Institute for Transport Studies
FACULTY OF ENVIRONMENT

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# Rail efficiency: cost research and its implications for policy

**International Transport Forum (ITF) Roundtable on Efficiency in Railway Operations and Infrastructure Management**

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# Outline

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1. Background and introduction
2. Efficiency measurement methodology
3. Studies of the British rail reforms
4. Studies of European rail policy
5. Conclusions

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# Policy context

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- EC wish to see rail as the main mode of medium distance passenger and long distance freight transport
- Requires a big improvement in service quality and capacity
- Only affordable if costs greatly reduced
- EC is relying on the impact of reforms to increase within-rail competition to achieve this
- So it is very important to:

Identify efficient railways and learn from them

Identify what reforms work in what circumstances

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# Particular problems in measuring railway efficiency I

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1. Continued monopoly in many areas

2. Government intervention on outputs and prices

Together these mean that methods which rely on competitive markets (e.g. measures of profitability) may be misleading.

What is generally in the hands of railway management is cost efficiency (although there may be political interventions even here)

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# Particular problems in measuring railway efficiency III

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Measuring inputs

Railways use a variety of inputs – staff, fuel, locomotives, passenger cars, freight wagons, infrastructure etc

All vary in capability

Also huge variations in subcontracting (maintenance of track and rolling stock, cleaning etc)

Cost measures may be more comparable

But still some problems especially regarding consistency of depreciation and interest

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# Particular problems in measuring railway efficiency II

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Railways produce a host of different outputs:

Carrying different types of passengers and freight between different origins and destinations with different levels of service at different times of day

A number of summary measures may be used:

Passenger km and freight tonne km

Train km by type of train

Vehicle km by type of vehicle

Ideally we would use them all as part of our measurement of outputs, along with indicators of service quality and operating environment.

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# Some definitions

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Technical efficiency: production function: **Y = f (inputs)**

- Are inputs ,minimised for the level of output required?

Allocative efficiency

- Is the combination of inputs used the minimum cost one?

Cost efficiency: cost function: **C = f (outputs; input prices)**

- The product of technical and allocative efficiency

Efficiency is a relative measure: productivity measures ratio of outputs to inputs (similar concept but important differences)

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# A starting point for measuring efficiency

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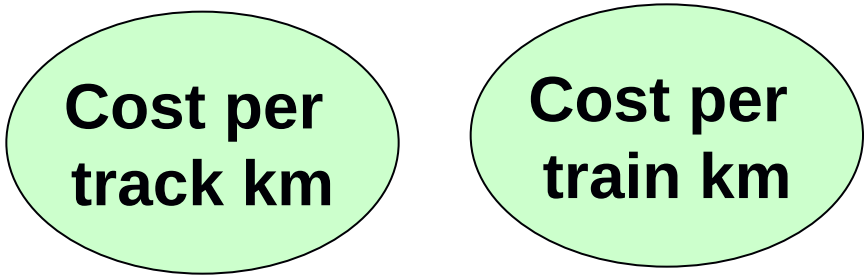
- Unit cost measures widely used as a starting point – but only partial measures (which denominator to use?)




- Relative efficiency scores **simultaneously** take account of variation in track km and train km (and other cost drivers)
- So potentially gives a single, more definitive measure of relative performance (if a robust model can be achieved)
- An added benefit of statistical models: we can determine what the data is telling us about the impact of key variables on cost (elasticities; scale / density economies)

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# Why a statistical / econometric model?

