, when compared to those in neighbouring countries, seems as first sight to be fairly economically successful in passenger transport, although not for freight (see below). But if we probe more deeply, other indicators reveal weaknesses and insufficient improvement in productivity. This lacklustre performance increases pressure on public finances and ultimately leads to poor operational efficiency that is closely linked to the organisational weaknesses in the French rail system.

Strong economic efficiency, but only for passenger transport

As stated in the introduction, France, and more specifically the SNCF[2], ranks first for rail passenger services in Europe, with 92.4 billion passenger-kilometres. Its economic efficiency is undeniable, since this figure was achieved with just 406 million train-kilometres, i.e. an average of 227 passengers per train. By comparison, Deutsche Bahn trains only carry a little over 100 passengers per train on average, which is just under the 130 passengers on Swiss railways. To understand this performance, we need to look at rail traffic across different market segments.

Table 3.1. Rail passenger transport in France
(in million passenger-kilometres; annual change in percent)

		Annual change					
	2013	2009	2010	2011	2012	2013	2013/ 2008
Long-distance rail transport	61 256	-1.4	-0.2	3.6	-2.7	-1.2	-0.4
High-speed rail[1]	53 768	-0.7	1.8	2.4	0.0	-0.5	0.6
Intercity services[1][2]	7 489	-4.9	-10.6	10.7	-17.6	-5.8	-6.1
Local rail services	31 184	-0.3	0.7	3.7	3.6	0.1	1.5
Trains under regional council contracts[3]	14 037	1.2	0.2	4.5	5.5	-1.2	2.0
Ile-de-France commuter trains and RER[4]	17 147	-1.4	1.1	3.1	2.0	1.2	1.2
Total excluding Ile-de-France commuter trains and RER	75 293	-0.9	-0.1	3.7	-1.2	-1.2	0.0
TOTAL	**92 440**	**-1.0**	**0.1**	**3.6**	**-0.7**	**-0.7**	**0.2**

(1) Including international services.
(2) Under government contract and non-contractual trains, excluding high-speed trains.
(3) Under regional council contract (excluding Ile-de-France and Corsica).
(4) Including the RERs operated by the RATP and the T4 tram line.

Source: CCTN-CGDD (2014).

This table shows that two-thirds of traffic is carried by high-speed trains. So this economic efficiency is the result of structural factors and has three major causes:

- First, depending on their destination, high-speed trains in France have between 450 and 1 000 available seats per train, which is far more than a regional train.
- Second, highly effective yield management delivers average occupancy rates of over 70% for high-speed trains.
- Most important, however, is their high speed, which allows them to cover long distances and automatically increases the number of passenger-kilometres.

But the TGV's success has come at some cost for other intercity services, which saw traffic fall by 6.1% every year from 2008 to 2013. Since high-speed traffic only grew by 0.6% during this period, despite additional services,[3] total long-distance traffic fell by 0.4% every year between 2008 and 2013. This is partly due to poor economic conditions, but there are other reasons, which cast doubt on the wisdom of the *tout TGV* strategy of creating a high-speed network across the entire country (Crozet, 2010; Cour des comptes, 2014), especially since the price elasticity of high-speed traffic is relatively low. Lower prices will not lead to a sharp rise in traffic (Crozet and Chassagne, 2013) because of competition from air travel on many routes and the recent growth of carpooling, which now accounts for almost 5% of long-haul traffic in France, i.e. the equivalent of 2 000 high-speed trainloads every month. High-speed travel is therefore facing an uncertain future in France. In order to increase the turnover generated by its 400 high-speed trains, the SNCF is considering changing its offering in order, for example, to keep these trains on high-speed lines only, with other trains, especially regional express trains, completing the terminal haul.

In fact, regional express trains saw the highest traffic growth (up 2% every year) in 2008-13, alongside Ile-de-France services (up 1.2% every year). For the former, however, economic efficiency is weak (40 passengers on average per train), because many trains are small, and because occupancy rates are low, at under 30% (Cour des Comptes*,* 2014). The Transilien commuter services in Ile-de-France, on the other hand, have high-capacity trains, which are often saturated during rush hour, and occupancy rates are very high (over 70%). This reflects the findings of Banister and Ghivoni in 2012, who showed that European countries that did not prioritise high-speed rail saw the highest traffic growth. This indicates that rail transport is most appropriate for everyday mobility in urban and peri-urban areas, which calls into question the expansion of high-speed rail not only in France but also on a European level, whereas the 2011 white paper forecasts a tripling of the high-speed network in Europe by 2030 (European Commission, 2011).

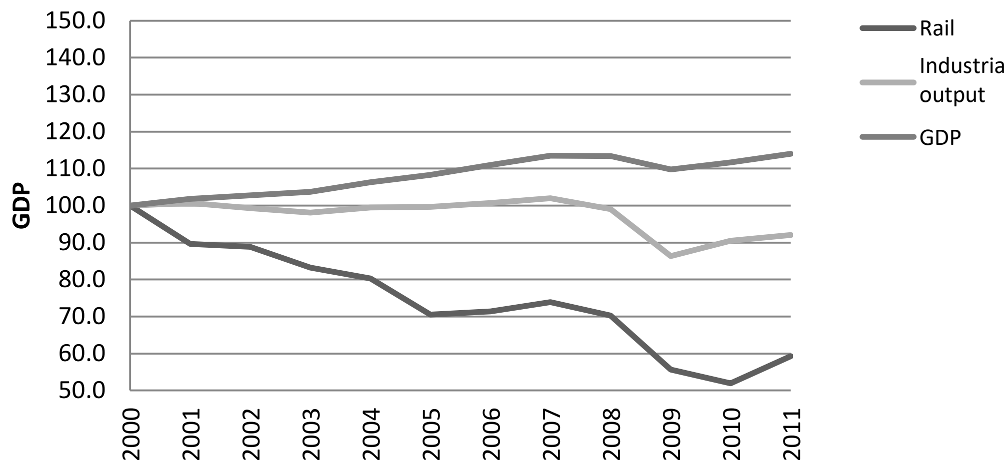
For passenger transport, then, the French rail system is not as successful as it appears at first sight. This is even more striking in rail freight, in which the legacy operator has manifestly failed to perform, despite high expectations. At the turn of this century, Jean-Claude Gayssot, the then transport minister, set a target of 100 billion tonne-kilometres by 2015. By 2013, rail traffic had collapsed to 32 billion t-km, just two-thirds of which was generated by the SNCF. What happened? Did economic efficiency fall because of de-industrialisation?

A report by the French Commission on Sustainable Development (CGDD, 2013) analysed freight by category, taking account of trends in different sectors of industry before the 2008 financial crisis. This analysis offers no reasons for the collapse in rail freight. Comparing rail freight to production in four key sectors reveals a complete divergence between 2000 and 2006:

- Food industry: production up 3%, rail freight down 37%
- Energy: production up 5%, rail freight down 34%
- Manufactured goods: production up 3%, rail freight down 35%
- Construction: production up 4%, rail freight down 13%.

As shown in Figure 3.2, freight traffic, and therefore economic efficiency, fell sharply despite rising GDP and, at least until 2008, stable industrial output.

Figure 3.2. The decline of French rail freight
(Base 100: year 2000)



Source: Eurostat.

The problem, then, is the relative competitiveness of the rail carrier, generally Fret SNCF, which was almost the sole operator until 2007. Between 2004 and 2010, Fret SNCF's average revenue per tonne-kilometre rose by 11%, from EUR 0.039 to EUR 0.043, while traffic fell by 50%. During the same period, Deutsche Bahn saw its average revenue fall by 8%, from EUR 0.043 to EUR 0.04 per tonne-kilometre, but traffic grew by 27% (CGDD, 2013). We need to look more closely at the reasons for this loss of efficiency, and they do not concern only freight.

Weak growth in productive efficiency seen only in France

To assess the performance of a rail system, indicators need to provide comparisons in time and space: efficiency is not measured in absolute terms but by comparing an indicator to different periods and different countries. Take, for example, a simple productivity indicator and track it through time. The numerator – "kilometric units" – will be the sum of passenger-kilometres and tonne-kilometres. The denominator will be the total number of SNCF and *Réseau Ferré de France* (RFF)[4] employees. Table 3.2, below, shows that productivity per capita grew by 22% between 1996 and 2008 (pre-crisis), and then remained flat at 0.73 million kilometric units per capita from 2008 to 2013. This stagnation is caused by the sharp fall in tonne-kilometres in the numerator, which is not offset by a rise in passenger-kilometres, as was previously the case.

Table 3.2. Unit-kilometres per capita in France from 1996 to 2013

	1996	2008	2013
Passenger-kilometres (millions)	59 700	82 400	92 400
Tonne-kilometres (millions)	48 600	37 300	20 700
Kilometric units (KU) (millions)	108 300	119 700	113 100
Employees	180 500	163 000	155 400
Millions of KU per capita	0.6	0.73	0.73

Source: CCTN-CGDD (2014).

We could settle for these results, observing that the decline in headcount and the level of traffic still gives 22% productivity growth between 1996 and 2013. But is this sufficient by comparison with two other giants of European rail freight: Germany and Switzerland or, more precisely Deutsche Bahn and *Chemins de Fer Fédéraux* (CFF) (Table 3.3.)?

Table 3.3. Unit-kilometres per capita in Germany and Switzlerland from 1996 to 2013

Germany	1996	2008	2013	Switzerland	1996	2008	2013
p-km (millions)	71 000	77 100	80 200	p-km (millions)	11 800	17 700	19 400
t-km (millions	67 400	91 200	75 200	t-km (millions)	8 500	12 260	11 800
kmu (millions)	138 400	168 300	155 400	kmu (millions)	20 300	29 960	31 200
Employees	288 700	240 200	155 000	Employees	32 000	28 000	27 000
Millions of KU per capita	0.48	0.70	1.00	Millions of KU per capita	0.63	1.07	1.16

Source: DB and Swiss Federal Statistics Office.

Like France, both Germany and Switzerland saw the effects of the crisis on freight traffic in the years following 2008 and, in Germany, the rise to prominence of competitors. But in both these countries, passenger traffic continued to grow, and this, coupled with a lower headcount, supported continued productivity gains. Between 1996 and 2013, productivity grew by 84% in Switzerland and by 108% in Germany, figures that overshadow France's result, which is almost four times lower.

Despite conditions that promote economic efficiency, therefore, (average of 230 passengers per train), the French rail system is relatively inefficient when outputs – passenger-kilometres and tonne-kilometres – are compared to inputs – employees. Another way to reach the same conclusion is to compare the number of train-kilometres (output) per employee (input) in 2010 (UIC data), which is 2 983 in France but 3 695 in Germany, or 24% more per employee. In other words, given the low growth in traffic in France, a far more drastic headcount reduction would have been necessary to prevent productivity falling behind that of Germany and Switzerland. The result is that the SNCF now has very little room for manoeuvre financially, since its payroll costs represent 47% of revenue, compared to 29% for DB (UIC data). This was discussed recently at a meeting of the SNCF's board of directors.[5] The presentation of an internal report highlighted the 5.5% rise in payroll between 2009 and 2013, when headcount declined by 4%, a paradox explained by the fact that average pay rose by 3.87% per year, when inflation was just 1.56%. This poses two problems for the SNCF:

- Low productive efficiency caused by overstaffing, which the company is struggling to combat in the face of the sharp fall in freight traffic and zero growth in passenger traffic since 2008.
- Additional unit costs generated by the balance of power being weighted in favour of the company and its staff rather than the public authority. This raises concerns over operational efficiency.

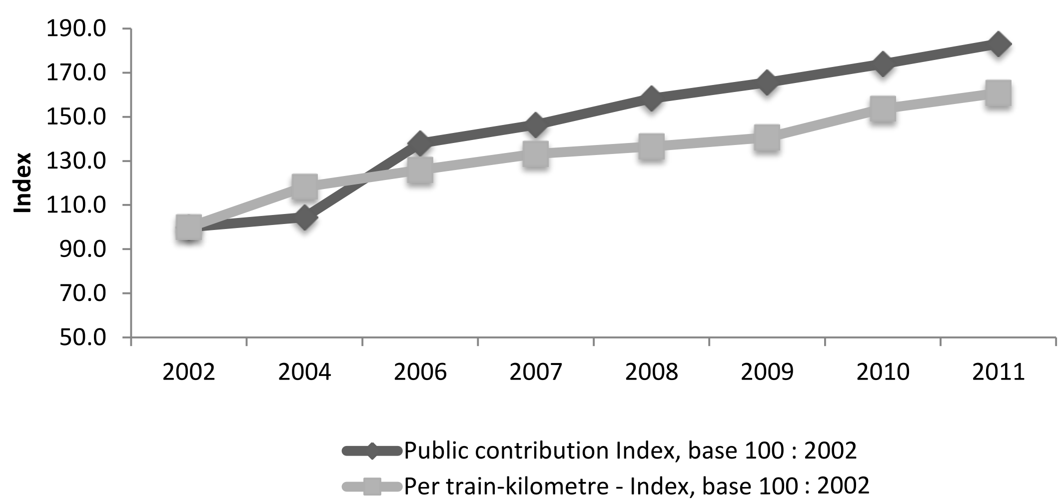
Poor operational efficiency

We have already mentioned that the French rail system draws heavily on the public purse. It is not high-speed rail that has cost so much government money. Most TGV projects have been funded by leveraging RFF and the SNCF. If we exclude the EUR 3.5 billion in annual subsidies that offset the severely unbalanced pension system (the SNCF has 1.8 times as many retirees as workers), the main flows

(EUR 5.2 billion in 2013[6]) fund regional passenger transport. RFF receives public money from the central government to cover regional express train infrastructure charges (EUR 1 941 billion in 2013). And the SNCF receives public money from regional authorities to subsidise the operation of regional express trains (EUR 3 263 billion in 2013). Given the rise in traffic on these services, one might think that public subsidies per train-kilometre had plateaued or fallen.

This is not the case, however (see Figure 3.3). Not only has the public outlay increased significantly (by 80% in nine years); the subsidy per train-kilometre has grown by almost as much. As the contracts between the regional authorities and the SNCF are cost plus, or fixed cost contracts, the cost per train-kilometre has grown by 60%, or 5.3% per year, which is three times higher than inflation. It seems as though the organising bodies, for various institutional and political reasons,[7] were simply unable to prevent the escalation of costs.

