TA39 - OR/OM Impact on Freight Railway Services

Session Chair: **Steven Harrod**, Technical University of Denmark, Kgs. Lyngby, Denmark

Effciency and Effectiveness Analysis of the Eu Ten-t Freight Railway Network

Steven Harrod , Shengdong Li

A Collection of Aspects Why Optimization Projects For Railway Companies Could Risk Not to Succeed - A Multi-perspective Approach

Christian Liebchen , Hanno Schülldorf

Retrospective Impact Of Operations Research & Operations Management On Freight Railway Operations

Marc Meketon, David T. Hunt

Service Network Design For China Railway Express Under the Belt and Road Initiative Considering Market Competition

Yingzi Peng, Lefei Li,

Efficiency and Effectiveness Analysis of the European Union Railway Freight Corridors

INFORMS Annual Meeting 2019, Seattle

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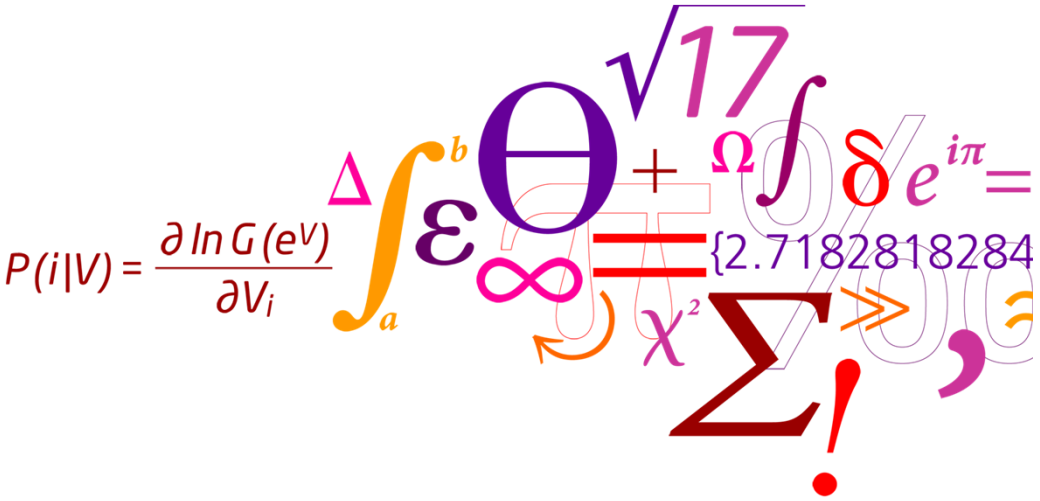


Introduction

- Organization of the ”One Stop” European Rail Freight Corridors
- Objectives of the study
- Introduction to Data Envelopment Analysis method, efficiency, and effectiveness
- Analysis results for the corridors
- Linking the corridor performance to the national railways