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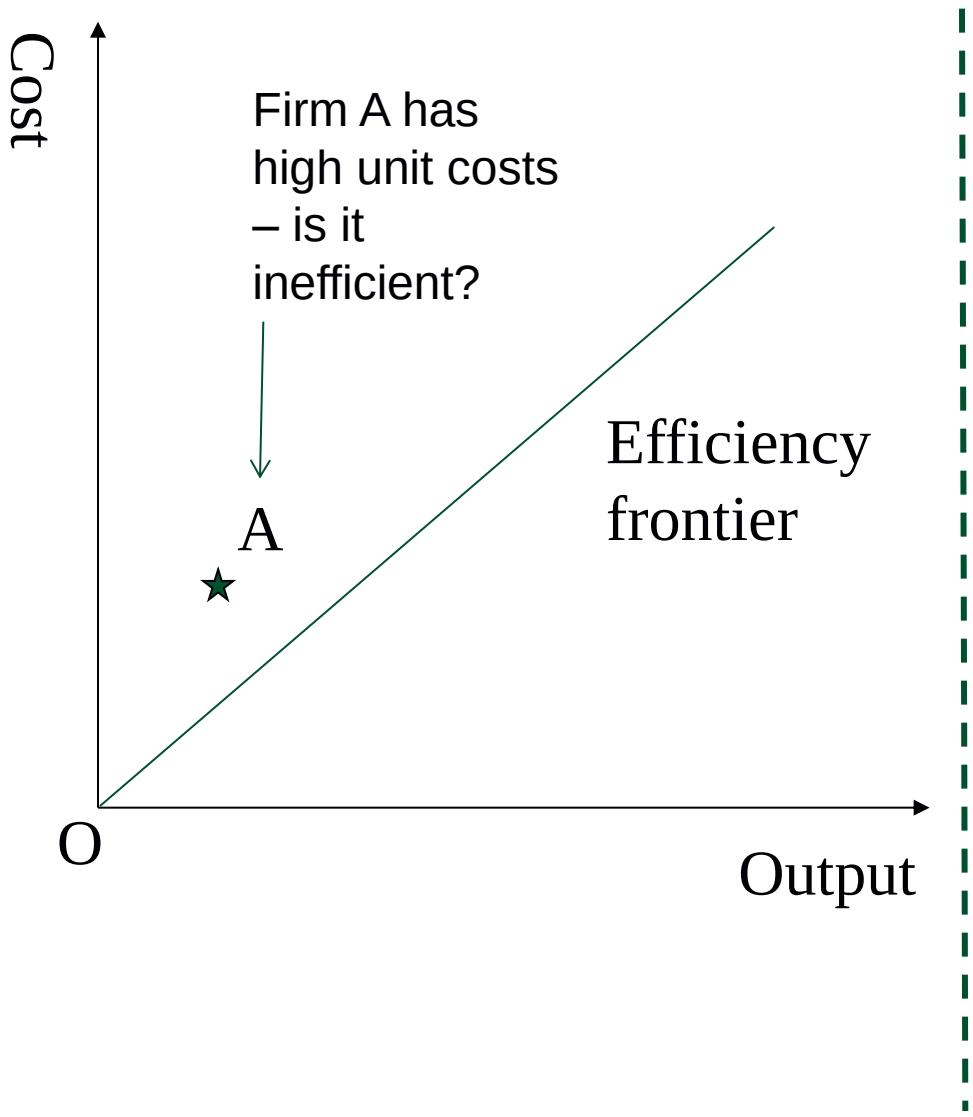


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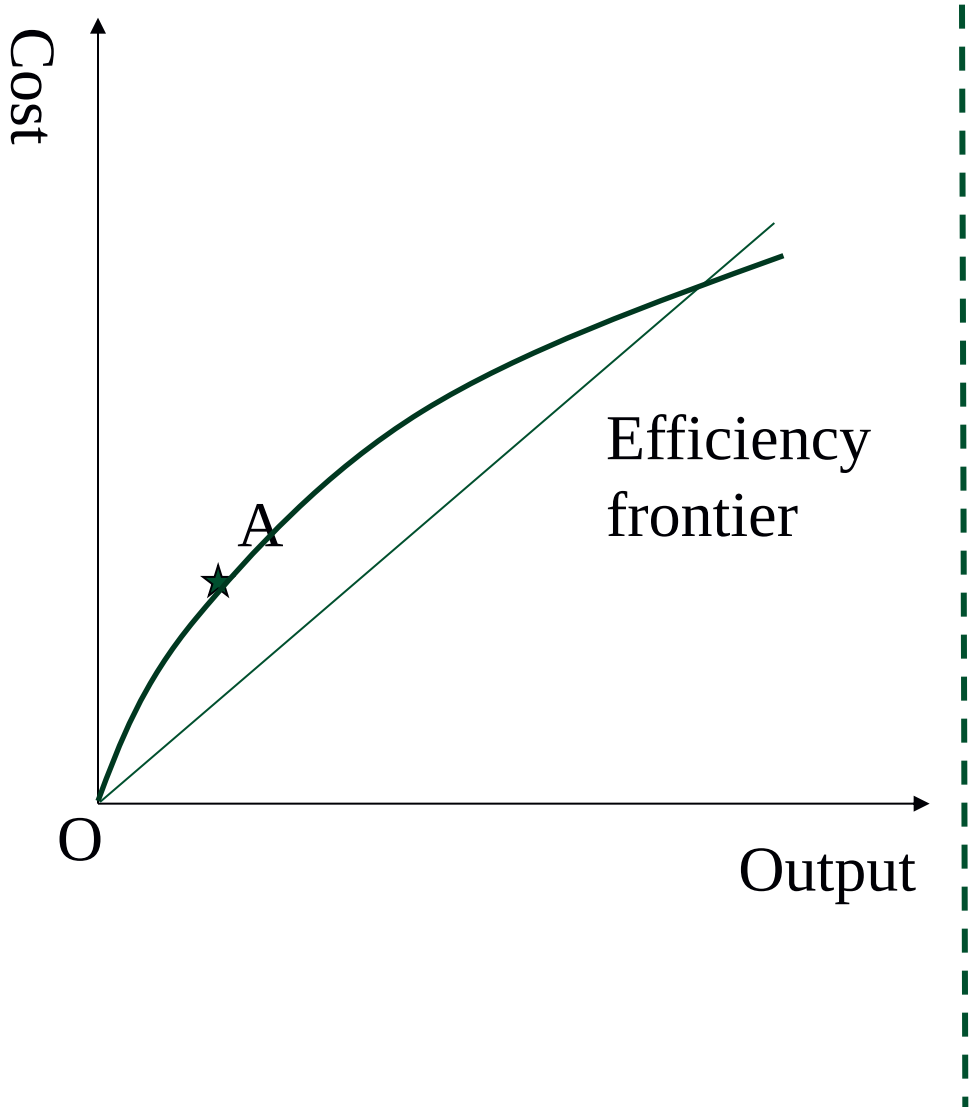