Figure 3.3. Regional government subsidies for regional express services in France (indexed to 2002)

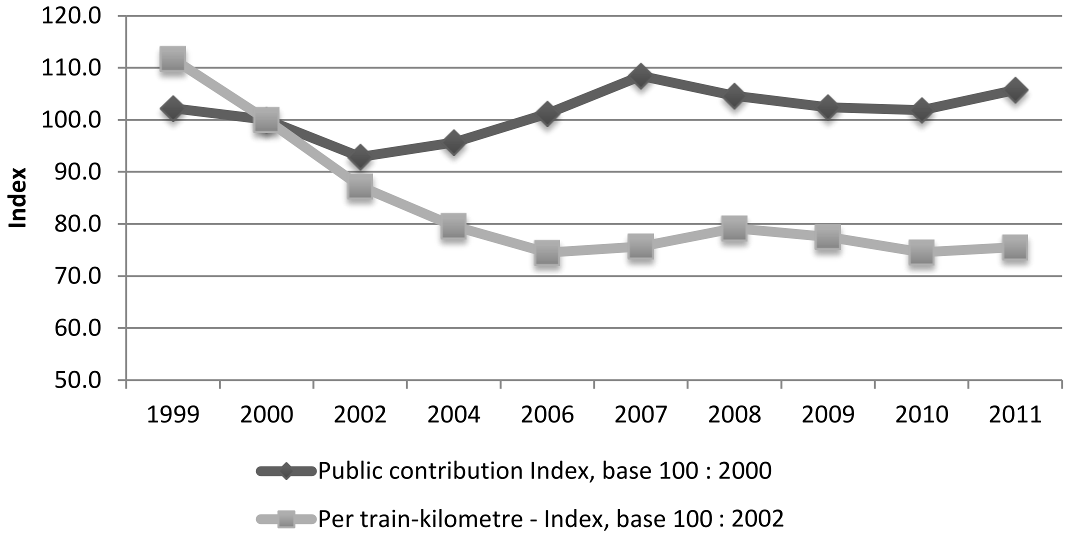


It is interesting to compare this picture to what was happening in Switzerland over the same period. Figure 3.4 shows total public contributions rising somewhat before falling off slightly, but the subsidy per train-kilometre fell substantially (-22%) because of the reduction of costs per train-kilometre.

As also shown by the example of Germany, it is thus possible to cut the cost per train-kilometre. The DB has had to face the arrival of new competition on the market, including the SNCF's subsidiary Kéolis. Although its rivals have only taken a small proportion of traffic in regional services (12% in 2012), unit costs per train-kilometre have recorded a significant fall, which can be broken down into two separate phases:

- Gains in market share made by DB's competitors, in response to which DB improved operating costs, management and the quality of rail service.
- Market stabilisation based on copycat win-win approaches. For local authorities and the taxpayer, the level of subsidies fell.

Figure 3.4. Confederation subsidies to CFF in Switzerland (indexed to 2002)



In 15 years, Germany has seen passenger-kilometres grow by 55% for regional services, reaching 47 billion p-km), but train-kilometres have risen by just 26% (to 630 million t-km). A 26% cost reduction for organising bodies has been measured across all contracts. Federal subsidies fell by 6% in real terms between 1996 and 2009. During this period, the service offered (in terms of t-km) by the *Länder* for EUR 1 (in real terms) has increased by 37%.

Our conclusion, at the end of this section, is that the efficiency indicators used for transport services can be established for chronological analysis and to produce series crossed with data that is generally published by UIC. Data for benchmarking network efficiency is far less accessible, as we shall see.

Network efficiency

The 1997 French rail reform saw responsibility for rail infrastructure entrusted to Réseau Ferré de France (RFF), an industrial and commercial public undertaking (*établissement public à caractère économique et commercial* – EPIC) which is completely independent from the SNCF but works in a very unusual way: the infrastructure manager has to work with a delegated manager, which is none other than the SNCF. The SNCF therefore retains the departments responsible for network maintenance and repairs (SNCF Infra) and traffic management, which is ensured by a special division that was not properly transferred to RFF until 2010.

The infrastructure manager's efficiency problems are quite unusual in this kind of system, insofar as the efficiency of the delegated manager is clearly a factor.

The efficiency of basic operations

In theory, the 1997 French rail reform was supposed to promote efforts to manage the network well, since responsibility for infrastructure management had been clearly devolved to RFF. But the requirement to "subcontract" to the SNCF posed problems that were, at first, formidable.

RFF toiled endlessly to change a procedure whereby it received a lump-sum invoice for network maintenance and repairs from the SNCF and had great difficulty in obtaining details on the state of the network and the maintenance operations carried out. After assuming full responsibility for development investment, RFF was only gradually able to implement a sensible policy and full ownership of major maintenance and renewal operations.

Table 3.4. Summary annual performance chart for 2012
(last year of the first performance contract, 2008-2012)

Strategic objective 1: Adapting to market liberalisation and increasing business revenue	
Six sub-objectives: mainly focused on customer satisfaction	Four sub-objectives achieved, two partially achieved: 1) the quality of freight paths has not improved as fast as expected; 2) costs are better reflected in charges.
Strategic objective 2: Modernising infrastructure and improving network performance	
13 sub-objectives: maintenance, maintenance management, safety	Seven sub-objectives achieved; Five partially achieved: mainly concerning the elimination of level crossings (only half the targeted number), the standard of programming and ensuring that renewal investment is effective; One failure: the multiannual view of renewals.
Strategic objective 3: Breaking even and establishing sustainable financing	
Six sub-objectives: improving the coverage of cost by revenue	Two sub-objectives achieved; One partially achieved: management control adapted to the strategic segmentation of the network; Three sub-objectives not achieved because of the freezing of EUR 341 million of the operating subsidy: costs not fully covered by revenue (charges or balancing subsidy); accounting targets consequently missed.
Strategic objective 4: Dynamic steering and responsible governance	
Eight sub-objectives: improving governance design and control	Seven sub-objectives achieved; One partially achieved, concerning the slower-than-expected establishment of the liaison with regional authorities (regional transport organising bodies).

The limited reform of 2010, which put the SNCF division in charge of capacity allocation under RFF's authority, led to major change in the establishment of train paths, and, by extension, timetables. For the first time in sixty years, the 2011 timetables were radically transformed, with the first introduction of clock-face scheduling, increased availability of freight paths and improved management of bottlenecks.

The progress made by the infrastructure manager in the exercise of its responsibility was recorded in a contract between RFF and the government, covering the period from 2008 to 2012. A new contract has been signed for 2013 to 2017. The first, now complete, demonstrates the progress made in the control of network management and maintenance efficiency and control of the main cost and revenue factors that determine its financial position.

The 2008-12 contract is based on four strategic objectives that are broken down into sub-objectives, representing a total of 33 RFF commitments. These commitments are tracked in a performance chart that is presented to the undertaking's Board of Directors every year.

Table 3.4 gives a condensed summary of the performance chart presented in 2013, which reports the results for 2012, the last year of the first contract. Most sub-objectives or commitments are tracked by indicators; we will mention a very few of these.

Table 3.5. Main indicators of annual reporting for the year 2012

Strategic objective	Examples of indicators
1. Adapt to the opening-up of the market and grow business revenues	Proportion of satisfied customers Tariff acceptance rates Number of pathways affected by maintenance work Punctuality within five min.
2. Modernise infrastructure and improve network performance	Length of track renovated (compared to five-year target) Number of switches and crossings renovated (idem) Number of level crossings removed (idem) Cost of renewing one km of track (idem) % of network in poor condition Centralised signals installed (compared to a programme) PDCAs for investment (*Plan-Do-Check-Act*) % of investment programme completed % of investment completed without cost overshoots % of investments completed on schedule
3. Target economic equilibrium and establish sustainable financing	% of revenues compared to business plan % of State subsidies compared to amounts pledged Cost fully covered by income % of accounting outcomes compared to business plan *Ex-post* financial evaluation of major projects (one year, five years, ten years)
4. Dynamic oversight and responsible governance	Provisions relate mainly to the organisation of the company and its management and are ill-suited to the use of performance indicators other than ratings by specialised agencies.

For strategic objective 1, "clients" – e.g. rail operators, combined transport carriers and organising bodies – are surveyed to establish satisfaction rates on issues considered to be sensitive; these rates have improved significantly. For strategic objective 2, network maintenance and safety (elimination of level crossings) are tracked on the basis of the number of points and kilometres of track that have been upgraded, compared to the forecast. For strategic objective 3, cost and income are tracked closely through, for example, the achievement of targeted kilometric maintenance cost savings. Strategic objective 4 is tracked through detailed analysis of the undertaking's management and its relations with the regulator.

The performance contract and charts reveal spectacular progress since the first years of RFF. It has not been possible to establish international benchmarks, however, which would be needed to measure the relevance of these indicators.

This effort to evaluate and monitor performance nonetheless has the merit of being based on a number of indicators that allow assessment of the extent to which strategic objectives have been achieved. Examples of the main indicators employed for this purpose are presented in Table 3.5.

Obviously, these indicators need to be tested through time series and particularly cross-sectional analysis, as the results can be interpreted for the purpose of international comparison.

Marginal capital efficiency

Investments are clearly of central importance to RFF, and this raises the issue of efficiency indicators to measure the marginal efficiency of capital.

Investments cover three categories of transaction that need to be distinguished. The most visible is the construction of new high-speed lines. Because of the size of these projects, they must be carried out in succession, and only after a lengthy preparatory process and ex-ante evaluations have culminated in a decision taken at government level. Depending on the programme, financing can range from EUR 1 billion to EUR 3 billion per year, a figure that can rise to over EUR 4 billion if we include transactions by public-private partnerships (PPPs).[8] The corresponding efficiency indicators can be taken to be those resulting from project evaluations, i.e. essentially internal socio-economic and financial profitability rates and the net present value per euro of public money.

The second category concerns investment in network expansion, excluding high-speed lines, and consisting mainly of network modernisation (centralised points, electrification, etc.) or extensions (port services). These usually require financing of around EUR 1 billion per year, and the same socio-economic and financial assessments apply as for new high-speed lines.

The third category consists of renewal investments that keep the different parts of the network in good operational condition. When RFF was set up in 1997 and during its first years of operation, the rate of coverage of full costs by charges was so poor (less than 20%) that these investments were kept relatively low. An audit on the state of the network carried out by the Lausanne École Polytechnique Fédérale (Rivier et al., 2005), highlighted their inadequacy. Since then, a policy to reverse the situation has pushed investments back up to around EUR 2.5 billion per year. Neither RFF nor SNCF Réseau has its own cash flow, so renewal investments are financed by a regeneration subsidy. There are specific problems involved in evaluating these transactions, not all of which have been resolved.

One of the main aims of the 1997 reform was to curb the rail system’s escalating debt. In theory, the solution that has been implemented prevents this escalation and, de facto, dominates the issue of marginal capital efficiency.

Article 4 and how it works

Article 4 of the Decree that created RFF in 1997 contains a debt-control rule for the rail industry that concerns new investments. It states that “*RFF may not accept any project to invest in the national rail network that has been assigned to a programme on the request of central government, local government or a local or national public body, unless the petitioners have endowed it with financial resources that will prevent any negative impact on the RFF’s accounts during the amortisation of the investment.*”

Under this rule, then, the funding of any new project must be assessed to determine the return on investment. This discounted revenue gives the amount that the infrastructure manager (RFF and, now, SNCF Réseau) is likely to commit and, by extension, the subsidies required. These financial resources correspond to a public financing rate for the project, sufficient to ensure that the financial profitability of the infrastructure manager's commitment covers both the amortisation of capital and a risk premium. In short, projects must cover the Weighted Average Cost of Capital (WACC).

To take an example, if long-term rates on the financial market[9] are 4% and if the risk premium is also estimated at 4%, the WACC for the funding secured by the public operator is 8%. As required by the applicable rules, the infrastructure manager may not launch a project unless its profitability rate is equal to or higher than 8%. If profitability is lower, additional funding is required to make up the shortfall.

Meeting the "Article 4" obligation therefore involves a particularly strict evaluation of every project, in addition to which the contracting authority – the network company, in the case of the rail industry – must also carry out an assessment of the project's socio-economic profitability. Under the official instructions, the socio-economic net present value (NPV) and the ratio of NPV to subsidy must be calculated for every project.

The issue of optimising investments and the marginal efficiency of capital is based on these evaluations.

Optimal investment programming

We can only define the right strategy for the system's efficiency, especially investment selection, if we know what we want to achieve. Do we need to minimise subsidies by looking for the highest possible financial profitability? Or, in the tradition of the public sector, should we be trying to maximise socio-economic NPV?

Factoring in the budgetary constraint answers the question. The network company's investments are rarely self-financing and almost always require some level of subsidy. The public body providing the subsidy will expect positive externalities in return, which can be considered to reflect a change in welfare and to be measured by socio-economic NPV. It therefore controls investment programming but has a limited financing capacity. Chronologically, the sequence of subsidies is clearly dictated by budgetary constraints. In theory, then, the public authorities are attempting to optimise investments within specific constraints. Put simply, for a given programme duration, the exercise is to determine which of the suggested projects will be selected, and to establish their optimum completion dates in such a way as to maximise the programme's socio-economic NPV for the amount of public money available.

Subsidy rates naturally play a very important role in the issue of programming, since subsidies represent the budgetary constraint. A project's subsidy rate is given by the project's inherent profitability and the financial profitability required by the investor, in the case of its being subject, for example, to an Article 4 obligation.

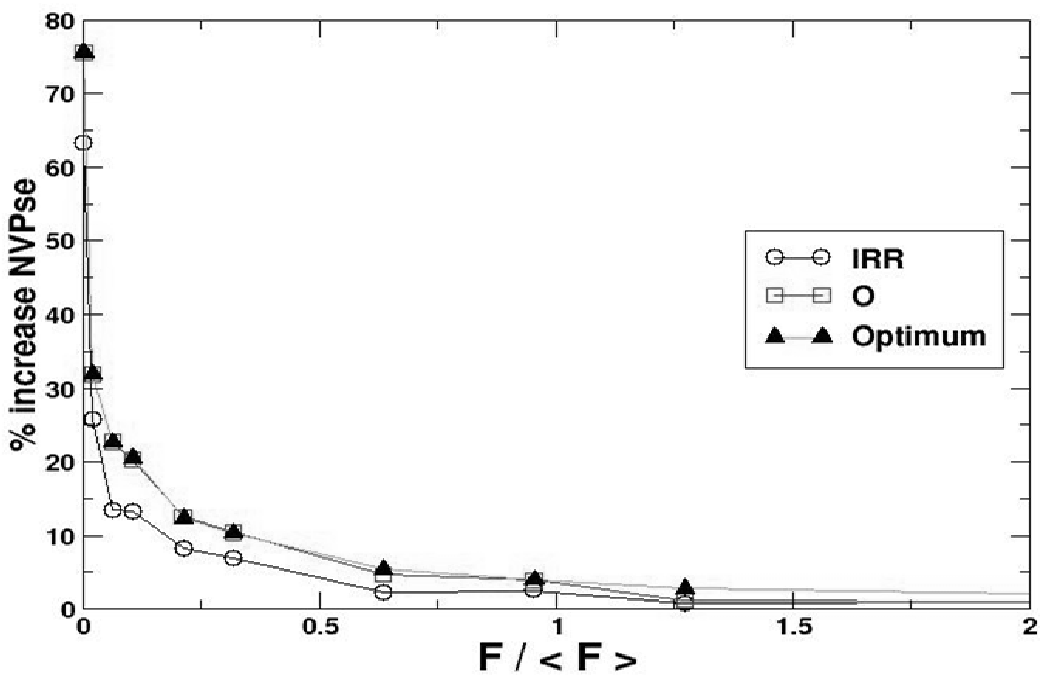
If we want to compare investment programmes subject to the same public financing constraint, we just need to know the required subsidy and expected socio-economic NPV for the proposed projects. In the early 1990s, this exercise was applied to a group of 17 proposed French motorways (Bonnafous and Jensen, 2005). The results are instructive.

To compare competing programmes, several different orders for the completion of the projects were tested, exhausting all available public money every year. The projects were ranked according to several different orders of priority: decreasing order of socio-economic return rate; decreasing order of financial return on investment; and decreasing ratio of NPV to public subsidy. The target function, i.e. the NPV of the programme given according to this exercise, is calculated in each case. The exercise was repeated for different levels of budget.

A first, counterintuitive, finding was that carrying out projects in decreasing order of financial return gave higher overall NPV than ranking projects by decreasing socio-economic profitability. The reason is simply that when projects are carried out in decreasing order of financial profitability they can be launched more rapidly because their higher financial profitability decreases the public money required. For the same public subsidy, the socio-economic NPV is therefore higher. This welfare gain is further improved by the financial profitability criterion when public money is limited, a result that has obvious significance for developing countries, where there is greater pressure on public finances.

A less surprising finding is that ranking projects by decreasing order of NPV to public subsidy ratio further improves a programme's welfare gain, whatever the budgetary constraint. On failing to find a clear demonstration in the literature, the authors proceeded to demonstrate that this order did determine optimal programming.

Figure 3.5. Additional welfare gain of programmes



Note: Additional welfare gain of programmes compared to the ranking by socio-economic profitability when ranked by financial profitability (IRR), the numerical ideal and the NPV public subsidy ratio (o) under different financing constraints.

Source: Bonnafous and Jensen (2005).

A set of 17 projects with 17 different permutations gives around ten[34] possibilities, so finding the optimum order calls for a sophisticated combinatorial search algorithm, used in experimental science to deal with this level of complexity. The programmes examined naturally exhaust the available public financing. These simulations determined a numerical optimum that corresponds to a programme automatically aligned with the NPV-public subsidy ratio, which supports the principle of value for money. These results are presented in Figure 3.5, in which the x-axis shows different financial constraints, based on <F>, an average value that has been empirically observed, and the y-axis shows the additional welfare gain generated by a programme, over and above that generated by a programme in decreasing order of socio-economic profitability.

This result has previously been formally demonstrated (Roy, 2005; Bonnafous, Jensen and Roy, 2006). Under a few fairly weak conditions, it was shown that the NPV/public investment ratio was the project-ranking criterion that maximised overall welfare within the budgetary constraint. This demonstration appears in Annex 3.A2 as an excellent illustration of the opportunity cost of public funds.

An indicator of the efficiency of the investment programme

Now that we have established an optimal standard, and observed that it is consistent with the value-for-money criterion, we automatically find ourselves with an efficiency indicator, insofar as we can now easily establish a virtual, optimal programme for any given period. For a duration of five years, for example, which is the term of the last performance contract between the government and RFF (2008-12), we know, for the investments made:

- the chronological order of the subsidies given to these investments every year
- the chronological order of the socio-economic NPV generated.

The decision maker had to choose among *n* projects *i* characterised by their net present value ΔU_i, and their need for subsidies Sub_i, within a budget B_t limiting public spending to the year *t*. The welfare function, *W*, generated by all projects implemented, can then be defined as follows:

$$W(x) = \sum_{i=1}^{n} x_{i_t} \Delta U_i$$

$$\text{s.c.} \quad B_t = \sum_{i=1}^{n} x_{i_t} Sub_i$$

The parameters x_{ti} are variables with a value of zero if the project is not implemented during the year *t* and equal to one if the project is implemented during that year.

The value of *W* given for the term of the programme must naturally be compared to the value of *W* generated by an optimal programme, or W_o. The optimal programme is easy to establish if we postulate the implementation of projects in decreasing order of the ratio $\Delta U_i/Sub_i$ and if we exhaust the *Bt* budgetary constraint every year.

This gives a definition for the global programme efficiency indicator as follows:

$$IGE = W(x)/W_o.$$

This indicator can just as easily be used to measure the efficiency of investments committed during the programme, with an ex-post evaluation of the loss of value compared to an optimal programme, as it can be to measure the ex-ante efficiency of a planned programme in a given time frame. In the latter case, we could consider assigning it a minimal value, since priorities are not exclusively determined for the sole purpose of generating value, as we shall see below.

Empirical illustration

The three major investment categories mentioned at the beginning of this section – high-speed lines, development investments and renewal investments – are naturally themselves liable to be judged according to profitability calculations, and our global efficiency indicator (GEI) could, in theory, be applied to the chronological order of investments. There are, however, some unresolved methodological problems with the evaluation of renewal investments, which do not generate the same kind of value as development investments.[10] It also seems reasonable to assume that high-speed lines can be considered separately, if only because of the concession schemes and public-private partnerships that are in use today.

This is, however, a useful exercise for development investments, which are usually programmed under planning agreements between central and regional government, renamed “project contracts” in 2007.[11] They cover all kinds of public investment, designed to meet social and territorial cohesion targets that are not covered by the idea of a project’s socio-economic profitability, as measured in a standard evaluation. Calculating a GEI offers a measurement of the total relevance from the point of view of the efficiency of the rail system.

We were unable to collect all the figures relating to current projects that were required for this exercise in time for this report. However, we can propose an experimental evaluation based on this GEI concept in that all figures are available (subsidies and net present values) for 40 investments by RFF scheduled under planning contracts between central government and the regions between 1997 and 2007:

- A programme that would have consisted in completing the ten contracts with the best $\Delta U_i/Sub_i$ ratio yields a GEI equal to 8.
- A programme that would have consisted in completing the ten contracts with the worst $\Delta U_i/Sub_i$ ratio yields a GEI equal to 0.5.

Expressed in simple terms, these findings mean that for every EUR billion of public investment the first programme creates value over time amounting to EUR 7 billion, and that for every EUR billion of public investment the second programme destroys value over time amounting to EUR 0.5 billion.

Conclusion

By separating out the relevance and consistency of the rail system management, and distinguishing between three different kinds of efficiency, we have arrived at some key indicators for measuring rail system performance.

We are able to deal with and evaluate government decisions in terms of relevance and consistency, especially in terms of investment, as described above. And more generally, comparing performance to public subsidy produces indicators that are useful for evaluating most rail activities.

The question of operational efficiency allows us to take the examination of subsidies further, with simple indicators such as cost or level of subsidy per train or passenger-kilometre. These indicators are most useful when benchmarking different rail operators and different countries. Similarly, we can use straightforward indicators to evaluate productive efficiency and economic efficiency. What these approaches have in common is the value-for-money approach or, if we turn the problem around, the minimisation of cost for a given service.

Finally, this study is based on the French system, which has just been reformed and will be replaced by a new system as of January 2015, under the law passed in 2014 (see Annex 3.A3). The new system is officially expected to generate productivity gains across the entire system. Many observers are sceptical as to the outcome.

Notes

1 French rail transport subsidies are distributed as follows: Infrastructure manager, EUR 4.2 billion; regional express trains, EUR 3 billion; Ile-de-France, EUR 1.2 billion; Freight, EUR 0.3 billion; SNCF pension fund, EUR 3.4 billion (CCTN, 2014, pp. 29-31).

2 With the single exception of the Paris-Venice Thello train, all passenger services in France are operated by the SNCF or its subsidiaries, such as Thalys and Eurostar. ICE trains between France and Germany are operated under a partnership with the SNCF.

3 Opening of the East high-speed line in June 2007 and the Rhine-Rhone high-speed line in December 2011.

4 This method allows for benchmarking against operators that remain integrated, like DB and CFF.

5 Lionel Steinmann, *Les Echos*, 22 October 2014, http://www.lesechos.fr/22/10/2014/LesEchos/21798-087-ECH_a-la-sncf--la-masse-salariale-progresse-quand-les-effectifs-reculent.htm .

6 CCTN, 2014, p. 29 and p. 31.

7 The SNCF has a monopoly over the operation of regional express trains and opening these services to competition is not openly advocated by local government representatives.

8 PPPs currently concern three high-speed lines: Tours-Bordeaux and two partnership contracts for the Brittany-Loire line and the Nimes-Montpellier Bypass.

9 For the purposes of our example, we have taken rates applied during the first half of 2012 in countries rated AAA or AA+ to long-term borrowings (20-35 or even 40 years).

10 RFF is currently attempting to resolve the methodological issue.

11 Project contracts are generally financed equally by central and regional government.

Annex 3.A1. SNCF Group and the SNCF and RFF industrial and commercial public undertakings

The *Société nationale des chemins de fer français* (SNCF) was created when the railways were nationalised in 1937, and for many years operated as a commercial undertaking in which the State was the majority shareholder. Its status did not change until the early 1980s, during the wave of nationalisations launched under François Mitterand's presidency, when the SNCF became an industrial and commercial public undertaking (EPIC). The infrastructure manager RFF (Réseau ferré de France), which was set up in 1997, has the same status. These undertakings are under full government control and therefore enjoy a de facto State guarantee. They cannot fail, and this allows them to borrow on the financial markets at preferential rates. The SNCF's main bank is the Banque de France.

The SNCF industrial and commercial public undertaking, which operates in France, is just one part of the SNCF Group. In 2012, the SNCF Group, which operates in 120 countries and employs 250 000 people, generated revenue of EUR 33 billion. The group's international activities account for just over one-quarter of this figure.

The group has five divisions:

- SNCF Infra, RFF's delegated infrastructure manager: EUR 5.5 billion in revenue
- SNCF Proximités: EUR 12.2 billion in revenue, 17% of which is generated outside France, mainly by Kéolis, a subsidiary dedicated to urban and regional passenger transport
- SNCF Voyages: EUR 7.5 billion in revenue, dedicated to long-haul passenger transport (20% of revenue generated outside France)
- Gares et Connexions: EUR 1 billion in revenue, chiefly generated by the management of 3 029 stations in France.
- SNCF Geodis: EUR 9.5 billion in revenue. SNCF Geodis is dedicated to freight transport. Rail transport accounts for only 17% of the total. Fret-SNCF – SNCF Geodis's industrial and commercial public undertaking – is part of SNCF Geodis. But it also has commercial subsidiaries, such as CAPTRAIN, which operates in Europe; VFLI, which operates mainly in France; VIIA; and a subsidiary dedicated to combined transport.

The development of private-sector subsidiaries, both in France and overseas, has allowed the SNCF to move into new sectors: coach transport (IDbus); carpooling (IDvroom); online travel sales; hotel bookings; and car rental (Voyages-Sncf.com), etc.

Source: www.sncf.com/fr/portrait-du-groupe/un-groupe-de-service.

Annex 3.A2. Formal demonstration of optimal order of project implementation

The theoretical model established by William Roy (2005) formally resembles the programme of the consumer for discrete goods. Let us assume that the decision maker has to choose among *n* projects *i*, characterised by their net present value ΔU_i, and their need for subsidies Sub_i, with $\Delta U_i>0$ and $Sub_i>0$ $\forall$ $i=1,\dots,n$. The objective function is the welfare function *W* generated by all the projects, subject to the budget constraint *B* capping public spending. The optimisation programme can then be written as follows:

$$\underset{x}{Max}\ \ W(x)=\sum_{i=1}^{n} x_i \Delta U_i$$

$$\text{s.c.}\quad \begin{cases} B-\sum_{i=1}^{n} x_i Sub_i \geq 0 \\ x_i \geq 0, \quad \forall i=1,\dots,n \\ 1-x_i \geq 0, \quad \forall i=1,\dots,n \end{cases}$$

The parameters x_i are continuous variables, which have a zero value when the project is not implemented and are equal to one when the project is fully implemented. We shall assume that it is possible to implement project *k* partially, with parameter x_k then ranging between zero and one.

The solution vector *x** is therefore constituted by a value set one (projects to be implemented), a value set zero (projects not to be implemented), and a value ranging between zero and one for the "borderline" project *k* (which is very likely not to be completed if the constraint is totally inflexible). Assuming that the projects are ranked by their implementation priority, we can write this solution vector as:

$$x^*=\left(\underbrace{1,\dots\dots.1}_{\text{projects accepted}}, x_k, \underbrace{0,\dots\dots.,0}_{\text{projects rejected}}\right)$$

The Lagrangian of the optimisation problem is written as follows:

$$L(x_1,\dots,x_n,\varphi,\alpha_1,\dots,\alpha_n,\beta_1,\dots,\beta_n)=$$

$$\sum_{i=1}^{n} x_i \Delta U_i+\varphi\left(B-\sum_{i=1}^{n} x_i Sub_i\right)+\sum_{i=1}^{n}\alpha_i x_i+\sum_{i=1}^{n}\beta_i(1-x_i)$$

The Kuhn and Tucker conditions imply that, at optimum:

- $\Delta U_i-\varphi.Sub_i+\alpha_i-\beta_i=0,\ \forall \mathrm{i}=1,\dots,\mathrm{n}$
- $\varphi\left(B-\sum_{i=1}^{n} x_i Sub_i\right)=0$

- $\alpha_i x_i = 0$ et $\beta_i (1 - x_i) = 0, \ \forall \mathrm{i} = 1,..., \mathrm{n}$

The economic interpretation of this optimisation is quite simple: φ is the variation in the community surplus generated by a loosening of the public-funding availability constraint. Being equal to the maximum surplus amount that the community can hope to obtain from an additional budgetary unit, φ represents the opportunity cost of public funds. It is important to distinguish this opportunity cost from the shadow cost of public funds, which results from the costs of collecting taxes and the price distortions associated with raising taxes by an additional unit. It is therefore not by chance that we are calling φ a scarcity coefficient: as the dual value of the budget constraint, it really is the signal "price" of the scarcity of public funding.

For the projects accepted (indexed *j*), the Kuhn and Tucker conditions imply that:

→ The constraint $x_i \geq 0$ is not saturated, and therefore $\alpha_j = 0$

→ The constraint $1 - x_i \geq 0$ is saturated, and therefore $\beta_j > 0$

whence $\Delta U_j - \varphi.Sub_j > 0 \quad \Leftrightarrow \quad \frac{\Delta U_j}{Sub_j} > \varphi$.

The set of acceptable projects is therefore composed of those having a $\Delta U_j/Sub_j$ ratio higher than φ, the opportunity cost of public funds. For projects rejected or postponed (indexed *l*), the optimisation conditions imply that:

– The constraint $x_i \geq 0$ is saturated, and therefore $\alpha_l > 0$

– The constraint $1 - x_i \geq 0$ is not saturated, and therefore $\beta_l = 0$

whence $\Delta U_l - \varphi.Sub_l > 0 \quad \Leftrightarrow \quad \frac{\Delta U_l}{Sub_l} < \varphi$.

In all, the projects indexed *j* selected, and the projects indexed l not selected confirm the fundamental relationship:

$$\frac{\Delta U_j}{Sub_j} > \varphi > \frac{\Delta U_l}{Sub_l}$$

Accepted projects must always have a higher ΔU/Sub ratio than rejected projects. Here, then, is the demonstration by numerical simulation presented previously: even if the decision maker ignores φ, he or she must prioritise projects with the highest "collective relevance per euro of taxpayer's money invested". This result confirms the wisdom of the widely accepted effectiveness of the value-for-money criterion.

Annex 3.A3. The 2014 rail reform

On 4 August 2014, the French Government's official journal of legal notices published a new law reorganising the French rail system, which will impact some of the changes made in 1997. In 2011, faced with the poor performance of the French rail system (Crozet and Raoul, 2011) and the pressure on the SNCF's revenue from the rise in high-speed rail charges, the government held a rail conference (*Les Assises du ferroviaire*). At the request of the SNCF, the conference focused on the transaction costs involved in separating the infrastructure manager and the rail operator. The reform is based on this work and on reports produced for the new administration since 2012 (Auxiette, 2013; Bianco, 2013). At the heart of the reform is the adoption of an institutional model, based on the Deutsche Bahn in Germany, where the infrastructure manager, DB Netz, is part of the rail holding company.