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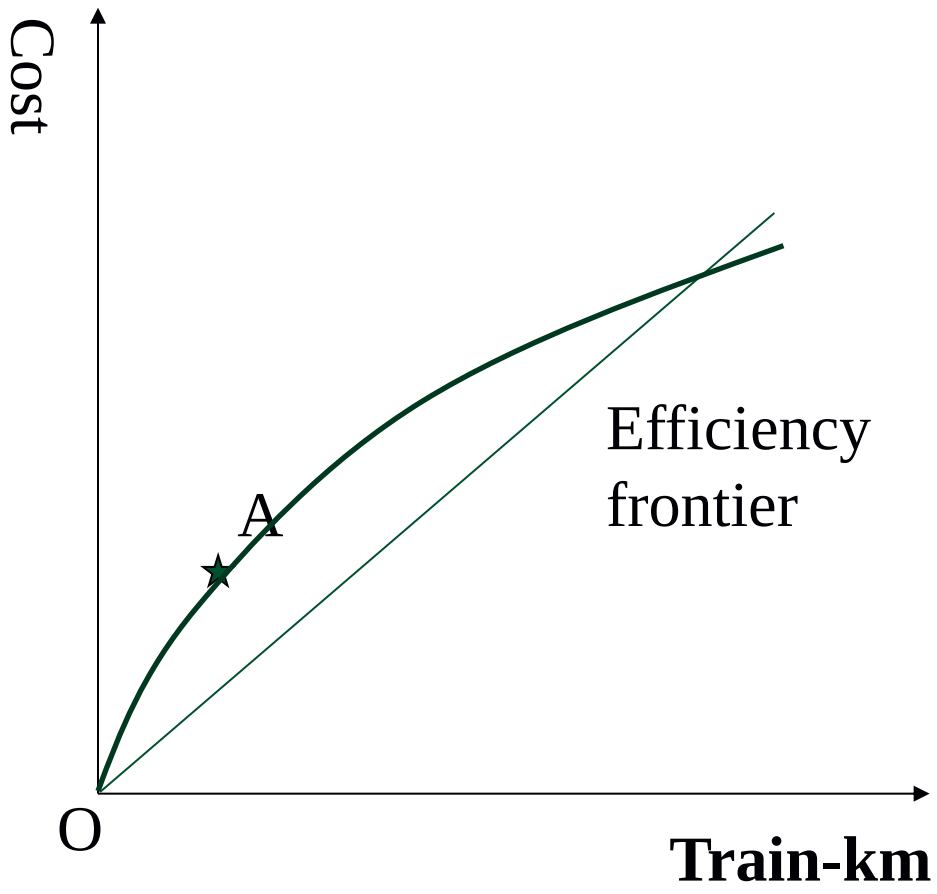


- Allow flexibility on the shape of the cost-output relationship (e.g. allow economies of scale)
- Allow multiple outputs / other cost drivers (e.g. train and track-km)