As of January 2015, there is an infrastructure manager called SNCF-Réseau and a rail operator called SNCF-Mobilité, with different entities for main lines, regional lines, stations and freight, etc. This is where parallels with Germany end, because the new entity will not be a public limited company, but an industrial and commercial public undertaking (EPIC). And there will be not just one EPIC, but three. The two mentioned above will be subsidiary to a main EPIC that will handle the strategic functions. Why three and not just one? And why no public limited company?

A single EPIC is not possible for financial reasons. Reconciling the RFF's statement of financial position and all its liabilities – including over EUR 33 billion in debt – with the SNCF's income statement amounts to an impossible consolidation. The SNCF's surpluses, such as they are, cannot support the financial costs of the debt and the RFF's chronic deficit, largely caused by regeneration costs. But the SNCF cannot receive balancing subsidies because it is in competition. To prevent this, the State would have had to shoulder the rail debt twenty years ago, as it did in Germany, before merging RFF with SNCF – an option it ruled out. Having a single EPIC would also infringe EU regulations and the rules of the fourth rail package that requires complete separation – a so-called "Chinese wall" – between the infrastructure manager and the rail operator.

So the three EPICs are there to ensure the financial separation of SNCF from RFF (no accounting consolidation; the SNCF does not have to fund RFF's deficit). They also help ensure the independence of the infrastructure manager, as required by the EU. So the problem is this: what exactly does the main EPIC do? Is it just a structure set up to co-ordinate the two separate entities and allow the Government to keep a watchful eye on the whole of the public unit and settle disagreements by, for example, entrusting its chairmanship to a political personage? It looks as if we are headed instead for an entity with over 10 000 employees, responsible both for finance and the management of human resources (with rail worker status). The question of personnel is crucial, and a collective bargaining agreement is planned for the rail industry that will define the HR framework applicable to these employees. The unions are demanding that SNCF's competitors be forced to adopt the same practices as the historic operator.

In its own way, in what it says and what it doesn't say (it breathes not a word about competition), the rail reform bill reveals the limits of public policy in the French rail industry. In focusing on institutional issues, such as the number and remit of the three EPICs, the reform skirts around such organisational issues as the incumbent operator's stranglehold on power (Laffont and Tirole, 1991).

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Chapter 4. Rail efficiency: Cost research and its implications for policy

Introduction

Studies of rail efficiency usually have one of two motivations. Firstly, they may aim to identify which railways are efficient and which are not, in order to draw lessons as to the level of improvement that may be required. An example of this is the benchmarking studies, conducted on behalf of the British rail regulator, to decide on the financial requirements of Network Rail – the infrastructure manager discussed below (see, for example, Smith, Wheat and Smith, 2010). Secondly, studies may seek to draw policy conclusions about which policies regarding industry structure, competition and regulation will be most beneficial. We consider both aspects in this paper.

In sectors of the economy in which markets vary from a reasonable approximation to perfectly competitive, a reasonable measure of overall efficiency may simply be the profitability of the firm. Under perfect competition, prices are not influenced by the individual firm and therefore the more profitable the firm, the more it has been able to minimise costs of production and to produce the most valuable combination of goods in the eyes of consumers.

But rail is a long way from being a perfectly competitive industry. In some sectors (e.g. coal, commuters) rail operators still have considerable monopoly power, while – for this and other social reasons – rail prices are often regulated by governments, who also play a key role in specifying passenger sector outputs. If the aim is to examine the efficiency of railway management, these factors must be allowed for. To the extent that railway managers (at least in the European passenger sector) have limited control over their outputs, the key issue is whether they produce them at minimum cost.

Economists are used to distinguishing between technical efficiency and allocative efficiency. Technical efficiency is measured by whether output is maximised for a given level of inputs (or conversely inputs are minimised for a given output). The standard economic approach to examining this is to estimate a production function using econometric methods, although non-parametric methods – such as data envelopment analysis (DEA) – have also been used. This approach is considered further in the next section.

Allocative efficiency considers whether the correct mix of inputs is used to minimise cost for a given level and quality of output. Cost efficiency, which is the product of technical and allocative efficiency and thus takes both into account, is the subject of the following section. We then examine evidence on both the efficiency impact of the approach to railway reform taken in Britain and the relative efficiency impact of the variety of approaches taken around Europe, before seeking to reach conclusions.

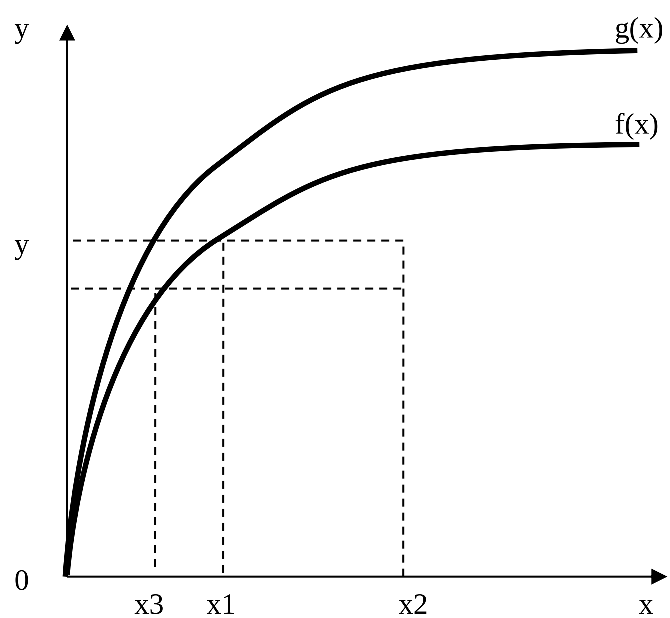
Technical efficiency

The material in this section draws partly on Smith (2004) and Nash and Smith (2007).

Before turning to a discussion of more advanced measures, it is first worth considering why it is important to go beyond simple partial productivity measures – such as train-kilometres per member of staff or per locomotive – which are often used as measures of technical efficiency. The first point to note is that they are partial measures and cannot therefore lead to conclusions about overall efficiency (unless the same railway is more efficient on every measure). Further, they are often impacted significantly by capital substitution effects (where capital is substituted for labour, therefore improving labour productivity). In a multi-input, multi-output environment such as the railways, the concept of total factor productivity (TFP) provides a more informative indicator of technical efficiency.

TFP is a measure of the ratio of all outputs to all inputs (with the different inputs and outputs weighted in some way). Under perfect competition, prices may be used as the weights, so the measure returns to one of the ratio of value of outputs to value of inputs or, in other words, profitability. Of course, the underlying assumptions of constant returns to scale/density and marginal cost pricing are highly restrictive, especially in the context of the world's railway systems, which are characterised by high, quasi-fixed costs and are heavily regulated. These restrictive assumptions mean that TFP measures are unable to distinguish changes in technical efficiency from underlying technical change, and from changes in TFP resulting from scale or density effects or departures of prices from marginal cost. Figure 4.1 illustrates, for the single input, single output case, how inefficiency (the gap between a firm's input-output combination and the frontier) differs from productivity effects (moving along the production frontier). Compared to input level x1, it can be seen that productivity changes if there is a move along the frontier to x3. Likewise, a move to x2, which represents an inefficient level of production, also results in a change in productivity. Over time, the production frontier may shift outwards [to g (x) in the diagram], driven by technical change.

Figure 4.1. Single input production frontier



One way of dealing with this problem is to estimate a cost function using econometric methods (see below). This approach allows the estimation process to calculate the elasticities of cost with respect to the outputs (and, in turn, the extent of returns to scale and density), productivity growth resulting from technical change, and changes in efficiency. Data envelopment analysis (DEA) is an alternative index number method for deriving productivity and efficiency measures. It is a non-parametric approach, in which the efficiency frontier is computed using linear programming techniques (rather than estimated, using econometric methods). The method permits the assumption of variable returns to scale, and Malmquist productivity indices can be computed from such models that also allow the decomposition of TFP changes into technical efficiency, scale efficiency and technical change.

One challenge that the DEA approach faces is its difficulty in characterising the technology, since the introduction of numerous inputs and outputs into the DEA tends to result in all firms being on the frontier. It can thus be difficult to distinguish between, for example, economies of scale and density. One way in which the approach can be augmented to deal with this criticism is through the use of a second stage, in which the efficiency scores from the first stage are regressed on a range of factors, such as train density and load factor (and indeed, policy variables, such as the degree of competition). However, the approach then starts to look much more like an econometric model, and it raises the question: why adopt a two-stage approach, instead of simply estimating an econometric model? A remaining major weakness of DEA is its inability to take account of random noise, meaning that measures of inefficiency can be overstated (or efficiency understated).

Historically, one supposed advantage of DEA has been its ability to deal with multiple inputs and outputs without recourse to potentially restrictive behavioural assumptions (for example, cost minimisation, as required in econometric cost function estimation). Another is the fact that it does not require the specification of a functional form for the underlying technology. However, both these advantages have been largely eliminated by the widespread use of flexible functional forms (e.g. the Translog) and by the development of econometric methods for estimating distance functions (see Groskopf et al., 1997).

Overall, the most advanced and widely-used approaches in the academic literature for estimating technical efficiency are econometric distance functions (see, for example, Kennedy and Smith, 2004 and Coelli and Perelman, 1999) and DEA (e.g. Cantos, Pastor and Serrano, 2010). However, as will be discussed below, econometric cost function/cost frontier estimation has numerous benefits, and this approach dominates the empirical discussion in this paper.

Importantly, whatever approach is adopted, a decision is needed as to what should be the relevant outputs and inputs, as well as associated output characteristic variables.

Outputs

At its simplest, transportation output may be regarded as the transport of passengers or freight. Thus measures such as passenger-kilometres and freight-tonne-kilometres are the usual starting point for output measurement. However, there are grave shortcomings with such simple measures of output.

Multiplicity of outputs is a common feature of transport firms. Strictly speaking, an output needs to be described in terms of the provision of transport of a specific quality from a specific origin to a specific destination at a specific point in time. Thus, an operator of rail passenger services running trains between ten stations ten times per day and offering two classes of travel is already producing 1 800 different products. A large European railway will have literally millions of products on offer. Of course, it is not possible to provide cost or performance measures that separately identify each product.

This is only really a problem if the different products have significantly different cost characteristics, and traffic on them is growing or declining at different rates. For instance, if it costs a similar amount to transport passengers (per kilometre) between London and Leeds and London and Manchester, then performance measures will not be distorted by regarding these as the same product. On the other hand, failure to identify different traffic having very different costs will be very distorting. For instance, part of the rapid improvement in productivity of British Rail freight wagons in the 1980s was because of the decline and eventual abolition of the movement of single wagonloads in favour of movement of traffic in full trainloads.

In passenger rail transport, longer-distance, faster-moving traffic and traffic moving in large volumes generally costs less per passenger-kilometre to handle than short-distance traffic or traffic that must move slowly and in small volumes. This is because of the spreading of terminal costs and the economies of operating longer trains. Peaks in demand also lead to poor productivity by requiring the provision of numerous resources that are only used for a small part of the day. Such peaks in demand are likely to be an issue in urban public transportation operations, with some services being more subject to peaks than others. Thus, a fundamental distinction is made between different types of rail passenger traffic, such as inter-city, suburban and regional. Economies of density occur when the adding of more traffic to the same network leads to a less-than-proportionate increase in cost, whereas economies of scale occur when a given increase in both network size and traffic leads to a less-than-proportionate increase in cost.

In any event, frequency of service is an important quality attribute. A transportation manager who was simply wishing to minimise costs – for a given number of passenger-kilometres – might run one high-capacity service per day, but this would not be very attractive to customers. No sensible transportation manager will provide the frequency of service that minimises costs if a more frequent service will improve net revenue or benefits. This suggests that, unless a way can be devised of adjusting passenger and freight-tonne-kilometres for the quality of service provided, a more radical change to the output unit to train-kilometres, rather than passenger- or freight-tonne-kilometres, might be desirable (it will still be necessary to disaggregate train-kilometres according to their cost characteristics, as it costs much more to shift a 5 000 tonne freight train than a two-car branch line passenger train). The use of vehicle-kilometres in place of train-kilometres may be a helpful further refinement of the train-kilometre measure, although this measure will still not account for different weights of train. Certainly, to regard operations where rolling stock is grossly overloaded as therefore performing well – as is the case in some developing countries, despite very inefficient production of the service itself – seems mistaken.

Freight traffic is particularly complex because of the lack of a homogeneous unit of measurement: at least in passenger transport we are always dealing with people. A tonne of freight may cost very different amounts to transport, according to whether it is a dense product or not (for a dense product a single wagon will contain far more tonnes than for a product that is not dense) and the form it is in (bulk solids or liquids may be loaded and unloaded much more simply than manufactured goods, although the latter will be easier to handle if they are containerised). It follows that loaded wagon-kilometres may be a better unit of measurement than tonne-kilometres, and that distinctions may be needed between trainload, wagonload, and container or intermodal traffic. If tonne-kilometres are used, a distinction by commodity is important: for instance, a railway that has declining coal traffic and rapidly growing intermodal traffic will almost certainly show declining productivity if tonne-kilometres are the measure.

Inputs

Providing a rail service requires locomotives, passenger coaches or freight wagons (or self-powered vehicles), track, signalling, terminals and a variety of types of staff (train crew, signalling, track and rolling stock maintenance, terminals and administration). While, ultimately, all may be regarded as forms of labour and capital, the length of life of the assets, as well as government intervention in employment and investment, will often mean that at a particular point in time an undertaking will not have an optimal configuration of assets and staff. This renders it difficult to measure inputs simply as labour and capital, as measures of the value of capital stock will need to allow for excess capacity and inappropriate investment. An alternative is to simply look at physical measures of assets (e.g. kilometres of track, numbers of locomotives, carriages and wagons for railways), but this obviously makes no allowance for the quality of the assets. Further, and importantly, physical measures such as staff numbers can be greatly affected by contracting out and, unless a balancing item such as other costs is included as an input, substantially distort measures of productivity and efficiency.

Problems in measuring technical efficiency

A key problem in measuring technical efficiency is that of joint costs and economies of scale and density. For instance, a single-track railway may carry both passenger and freight traffic, a passenger train first- and second-class passengers and a freight train a variety of commodities. In this situation, only some of the costs can be specifically attributed to one of the forms of traffic; the remaining costs are joint. The result is that railways typically are characterised by economies of scope; i.e. the costs of a single railway handling a variety of types of traffic are less than if each distinct product were to be handled by a different railway. Moreover, most evidence suggests that railways are subject to economies of traffic density. Putting more traffic on the same route generally reduces unit costs and raises measures of total factor productivity, unless the route is already heavily congested.

The result is that apparent rises in productivity may be caused by diversification into new products or by increased traffic density rather than being relevant to the measurement of performance. Of course, under conditions of economies of density, running more services (and possibly different types of service) on the network does lead to a genuine improvement in productivity. The argument here, however, is that the improvement in productivity arises naturally as a result of the shape of the cost function, and not because of any improvement in working practices.

The operating environment will also exert a strong influence on railway performance through its impact on the nature of the traffic carried. This has already been considered above. However, geography has other influences as well: gradient, climate and complexity of the network are all likely to influence costs. The quality of the service delivered will also impact on costs, for example, in terms of the rolling stock used (e.g. air-conditioned trains and trains that give greater access for disabled users) and, more widely, the punctuality and reliability of services. Other factors, such as the extent of passenger information provided and the quality of on-board catering services for rail, will also affect costs. Particularly in the case of rail, the quality of the service will depend critically also on the capability of the infrastructure.