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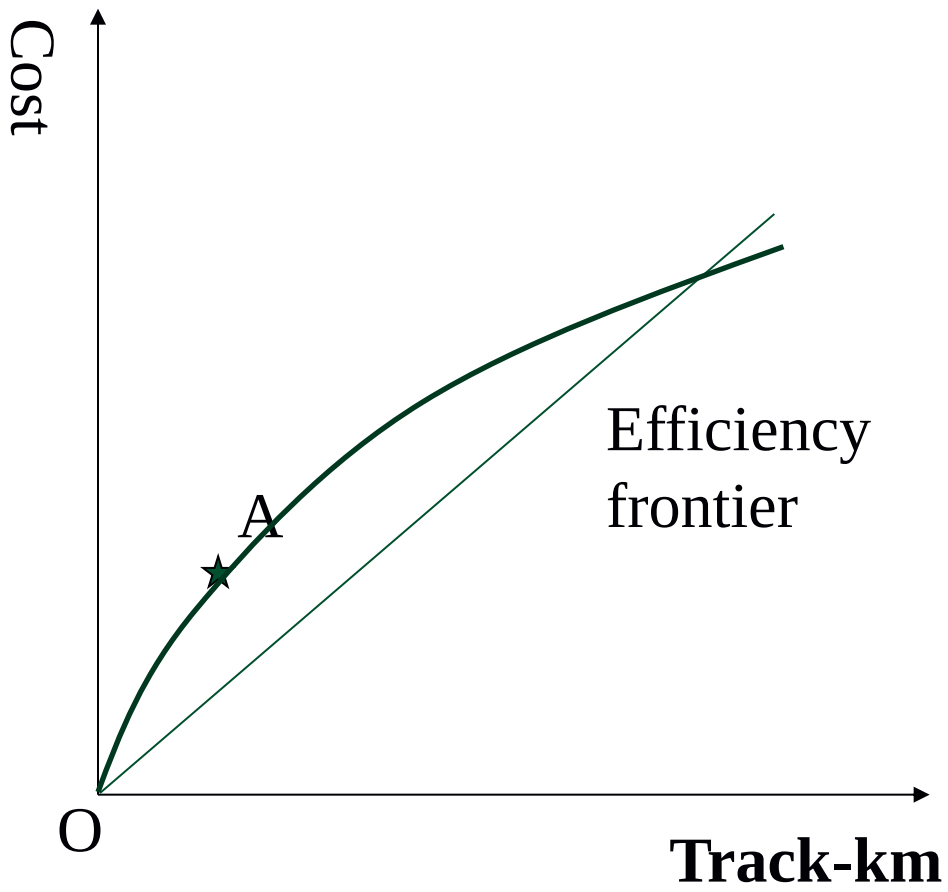


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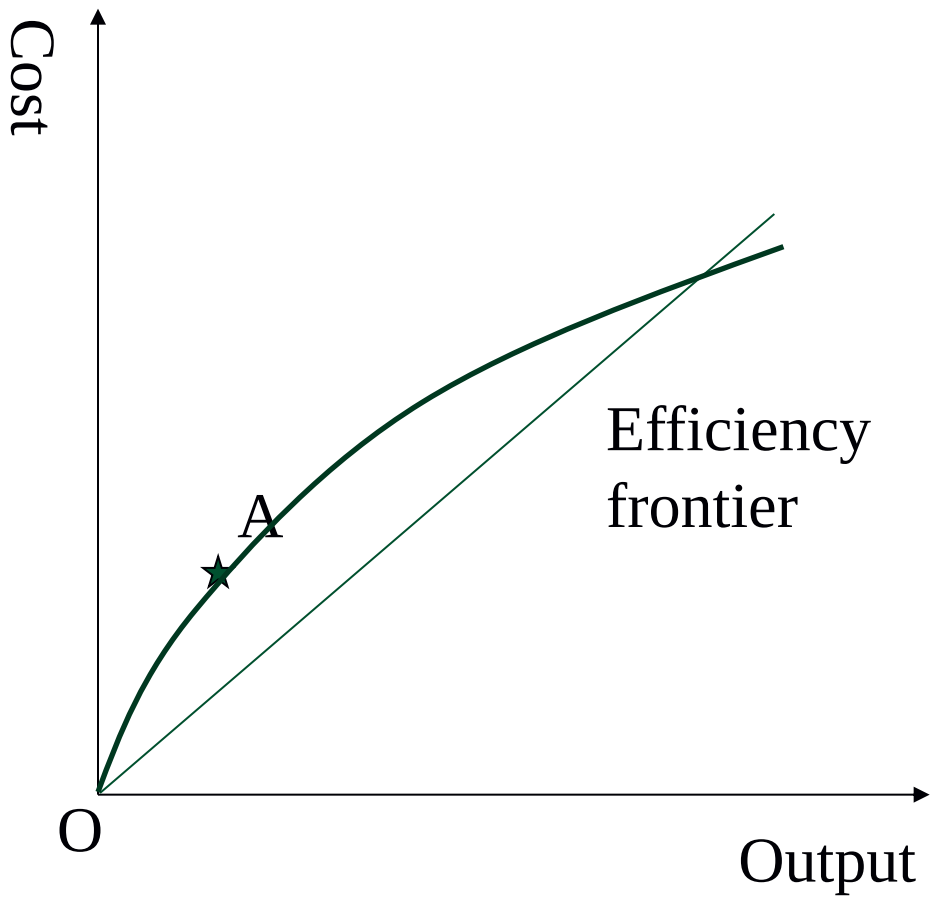