Of course, to the extent that the method used contains relevant measures of outputs and output characteristics, such that it can capture some of these features of the technology (e.g. scale and density effects; quality; network complexity), then it should be possible to obtain measures of technical efficiency after having taken account of these effects. We consider that econometric methods, as opposed to DEA or partial or TFP measures, give the best opportunities for getting at underlying technical efficiency; though as noted, DEA combined with a second-stage econometric model is a useful alternative. As we will argue later in this chapter, we consider cost econometric models to be the most suitable for achieving the objectives set out earlier; namely, assessing relative efficiency and understanding the impact of industry structure.

Concluding comments

There are many studies of railway technical efficiency using total factor productivity or DEA approaches. However, in addition to the problems of measuring outputs and inputs, there is a severe difficulty in terms of the data for this form of analysis. Typically, such approaches include physical measures of the labour input, combined with physical measures of the infrastructure and rolling stock measured in simple terms (track-km and number of rolling stocks). Usually other inputs are excluded, which risks giving misleading results, given that there are varying degrees of subcontracting in the rail sector (rolling stock may be leased; maintenance and cleaning of rolling stock and stations may be contracted out, as may track maintenance and renewals and so on). For this reason, as well as the technical reasons given above, we prefer studies based on costs, which should be comprehensive measures including all contracted out items. Moreover, it is ultimately costs that governments and regulators are most interested in, not measures of physical productivity.

Cost function estimation

In addition to the reasons outlined for preferring the approach of estimating cost functions, there is an additional practical reason; namely, that the data is more reliable, although there remain problems of inconsistencies in treatment of costs, such as depreciation and interest, particularly in international comparisons but even in one country over time. The problem is not simply different assumptions about asset lives. In some cases, where assets are purchased with grants, no depreciation or interest is entered into the accounts. In other cases, historic debts have been written off; in still others, interest is still being charged on them. Getting consistent data remains a challenge.

The problems regarding how to measure inputs and outputs also remain, as does the issue of the operating environment. How these problems may be handled in cost function analysis is considered below. However, overall, the cost function approach does at least ensure that all inputs are considered and the allocative efficiency (or inefficiency) associated with using different input combinations accounted for. This compares to technical efficiency analysis, which first of all does not, of course, take account of allocative efficiency but, perhaps more importantly for analysis of railways, often neglects some inputs (i.e. those represented by other costs).

Cost function estimation

Derived from assuming cost minimisation in a production process, the cost function relates costs (C) to the level of outputs (Y) and input prices (P) and, where data is available over time, some measure of how costs change over time (t) as a result of technical change. Thus:

$$C_{it} = C(Y_{it}, P_{it}, t) \qquad (1)$$

It therefore automatically allows for one key issue in comparing costs between railways in different countries, and in a single country over time: namely, different input prices.

There has been a vast array of functional forms proposed for the cost function. Notable developments include the constant elasticity of substitution (CES) (Arrow et al., 1961) and generalised Leontief (Diewert, 1971). The most widely employed cost function is the Translog (Christensen, Jorgenson and Lau, 1971; 1973). The Translog nests the simpler and widely-used Cobb Douglas function (see, for example, Beattie and Taylor, 1985) as a special (restricted) case; however, it is not derived from any production function using duality theory. Instead, the Translog cost function is usually presented as a functional form which is a second-order approximation to any cost function rather than being derived directly from economic theory. The general form of the Translog cost function for *m* outputs and *n* inputs is represented as:

$$\ln C = \alpha_0 + \sum_{i=1}^{m}\beta_i \ln y_i + \sum_{i=1}^{n}\gamma_i \ln w_i + \frac{1}{2}\sum_{i=1}^{m}\sum_{i=1}^{m}\beta_{ij}\ln y_i \ln y_j + \frac{1}{2}\sum_{i=1}^{n}\sum_{i=1}^{n}\gamma_{ij}\ln w_i \ln w_j + \frac{1}{2}\sum_{i=1}^{m}\sum_{i=1}^{n}\delta_{ij}\ln y_i \ln w_j \quad (2)$$

The function includes both first- and second-order terms in all variables. Importantly, the Translog allows for elasticities and marginal costs to vary flexibly with the level of outputs and prices. In this sense, the Translog does have appealing economic characteristics, such as the ability to deal with varying degrees of returns to scale and density as firm size varies.

Finally, we note that the Translog cost function is often estimated along with the factor share equations. Factor share equations are expressions for the proportion of total cost used by each input and are derived using Shephard's (1953) lemma as the partial derivative of the cost function with respect to each input price. Estimation can then proceed using Zellner's (1962) Seemingly Unrelated Regression (SUR) which is more efficient (in terms of estimation) than single equation ordinary least squares.

When it comes to measuring outputs, the need to distinguish between scale and density effects or the choice between passenger- and freight-tonne or train- or vehicle-km is only part of the wider issue of how to account for the heterogeneity of railway outputs. One way to deal with the heterogeneity in outputs is to group outputs (denoted y) into *m* groups and include a further set of *r* variables which characterise the outputs (denoted q):

$$C(y_1, \ldots, y_m, q_1, \ldots, q_r, w_1, \ldots, w_n) \quad (3)$$

The move from potentially hundreds or thousands of outputs to a more manageable number of *m* outputs is obviously a simplification. However, the inclusion of output characteristic variables is an attempt to reintroduce heterogeneity in outputs back into the model. Such variables may include revenue measures (such as passenger-km and freight-tonnes hauled) where availability measures such as train-km are adopted as output and vice versa. As such, it can become a little difficult to distinguish which variables represent outputs, versus output characteristics, versus network size.

Wheat and Smith (2014) present an attempt to introduce heterogeneity by means of a hedonic cost function (Spady and Friedlaender, 1978; Bitzan and Wilson, 2008). Under this approach, there is only one output as opposed to *n* outputs (this is relaxed in some applications, such as Wheat and Smith, 2014). Second, the output and output characteristic variables enter into their own function, and this then enters into the general cost function. The benefit of this approach is a more parsimonious model. It is perhaps surprising that there have not been too many applications of hedonic cost functions in transportation operations. In Wheat and Smith (2014), the model included three outputs (train hours, route length and number of stations operated) and many characteristic variables relating to the train hours output. This analysis provided rich insights into the impact of output heterogeneity on economies of scale and density (see below), whilst enabling a parsimonious model.

Stochastic frontier methods: Introduction

The above discussion has focused on the relationship between costs, outputs, output characteristics and input prices. As noted earlier, a key motivation for policy makers is to understand the relative cost efficiency of transport operators. The cost function relationships discussed above can be augmented to allow the relative efficiency of companies to vary and for this degree of variation to be estimated.

The efficiency measurement literature cites three functions which may be estimated, depending on the appropriate behavioural assumption: cost functions, production functions or distance functions (the latter two are focused on technical efficiency). Most applications in railways are based on cost functions, reflecting the fact that, due to the highly regulated environment in which most railways operate, it is appropriate to view railways as seeking to minimise cost for a given level of output (where the latter is more or less determined by the government). In this section we focus on cost function relationships or, more precisely now that we are introducing inefficiency into the approach, cost frontier relationships.

The simplest econometric approach is to use the method of corrected ordinary least squares (COLS). This method proceeds by ordinary least squares (OLS), but then shifts the regression line down by the amount of the largest negative residual (for the cost function case), thus translating an "average" cost line into a cost frontier. However, like DEA, the COLS method is a deterministic approach which does not distinguish between genuine inefficiency and statistical noise when looking at deviations from the frontier. It is, however, with suitable adjustments, widely used by UK economic regulators, in part due to its simplicity.

The alternative and more widely-used method in the academic literature (and increasingly by economic regulators) is stochastic frontier analysis (SFA); see equation (4) below. The stochastic cost frontier model can be represented as:

$$C_{it} = f(Y_{it}, P_{it}, N_{it}, \tau_t; \beta) + v_{it} + u_{it} \tag{4}$$

where the first term [$f(Y_{it}, P_{it}, Q_{it}, \tau_t; \beta)$] is the deterministic component;

and Y_{it} is a vector of output measures;

P_{it} is a vector of input prices;

N_{it} is a vector of exogenous network characteristic variables;

τ_t is a vector of time variables which represent technical change;

and β is a vector of parameters to be estimated.

C_{it} represents the cost variable to be explained.

The *i* and *t* subscripts refer to the number of firms and time periods, respectively.

Whilst some applications may use only cross-sectional data, most railway applications utilise panel data, and this type of data greatly expands the possibilities for increasing the richness of the analysis in a number of ways, as discussed further below. The v_{it} term is a random component representing unobservable factors that affect the firm's operating environment. This term is distributed symmetrically around zero (more specifically, assumed to be normally distributed with zero mean and constant variance). A further one-sided random component is then added to capture inefficiency (u_{it}).

For cross-sectional data, it is necessary to make distributional assumptions concerning the one-side inefficiency term, and the estimation proceeds via maximum likelihood. This is a significant limitation as these assumptions may not be valid. For panel data, there are additional estimation possibilities. Before turning to the panel data approaches, it is worth summarising the benefits of the econometric methods for studying the structure of railway costs and relative efficiency performance.

Compared to cost function (or average response function estimation), it is clear that frontier methods are a significant development, since they explicitly allow for the possibility of variation in efficiency performance among railways and over time. Compared with the DEA approach, econometric methods provide estimates of the underlying structure of production/costs; for example, the elasticity of costs with respect to different cost drivers, such as traffic volumes – which DEA does not. As noted, the study of these elasticities allows us to say something about the scale and density characteristics of the industry.

In addition, through the development of stochastic frontier analysis, econometric techniques are also able to distinguish between random noise and underlying inefficiency effects. However, econometric approaches do require the choice of an appropriate functional form, and the more flexible forms (such as the Translog) are not always straightforward to implement due to the large number of parameters to be estimated. In addition, the choice of distribution for the inefficiency term in stochastic frontier analysis is arbitrary. The precise method that researchers should use will therefore depend on a range of factors, and in many academic papers more than one method is used in order to provide a cross-check against the other approaches.

Stochastic frontier methods: Panel data approaches

The existence of panel data offers a number of important benefits. First of all, by combining cross-sectional and time-series observations, it provides additional degrees of freedom for estimation. This may be very important, particularly if the number of companies for which data exists is small, as it often is for economic regulators. Second, it provides an opportunity to simultaneously investigate inter-firm efficiency disparities, changes in firm efficiency performance over time, as well as industry-wide technological change over the period of the study. Third, for some models it can permit the estimation of firm efficiency without recourse to potentially restrictive distributional assumptions. Finally, it offers the prospect of disentangling inefficiency from unobserved factors. This latter benefit may be particularly important for railways, where substantial differences exist among railways, both within and between countries, but where it is hard to capture these differences in a set of variables to be included in the model.

One way of dealing with a panel is to treat each data point as a separate firm. In this case, each observation, including observations for the same firm over multiple time periods, is given a separate efficiency score. In the case of econometric estimation this assumption may not be appropriate, since it assumes that inefficiency is independently distributed across observations, even though it might be expected that an inefficient firm in one period is likely to retain at least some of that inefficiency in the next period.

The alternative and more usual approach is explicitly to recognise the panel nature of the data set. Within this alternative, there are two further options. Firstly, to estimate the model using traditional panel data methods (fixed effects or random effects [GLS]); see Schmidt and Sickles (1984). Alternatively, Pitt and Lee (1981) offer a maximum-likelihood version of the same approach. In both cases, inefficiency is assumed to be "time-invariant" and each firm is given one efficiency score for the whole period, rather than one score per firm for each period as in the simple pooled approach. The advantage of the traditional panel approach (fixed and random effects) is that it does not require distributional assumptions concerning the inefficiency term as in the maximum-likelihood equivalent. This benefit does come at a cost though, as it requires the assumption that inefficiency does not vary over time, which is restrictive.

For long time periods, the assumption of time invariant inefficiency is clearly problematic, and a number of approaches which allow for inefficiency to vary, whilst retaining some structure to the variation, have been developed. Time varying models have been developed for both the traditional panel data methods (e.g. Cornwell, Schmidt and Sickles, 1990), and the maximum-likelihood approach (e.g. Battese and

Coelli, 1992; Cuesta, 2000). Kumbhakar and Lovell (2000) describe these approaches in detail. A key distinction in the literature is between those models which make the assumption of independence in inefficiency over time (e.g. pooled SFA; Battese and Coelli, 1995) and those which permit firm inefficiency to change in a structured and not random way over time (Cuesta, 2000). The latter seem to have advantages from a regulatory and economic perspective.

An important and relatively recent development in the literature has revolved around the problem of disentangling inefficiency from unobserved heterogeneity. In the standard panel literature, fixed and random effects are assumed to represent unobserved, time-invariant factors that vary between firms. As noted, in the efficiency literature, these models have been applied as efficiency estimation approaches, with the firm effects reinterpreted as inefficiency. This approach risks labelling unobserved factors – genuine heterogeneity among railways – as inefficiency. Methods have therefore been developed in the literature to address this (Greene, 2005; Farsi, Filippini and Kuenzle, 2005; Kumbhakar, Lien and Hardaker, 2014; Colombi et al., 2014). One version of Greene's approach includes a firm-specific dummy, to capture unobserved heterogeneity between firms, which is assumed to be time invariant (e.g. environmental factors, such as topography or climate) as well as the one-side inefficiency term (which varies over time). The decomposition therefore relies on the assumption that inefficiency varies randomly over time, whereas unobserved heterogeneity is time invariant (as well as on the distributional assumptions of the model). The model is then estimated via maximum likelihood. This is one of the so-called "true" models, and there is also a random effects version of this approach.

The Farsi, Filippini and Kuenzle (2005) approach separates inefficiency from unobserved heterogeneity by making the assumption that the former is assumed not to be correlated with the regressors, whilst the latter may be (inefficiency being a function of the ability of management to control costs, given the exogenous set of output requirements and input prices that it faces – hence this would not be expected to be correlated with the regressors). Finally, the approaches set out by Kumbhakar, Lien and Hardaker (2014) and Colombi et al. (2014), seek to go further and separate the model residual into four components: random noise, time-varying inefficiency, time-invariant inefficiency and time-invariant unobserved heterogeneity. This model relies entirely on distributional assumptions to make this separation, which is a limitation. It further assumes that unobserved heterogeneity is uncorrelated with the regressors, which may not be valid. It is worth noting that these are relatively new approaches with relatively few applications as yet and none, to our knowledge, in railways.

Concluding comments

To conclude, then, there exists a wide range of methods for estimating cost inefficiency in the literature, some of them relatively simple and widely used, particularly by regulators, and others more complex. However, some of the more complex methods are now entering the economic regulation sphere in the United Kingdom. For example, the British Office of Rail Regulation (ORR) has adopted a range of advanced methods, and others, such as OFWAT (the economic regulator of the water sector in England and Wales), have at least considered these approaches, though to date have fallen back on simpler methods, given the data and results obtained. Panel methods offer much more scope for a rich analysis of the cost structure (economies of scale and density) and inefficiency, and these are the most widely used in railways. The question of dealing with random noise and heterogeneity (observed and unobserved) remains a key issue for all regulators in railways and other sectors. Ultimately, the choice of technique will depend on a number of factors, including the number of data points, availability of cost driver data, model performance, economic theory and practical considerations. Usually, it is appropriate to run a range of approaches and compare the results and in some cases it will not be easily possible to choose among them. Economic regulators in that case tend to average the efficiency results across a range of models.