- Allow flexibility on the shape of the cost-output relationship (e.g. allow economies of scale)
- Allow multiple outputs / other cost drivers (e.g. train and track-km)
- So we can explain costs in terms of a set of explanatory factors, e.g.
  - Network size; traffic density and type; other (e.g. electrification; multiple track); potentially, others…
- Having accounted for these factors, and random noise, produce an **overall measure of efficiency**

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# Statistical approach versus DEA

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1. DEA does not distinguish random noise (e.g. random events affecting costs; errors in data) from inefficiency

2. DEA does not give information on how costs vary with cost drivers – in statistical approaches this information is a useful piece of information in judging the robustness of the model

3. DEA sensitive to outliers and hard to incorporate a wide range of variables – except through a second stage approach, which is then a statistical model anyway

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# Links between methodology and data

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Input data: Physical → Production Function / Frontier
Distance Function / Frontier
DEA

Input data: Financial → Cost Function / Frontier

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# British experience

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- In 1994, a separate infrastructure company – Railtrack – was set up and subsequently privatised
- Over 1994-7 all train operations were privatised as:

- 25 passenger franchises
- 2 freight companies plus open access (2 main new entrants)
- What happened to costs and why?

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# Summary of findings on train operating company costs

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- Costs up from £4bn in 1998 to around £6bn (or more) in 2012:
  - A rise of at least 15% per train-km or 9% per vehicle-km
  - Contrasts with savings of 20-30% elsewhere in Europe
  - Cost-plus contracts in cases of franchise failure very damaging
  - No clear signs that costs are coming down substantially yet
- On scale and density:
  - British franchises may be too large
  - However, splitting up franchises might lead to more franchise overlaps – loss of economies of density
  - That said, service heterogeneity mean that economies of density found from earlier studies might be over-stated
- See Smith and Wheat (2012) and Wheat and Smith (2014)

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# Rail infrastructure cost trends in Britain

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| £m 2012 prices | 1998 | 2013 | Growth |
|---|---|---|---|
| Maintenance | 1,055 | 968 | -8% |
| Operating Costs | 1,004 | 1,390 | 39% |
| Renewals | 1,605 | 2,672 | 66% |
| Enhancements | 281 | 2,318 | 723% |
| | **3,946** | **7,349** | 86% |

- Total unit costs up by 45% per train-km
- OM&R unit costs up 7% per train-km
- Though, don't forget, substantial economies of density

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# International benchmarking study: national data – frontier parameters

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| **Preferred model** Dependent variable: Total costs (steady-state adjusted) | Coeff. | | **Comparator model** Dependent variable: Total costs (unadjusted) | Coeff. | | **Comparator model** Dependent variable: Maintenance costs | Coeff. | |
|---|---|---|---|---|---|---|---|---|
| **Frontier parameters** | | | | | | | | |
| CONSTANT | 6.2453 | *** | CONSTANT | 6.2382 | *** | CONSTANT | 5.4770 | *** |
| ROUTE | 1.0743 | *** | ROUTE | 1.0913 | *** | ROUTE | 0.8430 | *** |
| PASSDR | 0.3345 | *** | PASSDR | 0.3115 | *** | PASSDR | 0.1362 | ** |
| FRDR | 0.1792 | *** | FRDR | 0.1472 | *** | FRDR | 0.1567 | *** |
| SING | -0.9181 | *** | SING | -0.9681 | *** | SING | -0.7146 | *** |
| ELEC | -0.0370 | | ELEC | -0.0690 | | ELEC | 0.0733 | |
| TIME | 0.0556 | *** | TIME | 0.0561 | *** | TIME | 0.0469 | *** |
| TIME2 | -0.0048 | *** | TIME2 | -0.0048 | *** | TIME2 | -0.0027 | ** |
| **Efficiency parameters**[1] | | | | | | | | |
| $\lambda$ | 4.0541 | *** | $\lambda$ | 4.1810 | *** | $\lambda$ | 3.6678 | *** |
| $\sigma_u$ | 0.4560 | *** | $\sigma_u$ | 0.4694 | *** | $\sigma_u$ | 0.3374 | *** |
| $\eta_{R1}$ | 0.0585 | | $\eta_{R1}$ | -4.5467 | | $\eta_{R1}$ | 0.1634 | ** |
| $\eta_{N1}$ | 0.2252 | | $\eta_{N1}$ | 0.2031 | ** | $\eta_{N1}$ | 0.2689 | ** |
| $\eta_{N2}$ | -0.0570 | ** | $\eta_{N2}$ | -0.0513 | ** | $\eta_{N2}$ | -0.0520 | *** |