Rail privatisation in Britain

Over the period 1994-97, the British rail system underwent the most radical transformation of any European railway. Infrastructure was separated from train operations, and the new infrastructure company (Railtrack) privatised by sale of shares. The freight sector was privatised essentially as two companies, with open access for new entrants permitted. The passenger sector was largely franchised out in the form of 25 franchises, offered for a period in most cases of seven to ten years, on a net cost basis but with requirements as to what services should be operated and restrictions on the levels of some fares.

In the period since privatisation (1995 to 2010) passenger-km growth in Britain has been faster than in all other major European railways (Brown, 2013). To provide a few specific examples, between 1995-2010, passenger-kms increased by 84% (Britain); 65% (Sweden); and 17% (Germany).[1]

In the passenger market, many studies have shown that economic growth is the main driver of increases in demand. However, one major change which began in the 1990s was the degree to which the competitiveness of the automobile slowed markedly. Growth rates in car ownership and use abated significantly (and actually fell amongst men under 30); car journey times (which had greatly improved with construction of the motorway network) worsened as road building slowed and congestion increased; and car operating costs rose, after decades of decline (partly due to government taxation). Thus, the degree to which increases in traffic due to economic growth were offset by loss of traffic to the automobile was greatly reduced. Even to the extent that increases in rail traffic were brought about by improvements in services, reductions in regulated fares and new rolling stock, in a franchise system much of this improvement was prescribed by and paid for by government. The residual effect attributed to privatisation is a small share of the total (see Wardman, 2006).

Freight market growth has also been strong. From 1996-97 to 2012-13, rail freight grew from 15.1 billion tonne-kms to 21.5 billion tonne-kms – i.e. by 6.4 billion tonne-kms. Of this increase, 3.6 billion was coal freight and, from 1998-99 (earlier data not available), 2.8 billion was domestic intermodal freight (the name is slightly confusing as this is nearly all containers to and from ports). In other words, these two commodities account for all the growth – collectively, other commodities stayed constant.

Over this period, coal-tonnes transported declined from 52.2 million to 52 million – in other words, the growth was entirely due to increased length of haul. This was brought about by a shift in the supply of coal from domestic pits to imported coal brought in at deep-water ports, remote from the power stations. The growth in containers was partly due to increases in overall international container movements, although rail increased its market share.

Thus whilst restructuring and privatisation may have contributed to the strong performance of the British system, the major causes lie elsewhere. However, the story regarding passenger train and infrastructure costs is not so positive (Table 4.1). Both remain higher per train-kilometre than at the start of the process, when one might have expected that economies of traffic density would have led them to fall. The biggest increase is in infrastructure costs. Under strong regulatory pressure, Network Rail’s costs have been falling in recent years, although the company is not improving efficiency as quickly as the regulator would like.

To understand the drivers behind these trends, we will first consider studies of passenger train operating costs and then infrastructure costs to try to understand the reasons for this increase.

Table 4.1. Rail industry costs in Britain (infrastructure and passenger train operations), 1997 to 2012

Costs (£b2011/12 prices)	1996/97	2005/6	2011/12
Infrastructure expenditure			
Maintenance	1.1	1.4	1
Renewals and enhancements	1.5	3.7	4.6
Other operating costs	1	1.4	1.5
	3.5	**6.5**	**7.1**
TOC costs less access charge payments	**4.2**	**5.8**	**5.9**
Total passenger rail costs	**7.7**	**12.3**	**13**
Unit cost measures (£)			
Total passenger rail costs per passenger train km	20.2	27	25.4
Infrastructure costs per passenger train km	9.2	14.4	13.9
TOC costs (excluding access charges) per passenger train km	11	12.6	11.5

Source: ORR.

British passenger-train operating costs

There have been many studies of passenger-train operating costs in Britain, including: Affuso, Angeriz and Pollitt (2003); Cowie (2002a, 2002b, 2005 and 2009); Smith and Wheat (2012a), Wheat and Smith (2014) and Smith, Nash and Wheat (2009). Preston (2008) provides a review of, among other things, previous cost studies of the British rail sector. A variety of methods, including non-parametric DEA (Affuso, Angeriz and Pollitt, 2003; Cowie, 2009; Merkert, Smith and Nash, 2009) and index number approaches (Cowie, 2002a; Smith, Nash and Wheat, 2009), as well as parametric estimation of cost functions (Cowie, 2002b; Smith and Wheat, 2012a; Wheat and Smith, 2014), production functions (Cowie, 2005) and distance functions (Affuso, Angeriz and Pollitt, 2003). Clearly, the former methods

(DEA and index number approaches) can only consider cost or technical efficiency and produce no estimates regarding the actual cost structure.

Importantly, of the British Train Operating Company (TOC) cost studies, only four cover the crucial period after 2000 when TOC costs started to rise substantially; these being Cowie (2009), Smith, Nash and Wheat (2009), Smith and Wheat (2012a) and Wheat and Smith (2014). Cowie (2009) covers the period to 2004, whilst the two further papers cover the period to 2006. Wheat and Smith (2014) provide analysis up to 2010.

An important issue is whether to include an infrastructure input in any analysis of train operating costs. Clearly, the infrastructure input may be an important part of the transformation function and so should be considered for inclusion in any analysis. The four papers by Cowie all include some measure of infrastructure input in the analysis, which is some combination of route-km and access charges paid by operators to the infrastructure manager (to form a price, if applicable).

This, in turn, raises two important and related problems: 1) the infrastructure input is hard to measure (this is particularly the case in Britain where access charges change significantly from year to year, depending on the degree of subsidy); and 2) the inclusion of this input turns the analysis into an assessment of rail industry costs/production, rather than being targeted on the TOCs. In their study, Affuso, Angeriz and Pollitt (2003) produce two models: one including the infrastructure input, and one not. The results differ as a consequence, although this problem is less severe during the early period after privatisation (which the study covers), since access charges and infrastructure costs were fairly stable during that period. Whilst there are good reasons for capturing the infrastructure input in a study of TOC performance, to capture the possibility that this input affects the TOC transformation function, Smith and Wheat (2012a) and Wheat and Smith (2014) argue that, given the measurement problems noted above, infrastructure inputs are best left out of the analysis. The dependent variable in their paper is thus defined as TOC costs, excluding fixed access charges. Route-km is also included as an explanatory variable in their model – not as a measure of the infrastructure input, but to distinguish between scale and density effects.

The focus of Smith and Wheat (2012a) was on the impact on cost efficiency of contract regimes, after several renegotiations and temporary contracts being introduced following franchise failure. They used a panel data stochastic frontier framework which allowed efficiency to evolve over time (based on Cuesta, 2000). They also included dummy variables in the cost function to allow the extent of cost effects of different contract types to be directly estimated.

The focus of the Wheat and Smith (2014) work, in contrast, was how to best model the cost structure of the industry. This work utilised a hedonic cost function and the description of the data used is given in Table 4.2. In particular they defined three generic outputs (route-kms, train-hours and number of stations operated) and defined nine characteristics of train services which go into the train-hours output function. These characteristics control for the heterogeneity in train service provision. They also define two inputs and associated prices.

Table 4.2. Data used in Wheat and Smith (2014)

Symbol	Name	Description	Data source
y_1	Route-km	Length of the line-km operated by the TOC. A measure of the geographical coverage of the TOC	National Rail Trends
y_2	Train-hours	Primary driver of train operating cost	National Modelling Framework Timetabling Module
q_{12}	Average vehicle length of trains	Vehicle-km/Train-km	Network Rail
q_{22}	Average speed	Train-km/Train-hours	National Modelling Framework Timetabling Module
q_{32}	Passenger Load Factor	Passenger-km/Train-km	Passenger-km data from National Rail Trends. Train-km data from Network Rail.
q_{42}	Intercity TOC	Proportion of train services intercity in nature	National Rail Trends for the categorisation of TOCs into intercity, LSE and regional. Where TOCs have merged across sectors, a proportion allocation is made on an approximate basis with reference to the relative size of train-km by each pre-merged TOC.
q_{52}	London South Eastern indicator	Proportion of train services into and around London (in general commuting services)	
q_{62}	$q_{42}q_{52}$	Interaction between Intercity and LSE proportions	
q_{72}	$q_{42}(1-q_{42}-q_{52})$	Interaction between intercity and regional (non-intercity and non-LSE services) proportions	
q_{82}	$q_{52}(1-q_{42}-q_{52})$	Interaction between LSE and regional proportions	
q_{92}	Number of rolling stock types operated	Number of "generic" rolling stock types operated	National Modelling Framework Rolling Stock Classifications
y_3	Stations operated	Number of stations that the TOC operates	National Rail Trends
Prices			
P_1	Non-payroll cost per unit rolling stock		TOC accounts for cost, Platform 5 and TAS Rail Industry Monitor for rolling stock numbers
P_2	Staff costs (on payroll)		TOC accounts (both costs and staff numbers)

Source: Wheat and Smith (2014).

Findings on the cost structure of passenger train operations

In this sub-section, we present some results of the work undertaken to date, to illustrate the richness and usefulness of the methods employed. Returns to scale (RtS) and returns to density (RtD) can be defined specifically for operations (as distinct from infrastructure). RtS measures how costs change when a firm grows in terms of geographical size. RtD measures how costs change when a firm grows by running more services on a fixed network.

The DEA analysis yields few results with relation to economies of scale or density. Indeed, the paper by Cowie imposes constant returns to scale. Merkert, Smith and Nash (2009) did estimate a variable returns-to-scale model and found that British and Swedish TOCs were below minimum efficient scale, while the largest German operators were above. Of the parametric papers, Cowie (2002b) estimates a cost model which provides evidence on economies of scale. Cowie finds evidence for increasing returns to scale. There is no attempt to differentiate between scale and density economies in the analysis.

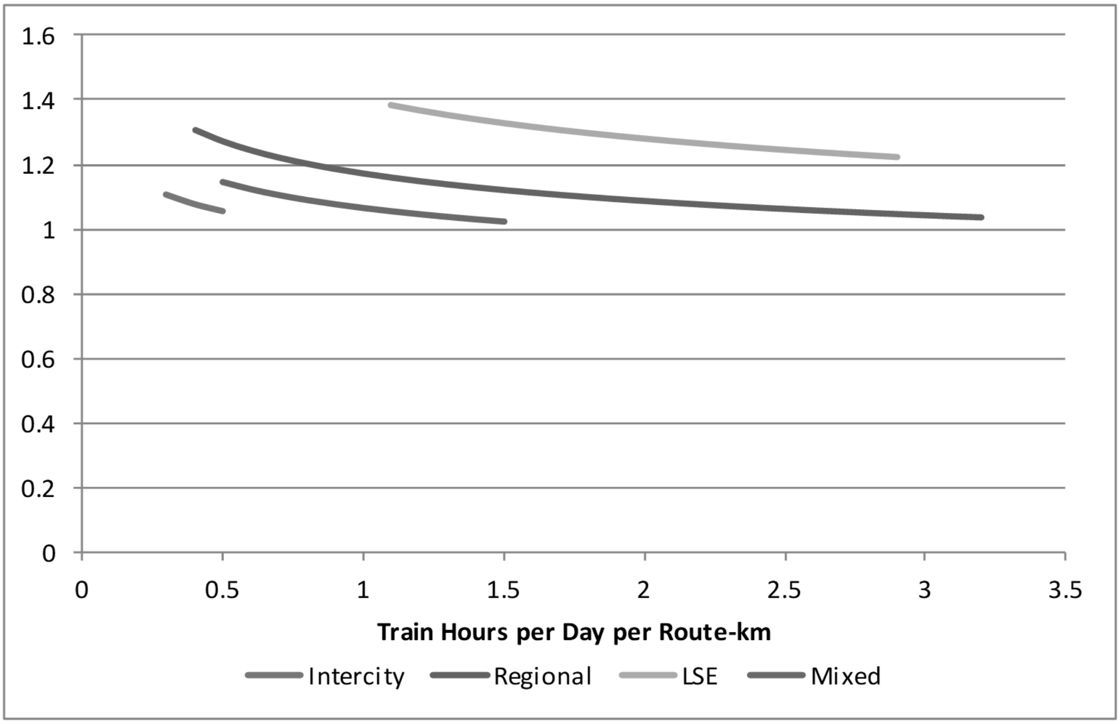
Smith and Wheat (2012) put forward a model which yields estimates of the extent of both economies of scale and economies of density, where the primary usage output is train-kilometres. They found constant returns to scale and increasing returns to train density. The policy conclusion of this finding is that, whilst there would not be scale benefits from merging franchises, such mergers may reduce costs by allowing greater exploitation of economies of density (a single operator running trains more intensively down a given route); though see further discussion on economies of density and heterogeneity below. One limitation of the Smith and Wheat (2012) work was the inability to estimate a plausible Translog function. Instead, a restricted variant was estimated, selected on the basis of general to specific testing and on whether key elasticities were of the expected sign. This implicitly restricts the variation in economies of scale and economies of density.

Further work by Wheat and Smith (2014) estimated a Translog simultaneously with the cost share equations and adopted a hedonic representation of the train operations output in order to include characteristics of output in a parsimonious manner. This work provides new insights into the scale and density properties of train operations, since it allows RtS and RtD to vary with the heterogeneity characteristics of output. Figures 4.2 and 4.3 summarise the findings on RtD and RtS.

Figure 4.2 shows that all TOC types exhibit increasing RtD and that this does fall with density, although RtD are never exhausted within the middle 80% of the sample. At any given train-hours per route-km level, intercity TOCs exhibit the lowest RtD, while LSE (commuter services into London) exhibit the strongest (and indeed even at the 90th percentile density in sample the RtD estimate is in excess of 1.2). Intuitively, the curve for mixed TOCs is somewhere in-between the curves for intercity and regional. The policy conclusion from the analysis of RtD is that most TOCs should be able to reduce unit costs if there is further growth in train-hours (on a fixed network) in response to future increases in passenger demand.