*** (**, *) indicates parameter significance at the 1% (5%, 10%) level

[1] Other firm specific $\eta$ parameters are included in the model but not shown for confidentiality reasons. $\lambda = \sigma_u/\sigma_v$

- Source: Smith (2012)

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# Efficiency estimates for Network Rail (PR08)

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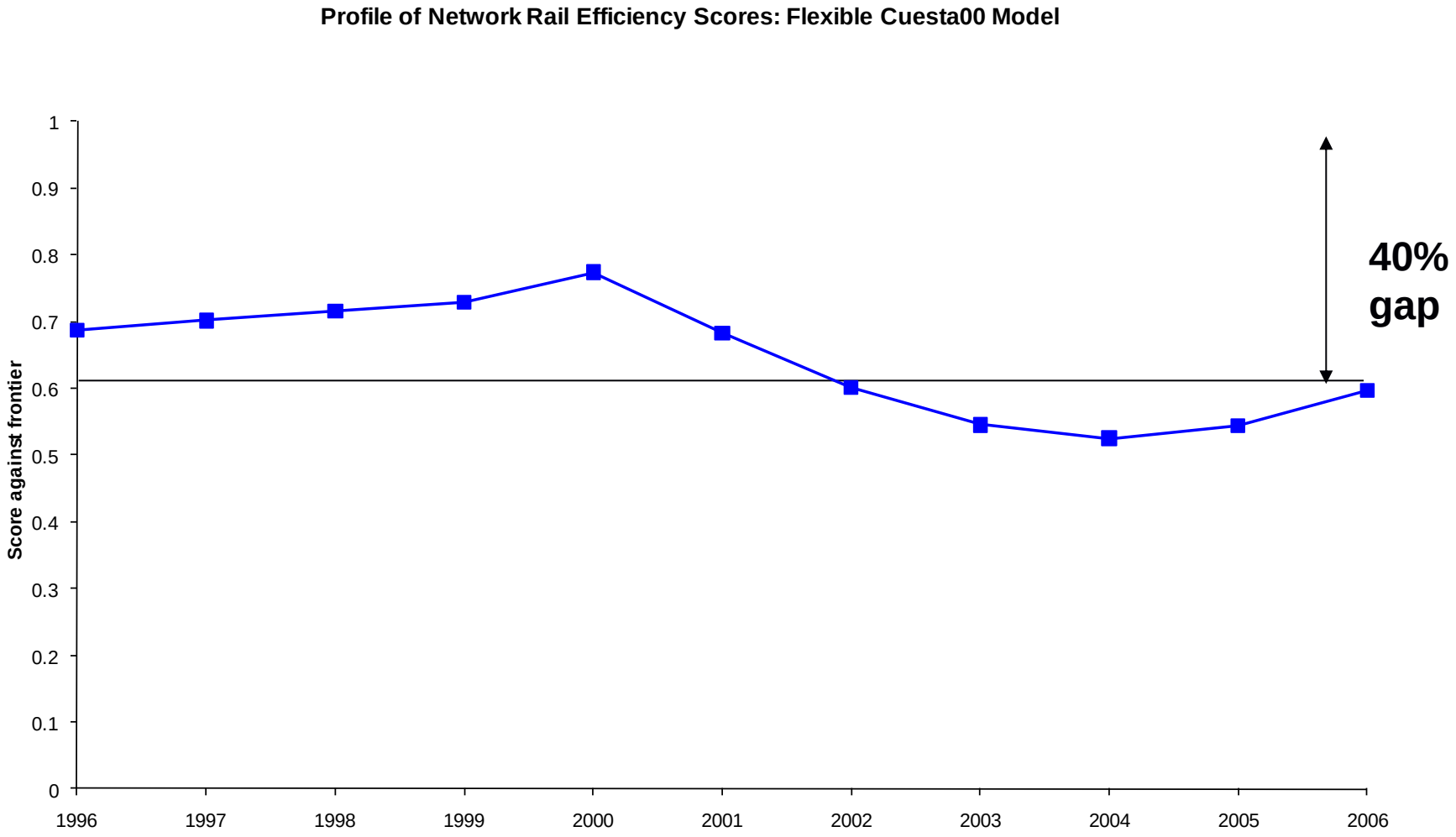


**Implies a gap against the frontier of 40% in 2006**

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# PR13 results

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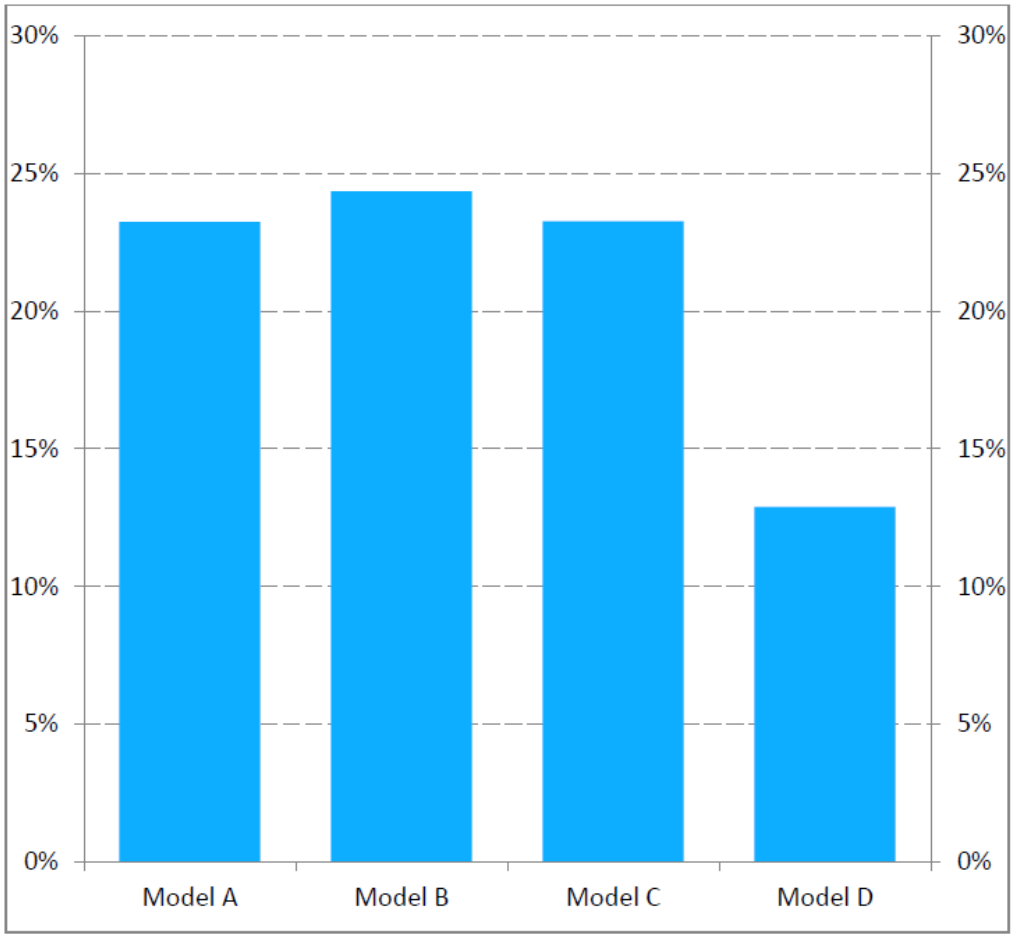
**Figure 8.17: Estimates of Network Rail's efficiency gap with preferred models**




- Range 13-24%
- Ignoring the extremes would suggest a gap of 23% (ORR)
- As an aside: overall assessment based mainly on bottom up studies:
  - 16% for maintenance
  - 20% for renewals

- Source: Office of Rail Regulation (2013)

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# Another approach: Dual Level Inefficiency Model

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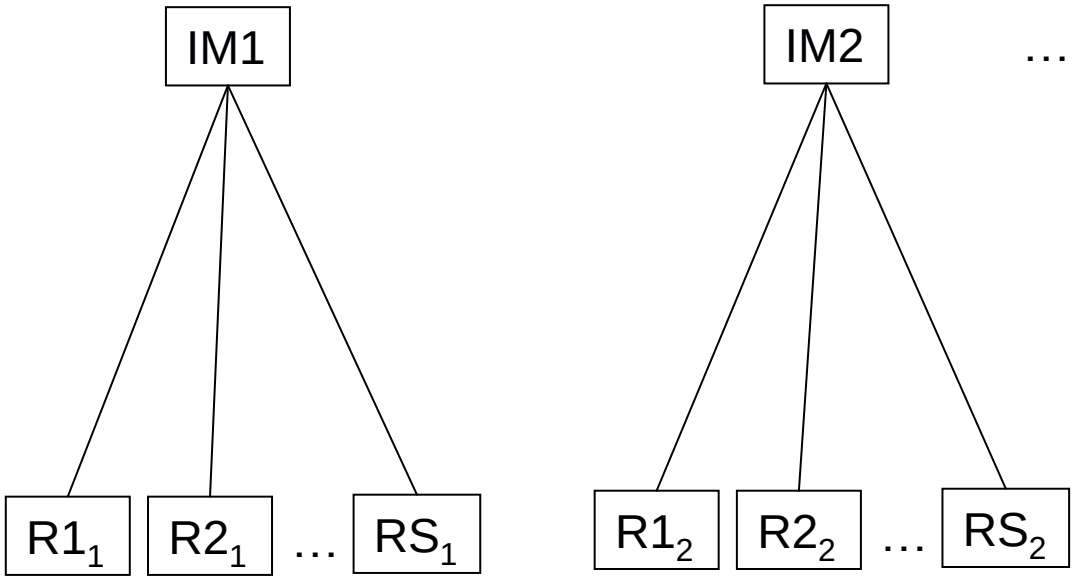
Infrastructure Manger