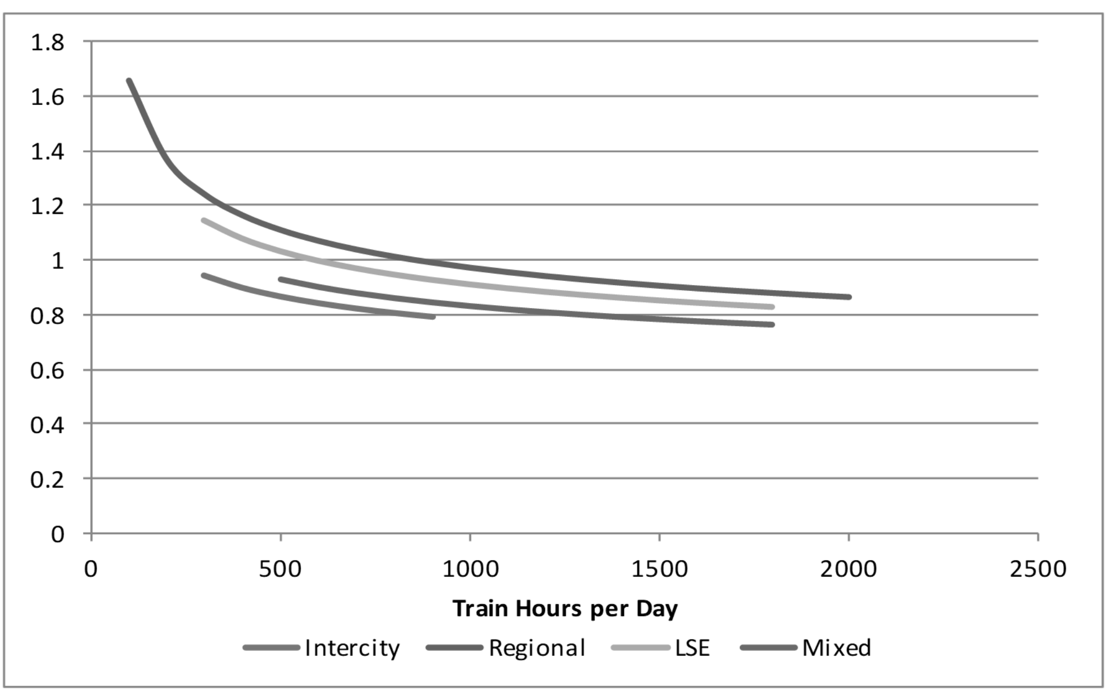
Figure 4.3 provides a similar plot for RtS. This shows that for all of the central 80th percentile of the train hours distribution, intercity (and mixed) TOCs exhibit decreasing RtS. LSE TOCs exhibit increasing returns to scale only for the very smallest in sample, whilst regional TOCs are the only TOC type to have an appreciable range exhibiting increasing returns to scale. The results are consistent with a u-shaped average cost curve, although it would appear that most TOCs are operating at or beyond the minimum unit cost point. This finding has important implications for examining the optimal size of TOCs, and is relevant to the recent franchise policy change that has resulted in substantial franchise re-mapping and, in turn, larger franchises.

Figure 4.2. Returns to density for different TOC types holding other variables constant



Source: Wheat and Smith (2014).

Figure 4.3. Returns to scale for different TOC types holding other variables constant



Source: Wheat and Smith (2014).

The overall conclusion from this section is that modelling returns to scale and density in passenger train operations potentially requires a rich model to fully capture the effects. The initial work published in Smith and Wheat (2012), based on a restricted Translog model, suggested broadly constant returns to scale combined with fairly strong economies of density. This may suggest that there could be a case for making franchises smaller, which could additionally help in reducing the risk of franchise failure, which has been a key problem in Britain. Britain's franchises are already considerably larger, in general, than those elsewhere in Europe. However, if reducing the size of franchises also increases the degree of franchise overlap, then important economies of density may be lost in the process, so it is not a clear policy conclusion. Turning the argument the other way round, larger franchises, that result in reductions in franchise overlap and the exploitation of economies of density, may reduce costs.

That said, Wheat and Smith (2014) develop a richer model, which takes account of service heterogeneity (in particular, in terms of train speed and TOC type) in relation to returns to scale and density. In that later paper, it is found that the ability to exploit economies of density may be constrained by service heterogeneity. Likewise, the losses of economies of density from reducing franchise size might be smaller than indicated above. It is further found that some franchises in Britain are operating at decreasing returns to scale, and may therefore be too large.

What the above research suggests is that it is possible to shed new light on the structure of costs of passenger train operations, and draw broad conclusions about the economies of scale and density of those operations. The most recent work suggests that there could be cost savings from reducing franchise size (because of scale diseconomies) and that losses in economies of density might be reduced by service heterogeneity. Whilst we can draw these general conclusions, we would, however, recommend that more detailed, bottom-up modelling work be carried out on a case-by-case basis, if a decision is required on franchise mergers/de-mergers. It may not be possible in an econometric model to fully reflect the service and rolling-stock possibilities that result from such changes.

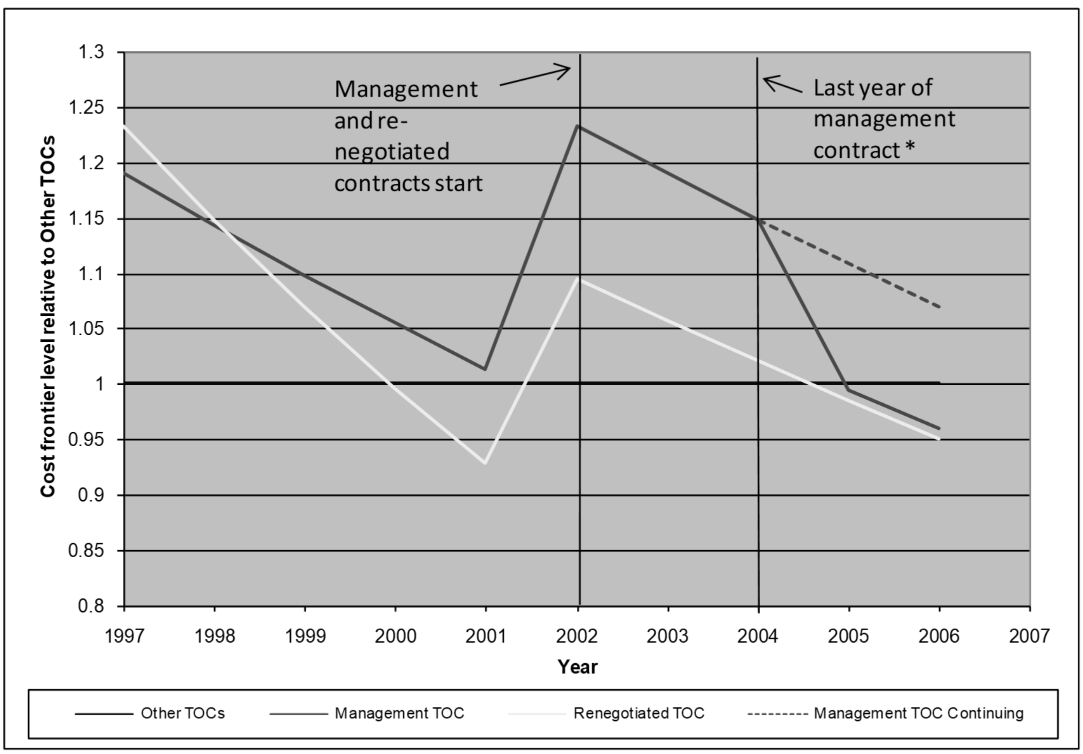
Findings on efficiency variation

The purpose of this section is to illustrate the potential of the methodologies with respect to measuring efficiency of railway operators. There is extensive literature analysing the efficiency and productivity performance of vertically integrated railways around the world (Oum, Waters and Yu, 1999; Smith, 2006). More recently, there has also been an interest in understanding the impact of vertical separation on total industry costs, mainly focussed on European evidence (Friebel, Ivaldi and Vibes, 2010; Asmild et al., 2009; Growitsch and Wetzel, 2009; Cantos, Pastor and Serrano, 2010 and 2011; Mizutani and Uranishi, 2013; Nash et al., forthcoming; van de Velde et al., 2012), although some studies considered evidence from North America (e.g.Bitzan, 2003). Overall, the results seem inconclusive, suggesting that much depends on the circumstances of the country concerned and the way in which the system is managed. However, we consider the recent work by Nash et al. (forthcoming) and van de Velde et al. (2012) to offer interesting new insights on the circumstances in which vertical separation and the holding company model might result in lower or higher costs. We review this work in more detail below.

There have also been a small number of studies focusing on the impact of competitive tendering on one part of the rail industry; namely, passenger train operations. In Germany and Sweden, the experience of competitive tendering has generally been positive, with the evidence suggesting that savings in the region of 20-30% can be achieved, alongside increased patronage (see Brenck and Peter, 2007; Lalive and Schmutzler, 2008; Alexandersson and Hulten, 2007; Nash and Nilsson, 2009). Even here, though, some franchises have failed to achieve favourable results. Kain (2009) describes the major problems that emerged in Melbourne, though the impact of the policy response is not described in any detail. Long-term passenger (as well as freight) rail franchises have also been signed in Latin America, generally leading to radically improved performance, although in most cases re-negotiation has been required due to changed economic circumstances (in particular, the severe economic recession in the late 1990s: see Kogan, 2006).

Turning to studies of British TOCs, Affuso, Angeriz and Pollitt (2003) and Cowie (2002a, 2002b, 2005) study the early years after privatisation (prior to the major cost rises) and all find improving productivity during this period. Only two studies cover the post-2000 period, after which costs started to rise. Cowie (2009) finds declining productivity growth after 2000, with the absolute productivity level falling post-2002. Smith and Wheat (2009) report productivity levels falling as early as 2000 and not recovering over the remainder of the sample (to 2006). Smith, Wheat and Nash (2010) review this literature. Thus Britain's franchising experience appears to be the outlier (at least within Europe), with costs rising rather than falling, as in Germany and Sweden.

Figure 4.4. Findings for TOCs in Britain that were subject to short-term management or renegotiated contracts relative to other TOCs



* Some TOCs saw re-franchising during this period and came off their management contracts. Other TOCs (dotted line in the above chart) continued on their management contracts to the end of the period.

Source: Smith and Wheat (2012).

Smith and Wheat (2012) investigate the impact of the response of the franchising authority in Britain to franchise failure. Two approaches were adopted. First, most operators were placed onto annually-negotiated management contracts (similar to cost-plus contracts). The second approach saw some operators placed onto newly-negotiated short-term franchise arrangements. Figure 4.4 summarises the findings on the cost effect of different franchise contracts. This shows that the franchising authority's decision to place a large number of TOCs on management contracts for an extended period led to a substantial deterioration in efficiency relative to other TOCs. Furthermore, this effect was persistent and led to costs being considerably higher than other TOCs for several years. However, the relative inefficiency was eliminated by competitive re-franchising for those TOCs that were subject to this process during the sample period. The short-term franchise agreements which, once signed, retain incentives to reduce costs, saw a more positive pattern, with costs remaining in line with other operators (those that remained on their original franchise agreements throughout).

Infrastructure costs

As noted above, infrastructure costs have risen even more than train operating costs. A major reason for this was the expansion of maintenance and renewals activity following the fatal accident at Hatfield in 2000, which was caused by a broken rail, but the cost of the West Coast Mainline renewal and upgrade programme also rose to some GBP 8 billion from an original estimate of GBP 2 billion. The result of these two events was that the privately-owned infrastructure manager, Railtrack, was placed in administration in 2001, and was ultimately succeeded in 2002 by Network Rail, a company limited by guarantee, responsible to its members rather than shareholders and with its debts guaranteed by the Government. The Office of National Statistics has recently ruled that, under current EU regulations, Network Rail is to be regarded as a public sector organisation.

How did these events affect the efficiency of the British infrastructure manager over time, and how does it compare with its European peers?

As noted above, rail infrastructure costs rose substantially after the Hatfield accident. Whilst part of this increase was driven by the need to increase maintenance and renewal activity, in the light of genuine concerns over the quality of the network, a wide range of evidence has shown that Network Rail's efficiency performance deteriorated sharply over that period. Strong regulatory action has therefore resulted, with Network Rail being tasked with making large efficiency gains in recent and coming years.

Kennedy and Smith (2004) showed that Railtrack delivered substantial real unit cost reductions in the early years after privatisation (6.4% to 6.8% for overall maintenance and renewal activity between 1996 and 2002). However, these improvements were more than offset by the post-Hatfield cost increases, which resulted in unit cost increases of 38% for overall maintenance and renewal activity. Indeed, costs continued to rise after 2002 (see Smith, Nash and Wheat, 2009). A further finding of Kennedy and Smith (2004) is that there was scope for the infrastructure manager to reduce its costs by reducing intra-company performance differences.

ORR carried out a review of Network Rail's efficiency performance, in the light of the large cost increases, and commissioned a wide range of studies for its 2003 Interim Review of the company's finances. A key weakness of the 2003 Review, though, was that ORR's efficiency determination was ultimately based on two bottom-up consultant reviews of Network Rail's business plan (LEK, TTCI and Halcrow, 2003 and Accenture, 2003). These results were supplemented by internal benchmarking, which indicated the kind of savings that could be achieved if Network Rail implemented its own best practice consistently across the network.

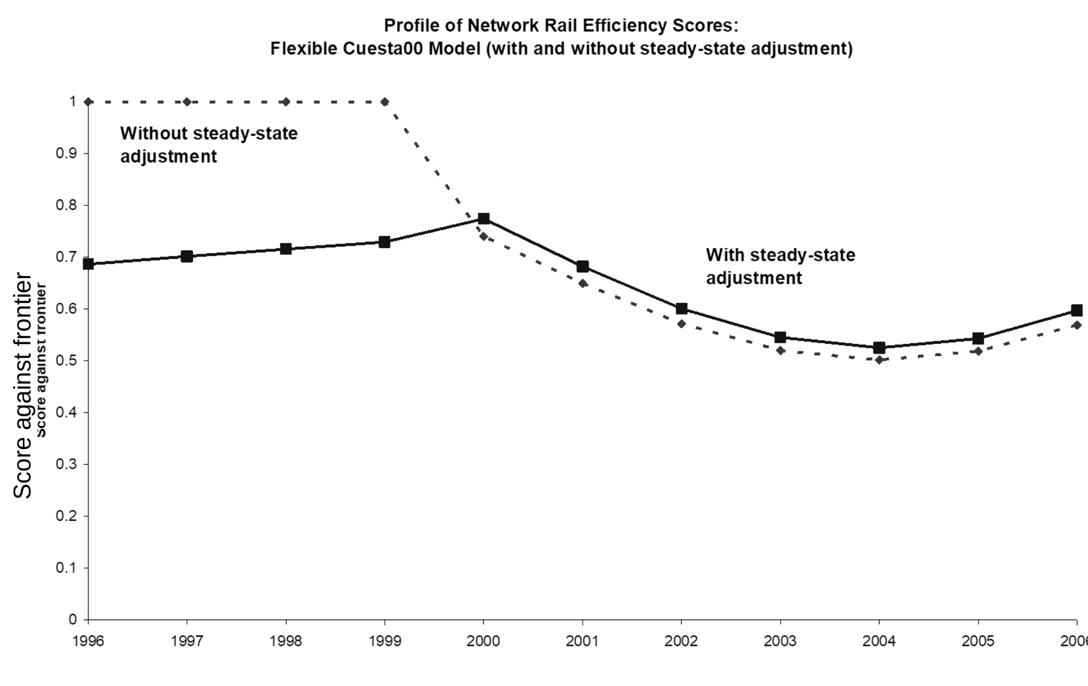
Ultimately then, the 2003 Interim Review was unable to provide a clear, empirically-based assessment of Network Rail's relative efficiency position based on hard data from external sources. ORR nevertheless set a tough efficiency target of 31% over five years (2004-2009). However, costs were starting from a very high base. Thus, although costs then started to fall as Network Rail set about delivering its efficiency targets, by the time of the next periodic review in 2008, the scene was set to take the benchmarking approach a step forward by attempting international comparisons.

Two approaches were adopted during the 2008 review. The first used a panel of thirteen European infrastructure managers over an eleven-year period. The data was provided from the Lasting Infrastructure Cost Benchmarking (LICB) project, undertaken by the UIC. The dataset included data on costs (adjusted, based on PPP exchange rates), traffic volumes (by type), network length, and a range of other variables characterising differences between the companies (for example, extent of electrification, network density).