Region (sub-company)




Inefficiency due to systematic differences between firms – external inefficiency

Inefficiency due variation in performance at regional level – internal inefficiency

- Source: Smith and Wheat (2012)

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# Challenges

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- Data quality / number of data points?
- Time consuming to collect your own data set – requires commitment over many years from the industry
- How to deal with lumpy / cyclical capital costs?
- Modelling fundamental differences in characteristics and quality of railways – there are new methods that can better control for unobserved heterogeneity than in the past
- Understanding uncertainty in efficiency modelling - See Wheat, Greene and Smith (2014)

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# EU rail policy

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- EU Policy of introducing competition within mode for freight and passenger
- Requires non discriminatory access to infrastructure for competitors
- Current legislation requires separate accounts and separation of ‘key powers’, but holding company model permitted
- Big issue: should complete vertical separation be required?



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# Results of past studies

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- US studies (e.g. Bitzan, 2003) – vertical separation raises costs
- 4 European studies. E.g. Growitsch and Wetzel (2009): vertical separation raises costs
- Friebel et. al. (2010). Reforms improve efficiency but only where they are sequential and not in a package
- Cantos et. al. (2010). Vertical separation with horizontal separation and new entry in freight improves efficiency. Cantos et. al. (2011). Vertical separation effect not statistically significant; passenger tendering found to improve efficiency
- Merkert, Smith and Nash (2011). Transaction costs around 2-3% of total costs
- Mizutani and Uranishi (2013). Impact of vertical separation depends on traffic density

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# Contribution of EVES-rail cost modelling

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- Data
  - Adding the British data to the sample.
  - Updating in time from 2007 to 2010.
  - Uses UIC data but verified, improved and extended by CER members via questionnaire
- Develop structural dummies to better answer the research questions
  - In particular: holding versus vertical separation
- Improve modelling of market opening dummies
  - Actual rather than potential freight entry
  - Passenger competition index that reflects degree of entry
- Improve accuracy of timing of structural and market opening reforms

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# Cost regression model

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- 26 OECD countries – 1994-2010
- Total rail industry cost = f (control variables, test variables)

| **Control variables** (cost drivers not related to policy) | **Test variables** (policy variables that may affect costs) |
|---|---|
| • Passenger output | • Vertical separation dummy variable |
| • Freight output | • Vertical separation dummy variable * train density |
| • Route length | • Vertical separation dummy variable * freight revenue proportion |
| • Technology index | • Holding company dummy variable |
| • Wage rate | • Holding company dummy variable * train density |
| • Energy price | • Holding company dummy variable * freight revenue proportion |
| • Materials price | • Horizontal separation dummy variable |
| • Capital price | • Passenger competition measure |
| | • Freight competition dummy variable |

# Cost regression – key findings

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- Passenger and freight market opening had no significant impact
- Horizontal separation of freight  has reduced costs
- At higher traffic densities, vertical separation increases costs
  - At mean traffic densities, vertical separation does not significantly change costs
  - Whereas a holding company model reduces them, compared with complete vertical integration (weakly significant)
- A higher share of freight in total revenues increases the costs of vertical separation
  - Freight traffic may cause more coordination problems in a separated environment than passenger traffic

# Concluding remarks

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- Econometric approach to efficiency measurement has strong advantages in:

  - Allowing for multiple outputs: but singe measure of efficiency

  - Controlling for other differences between railways

  - Allowing for random noise in the model

- Main challenge is data:
  - Number of data points (companies; time; regions)
  - Comparability of data over time and between countries
  - Needs to incorporate quality and other factors in the model
  - Collecting good quality data takes time and commitment – ideally economic regulators / Ministries need to co-ordinate

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# Concluding remarks

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- The evidence on the impact of reforms is mixed – they seem to have worked in some circumstances but not in others
- There is a need for a pragmatic approach that looks at what works in what circumstances rather than a ‘one size fits all’ approach

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Thank you for your attention

Chris Nash and Andrew Smith