A structured inefficiency model (Cuesta, 2000; see above) was used that permits inefficiency to vary by firm over time, but in a structured way that recognises the panel nature of the dataset. The results are shown for Network Rail in Figure 4.5 (other companies cannot be shown for confidentiality reasons); see Smith (2012). Results are shown for maintenance only and for maintenance and renewals, with the additional model variant to allow for Network Rail's renewals costs to be reduced downwards prior to modelling, to allow for the fact that the company was renewing at above-steady-state levels in terms of renewal volumes. The overall message of Figure 4.5 is that Network Rail's efficiency deteriorated sharply after 2000, compared to its European counterparts, leaving the company with an efficiency gap of around 40% by the end of the period. The analysis was carried out by the University of Leeds, with ORR and in conjunction with Network Rail and UIC.

In a separate, supporting study, ORR and the University of Leeds collected a new dataset, comprising five other rail infrastructure managers in Europe and North America. This includes data on costs, outputs and network characteristics at the regional level within each country. Thus, although the number of companies included was smaller than in the LICB dataset, the sample size was expanded via the use of regional data within companies (sub-company data structure). The dataset also allowed ORR to study within-country variations in inefficiency. The results broadly confirmed the results of the main study using LICB data (see Smith, Wheat and Smith, 2010; Smith and Wheat, 2012b).

Figure 4.5. Profile of network rail efficiency scores: preferred model



Source: Smith (2008, 2012).

It is further worth noting that the ORR carried out a range of other studies, principally based on bottom-up evidence. These confirmed the existence of a substantive gap, supported by examples of best practice in other countries (see Table 4.3).

Table 4.3. Examples of European best practice

Asset inspection and asset management	In general, best practice European railways undertake fewer track inspections but inspections are generally of higher quality. It is estimated that similar techniques applied in Britain could reduce foot patrolling inspection costs by around 75% and tamping expenditure by 20%.
Recycling components	This is common European practice. In Switzerland, for example, rail, point motors, sleepers and signal heads are regularly refurbished then cascaded from higher to lower category routes. Cascaded rail on lines re-laid with steel sleepers could lead to savings. Additionally, ballast cleaning (partial renewal) as opposed to traxcavation (complete renewal) could reduce ballast renewal cost in Britain by 40%.
High output rail stressing	Stressing continuously welded rail by heating it, rather than physically stretching it, is a process discontinued in Britain in the 1960s and 70s. Some European networks (using modern equipment) have reintroduced this method which doubles on-site productivity and, if applied to the renewals re-railing workbank in CP4, could lead to significant annual savings for Network Rail.
Formation rehabilitation trains	Modern high output European plant is regularly used to undertake formation and also ballast renewals. If applied to Network Rail's CP4 category 7 and 12 track renewals, RailKonsult estimate that it could reduce unit costs for both activities by around 40%.
Lightweight station platforms	The use of modular construction polystyrene station platforms in the Netherlands could provide opportunities in Britain, given the substantial CP4 platform extension workbank. Analysis suggests a unit cost saving of around 25% in Britain.
Efficient European re-railing techniques	This particular study brought together many themes from the previous RailKonsult work, by focussing upon the Swiss re-railing method. Bespoke plant, high output welding techniques and dedicated teams are applied routinely. Put together for basic re-railing work alone, this method is around 40% more efficient than current Network Rail practice.
Use of dedicated teams	Contractors are widely used by most continental railways, as they are in Britain. However, there is generally a greater degree of specialisation by activity in Europe (such as S&C renewal or tamping). This ensures a highly skilled and productive workforce dedicated to particular tasks, in contrast to the situation in Britain where contractors are often not even dedicated to rail.

Source: Smith, Wheat and Smith (2010).

Although ORR carried out/commissioned a wide range of studies – all of which pointed in the direction of a large efficiency gap – it was the output of the LICB-based econometric model which was used to set Network Rail's efficiency targets. ORR chose to compare Network Rail against the upper quartile of the peer group, rather than the frontier, thus meaning that the starting efficiency gap for its analysis – based on the preferred econometric model from the analysis of the LICB data – was 37% rather than 40%. ORR also gave the company ten years to close the gap, with only two-thirds of the gap targeted to be closed during the immediate control period (control period 4 [CP4]; 2009-2014).

In the next periodic review (PR13), ORR shifted the emphasis of its approach to bottom-up methods. This was driven by a number of factors, but in part reflected increased doubts after 2008 about the quality of the LICB data and the commitment of the different companies to providing accurate information. A re-run of the sub-company approach was also attempted, but again it was considered that there was insufficient time to get enough certainty about the quality and comparability of the data received. Therefore, although Network Rail acknowledged the size of the efficiency gap resulting from the PR08 econometric modelling, emphasis switched in the PR13 review to bottom-up analysis. Whilst new econometric modelling with an updated LICB dataset was carried out and reported, in the process also applying more advanced techniques (including the more recent methods set out previously), the econometric modelling played a supporting role to the bottom-up analysis (thus reversing the approach taken in PR08; see ORR, 2013).

Perhaps one of the lessons that may be learned here is that international benchmarking is problematic because it takes considerable time and commitment from a group of countries to make the analysis credible and usable. In PR08, ORR had the advantage of a ready-to-go dataset, produced by UIC, and this enabled top-down, econometric international benchmarking to play a more significant role than it has in other regulated sectors. A further factor at play in PR08 was the sheer size of the cost increases that had occurred and the scale of the cost challenge and, given the lack of domestic comparators, there was a strong imperative to use this kind of approach. In PR13, with Network Rail acknowledging the size of the gap, with the gap closing already, and with new uncertainties arising in the LICB dataset, ORR has become more cautious about top-down international benchmarking and, arguably, the need to rely on it has diminished. ORR also considers that its leading role in collecting new data for the sub-company modelling approach is questionable – and that perhaps this kind of work should be led and funded by companies rather than regulators.

One consideration going forward, however, is the extent to which ORR, and regulators in general, can avoid the use of top-down benchmarking. Further, if international benchmarking is to work, then it may require concerted efforts by regulators/governments across Europe, working together to establish a common benchmarking framework against which all companies can be compared, thus also implying that data can be requested and audited by regulators and policy makers. Finally, a further opportunity for benchmarking remains the notion of internal benchmarking. Whilst not without its problems, it remains a useful part of a regulator's toolkit, as it establishes the savings that could be achieved if best practice (within-country) is consistently applied. The existence of disaggregation into units that have managerial autonomy (at least to some degree), as with Network Rail's routes, is, of course, a pre-requisite for such an approach but these groupings/disaggregations do also exist in other railways.

European rail systems

The previous section considered the impact of reforms on costs in Britain and attempts to benchmark Network Rail (and, to an extent, the TOCs) with a view to challenging their costs and improving efficiency. In this section, we consider the wider European experience. Most past studies on the impact of reforms at the European level have applied data envelopment analysis to physical data; our problems with that approach have been outlined above. Moreover, they have usually used the data published by the Union International des Chemins de Fer (UIC),[2] data which has been shown to contain inconsistencies (van de Velde et al., 2012). Furthermore, this source only contains data on UIC members, generally the incumbent but not new entrants, and in some cases covers their activities in a number of countries rather than just their home country. A rare example of the estimation of cost functions to study the impact of European reforms is Asmild et al. (2009); they also went to considerable efforts to clean up and supplement the UIC data. They found that competitive tendering for passenger services, open access for freight services and accounting separation of infrastructure from operations all improved efficiency, but could find no further effect of complete separation of infrastructure from operations. However, their data series ended in 2001 before many reforms took place.

A recent example of the use of a Translog cost function with panel data from a large number of countries is Mizutani and Uranishi (2013). They used data for 30 railway companies from 23 OECD countries for the years 1994 to 2007, giving 420 observations. Whilst most of the observations were from Europe, they included the vertically integrated passenger railways of Japan, as well as South Korea and Turkey. Where vertical separation had been implemented, they added together the infrastructure manager and the train operating company to form a single observation. The basic source of data was the UIC, but this was supplemented as necessary by data from company annual reports.

Two separate models were estimated, one using passenger-kilometres and freight tonne-kilometres as outputs and the other, total train-kilometres, with the share of passenger revenue to total revenue, passenger load factors, length of haul and number of freight cars per train to reflect differences in the characteristics, and therefore costs, of the train-kilometres. Factor prices for labour, track, rolling stock and other materials were estimated. Finally route-kilometres, train-kilometres per route-kilometre and the percentage of electrified line were included as descriptors of the network.

The rail reform variables were dummies reflecting complete vertical separation (the holding company model being regarded as integrated) and horizontal separation of passenger and freight operations. It was found that whilst horizontal separation unequivocally reduces costs, vertical integration only reduced costs for densely trafficked railways; for most European railways it increased them. Given that there are no separate variables representing the degree to which competition is permitted or actually takes place, it must be assumed that these impacts are the net effect of any additional costs directly caused by vertical separation and of the impact of competition, which in most of Europe must presumably be sufficient to outweigh these costs. The explanation given for the impact on costs varying with density is that given above, that the transaction costs caused by vertical separation will be much greater in densely trafficked networks than in less densely trafficked ones.

Van de Velde et al. (2012) take this work further by updating and improving the data set and introducing separate dummy variables for holding companies and complete vertical separation (this work has also been published later in the academic literature (see Nash et al., forthcoming; and Mizutani et al., 2014). They also include Britain, the country in which the most radical reforms had taken place, but which had been excluded from most previous studies due to lack of data. Finally, they introduce dummy variables representing passenger and freight market competition.

They confirm the previous finding that, compared with complete vertical integration, vertical separation reduces costs at low levels of density but increases them at high levels: at mean European density levels, costs are not affected by the change. This effect is not likely to be one of pure transaction costs (negotiating and enforcing contracts), which have been shown to be a relatively small proportion of total systems costs (Merkert, Smith and Nash, 2012) but is more likely a problem of misalignment of incentives leading to poor integration of infrastructure and operations in circumstances (dense traffic) where this is particularly important. They find weak evidence (significant at 10% only) that the holding company model reduces costs compared with vertical integration, but this does not vary with density, so the holding company would be preferred to vertical separation at high levels of density but not at low.

Within the range of the data, the introduction of competition seems to have had no effect on costs. Horizontal separation of freight and passenger undertakings seems to have sharply reduced costs (perhaps because this has typically been associated with preparation of the freight undertaking for privatisation), whilst a high proportion of revenue coming from freight rather than passengers tends to increase the costs of vertical separation (perhaps because planning freight services efficiently requires closer day-to-day working than for passengers, since freight services vary from day to day whereas passenger services are generally fixed for the duration of the timetable). The paper also provides qualitative evidence on the issue of how misalignment of incentives may raise costs and shows how, whilst efficiently set track-access charges and performance regimes are important, they do not provide incentives for railway undertakings to assist infrastructure managers in seeking the minimum cost solution to infrastructure provision. Only a mechanism for sharing of changes in costs and revenues, as provided for in some of the alliances now being negotiated in Britain, will achieve that.

The conclusion of the studies in this section is that there is no one-size-fits-all policy for European railways. Based on a mixture of qualitative and quantitative research, the evidence suggests that vertical separation may perform less well than the holding company model for intensely used networks, whilst being the structure of choice for less dense networks. Whilst this is in part intuitive, it is not totally clear why separation reduces costs for lightly used networks, particularly if there is little competition. It is further disconcerting that it has not been possible to find clear competition effects in the data. To date, no research has yet been published to consider the impact of regulation on costs, though research is ongoing at the University of Leeds in this respect. A final note must be that although we consider the cost-function approach to be the best, and with the van de Velde et al. (2012) study incorporating new data from CER members to supplement published data, there nevertheless remains work to be done on the data side to improve its comparability.

Conclusion

There are various measures of efficiency available, and all have their uses. Partial productivity measures may have their value in shedding light on the utilisation of particular resources, but they are inadequate as measures of overall efficiency, such as are needed in econometric studies of the influences of alternative policies on the efficiency of the rail industry as a whole. For this there are a number of possibilities, including total factor productivity measures and Data Envelopment Analysis but, for various practical reasons, we prefer the econometric estimation of cost functions.

Detailed studies of Britain suggest that the reforms in Britain did not achieve lasting improvements in cost efficiency. In the case of the infrastructure manager, the events surrounding the placing of Railtrack into administration brought about a major reduction in efficiency, from which the current infrastructure manager, Network Rail, is only gradually recovering. Surprisingly, competitive tendering did not achieve a reduction of train operating costs, which have risen substantially. There appear to be various reasons for that, but the use of management contracts to deal with cases of financial failure, the use of too-large areas as the basis for franchising (from a cost and risk of failure point of view) and the loss of economies of density through overlapping franchises, all seem to be factors in this (though it must be noted that splitting franchises to reduce their size increases the prospect of franchise overlaps). Most continental franchises are smaller and subject to less overlap of homogeneous services, and they appear to be more successful. However, it must still be noted that the studies carried out other than in Britain are based on data on subsidies and not on cost, and it may be that costs have been reallocated elsewhere in the system.

Studies of European-wide reforms suffer even more data problems than studies in a single country, but a recent study which sought to overcome these was van de Velde et al. (2012), using partly published data and partly new data provided by CER members. They found that complete vertical separation only reduces cost in low-density countries; at higher densities it raises cost. The reason for this is likely to lie in the misalignment of incentives, a factor considered important in Britain by the McNulty Report (McNulty, 2011). The level of competition in both freight and passenger markets appears to be an insignificant factor in determining costs.

It is clear from all these studies that much still needs to be done to understand the determinants of rail cost efficiency. The most fundamental requirement, whether within or across countries, is for good-quality, consistent data on the variables we are seeking to measure (in cost analysis, a key area here is the costs of depreciation and interest). Better measures of policy variables are needed, including in particular the quality of regulation and the degree of competition. At the same time, the measurement of service quality is an important factor – as noted above, no sensible operator minimises costs wholly at the expense of service quality.

The data challenges are unlikely to be overcome based on published data. Experience suggests that some progress can be achieved by working with companies; however, this takes time and commitment, and sometimes companies may start involvement in a benchmarking project, only to withdraw later. Long-term commitment to developing a framework and data collection exercise is required. Ultimately, it may be that data issues cannot be fully addressed without a concerted, European-wide effort by multiple policy makers and regulators to require data to be collected to a common set of definitions, with appropriate audits in place to achieve comparability.

Whilst the data will never be perfect and there will never be data on every possible variable that may drive differences among companies, methodological advances mean that, with enough data points (and with panel data), there are ways of disentangling inefficiency from unobserved factors that cause costs to vary among railways. Thus, we consider that it is both possible and sensible to continue to develop our understanding of railway costs and efficiency performance using existing datasets, improved where possible, and applying state-of-the-art methods.

Finally, we note that the challenges facing policy makers seeking to compare performance are further hampered by the increased need for railways to improve the quality of what they deliver, whilst expanding capacity and reducing carbon as well as responding to the increased challenges posed by climate change. All of these raise new data and methodological challenges which researchers and policy makers will need to grapple with in the coming years.

Notes

1 Source: European Commission Transport in Figures.

2 This is published data as distinct from the confidential data from the LICB project described earlier.

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International Transport Forum

Efficiency in Railway Operations and Infrastructure Management

This report provides a framework for making reliable comparisons of the efficiency of rail systems. Efficiency is of concern to all governments but measuring it for railways is challenging. This is because of the complexity of providing rail services and the diversity of business models adopted to deliver them. Restructuring of the sector in many countries makes trends in costs and efficiency particularly difficult to track. There are also trade-offs to be made in how detailed the analysis needs to be and the availability of consistent data over time. The report proposes a balanced scorecard for characterising performance.

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