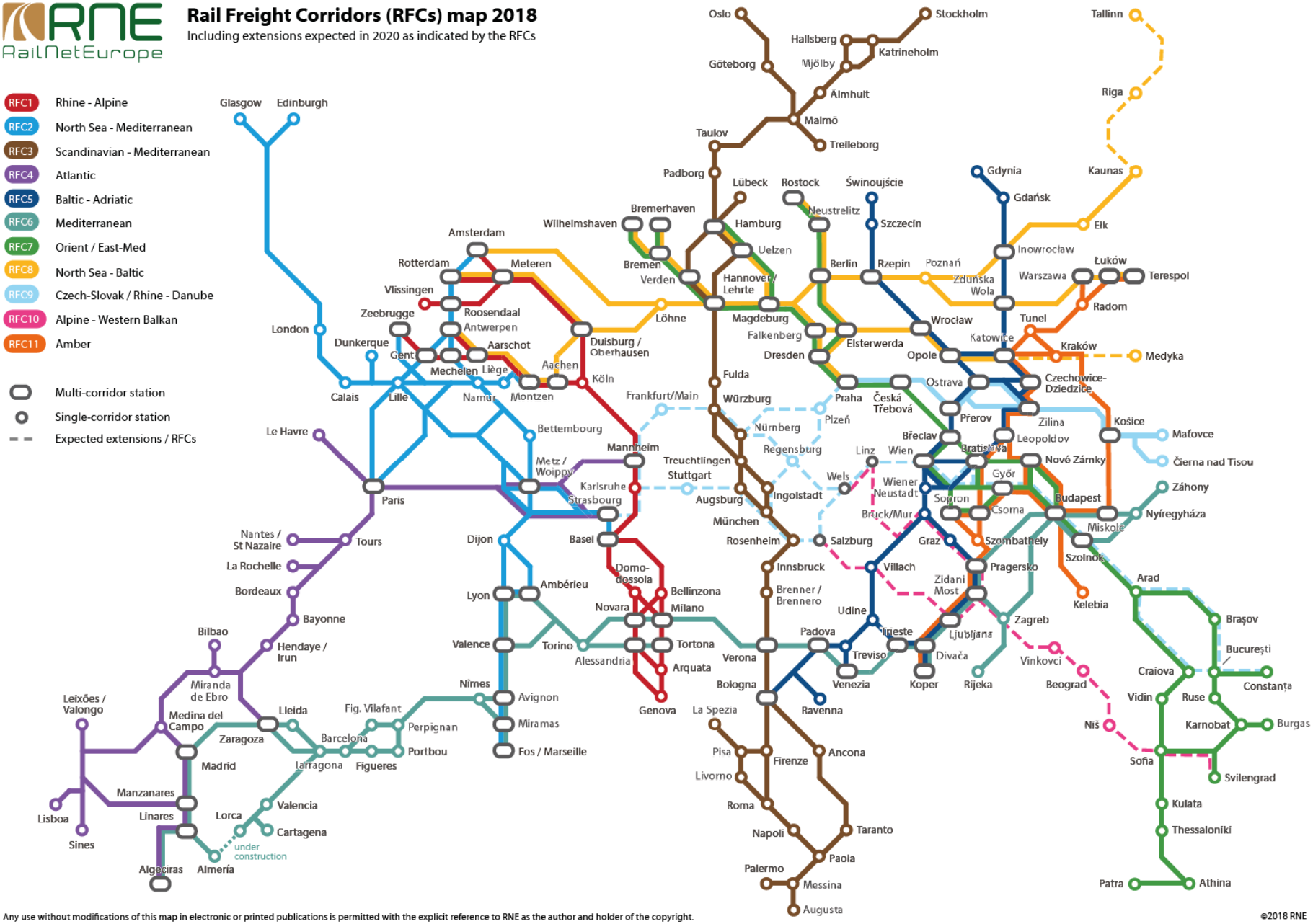
Legacy Structure of European Railways

- Nearly entirely national railway monopolies
- Only freight cars (wagons) crossed borders
- Water barriers crossed with ferries
- Bi-lateral trade
- Relatively low international trade volumes

Colourbox (2019)

European Union Integration

- Open, barrier-free trade among nations
- Analogous to free movement in the United States
- Rise of ”Just-in-Time”
- European actions:
  - Channel tunnel, 1994
  - TEN-T transport network, 1996
  - Øresund bridge, 2000
  - ”One Stop” Rail Freight Corridors, 2010
  - Gotthard Base Tunne, 2016



RailNetEurope (2018) Rail Freight Corridors (RFCs) map 2018, Vienna, (http://www.rne.eu).

Study Corridors

RFC	Name	Countries Traversed
1	Rhine-Alpine	Netherlands, Belgium, Germany, Switzerland, Italy
2	North Sea-Mediterranean	Netherlands, Belgium, France, Luxembourg, Switzerland, United Kingdom,
3	Scandinavian-Mediterranean	Finland, Norway, Sweden, Denmark, Germany, Austria, Italy
4	Atlantic	Germany, France, Spain, Portugal
5	Baltic-Adriatic	Poland, Czech Republic, Slovakia, Austria, Italy, Slovenia
6	Mediterranean	Spain, France, Italy, Slovenia, Croatia, Hungary
7	Orient/East-Med	Germany, Czech Republic, Slovakia, Austria, Hungary, Romania, Bulgaria, Greece
8	North Sea-Baltic	Belgium, Netherlands, Germany, Poland, Lithuania, Latvia, Estonia, Finland
9	Rhine-Danube	France, Germany, Austria, Czech Republic, Slovakia, Hungary, Romania, Bulgaria

Objectives of the Study

- Can differences in performance be attributed to management?
- Are resources
  - Sufficient?
  - Relevant?
- What is the relation between host national railway performance and corridor performance?

Data Envelopment Analysis

- Non-parametric method of estimating comparative rates of conversion of inputs to outputs
- A linear program solved separately for each ”Decision Making Unit” (a business or management authority)
- Determines a set of one or more leading DMU which are 100% efficient and ranks the others at relatively lower efficiency

$$h_o = \theta_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

Efficiency

Outputs

Inputs

Example Formulations

$$\max h_o = \sum_{r=1}^{s} \mu_r y_{ro}$$

$$\sum_{r=1}^{s} \rho_r y_{rj} - \sum_{i=1}^{m} \omega_i x_{ij} \le 0$$

$$j = 1, 2, \ldots, n$$

DMU

$$\sum_{i=1}^{m} \omega_i x_{io} = 1$$

$$\omega_i, \rho_r \ge 0$$

$$i = 1, 2, \ldots, m$$

inputs

$$r = 1, 2, \ldots, s$$

outputs

(Dual)

$$\min z_1 = \theta_o - \varepsilon \left[\sum_{i=1}^{m} l_i^- + \sum_{r=1}^{s} l_r^+ \right]$$

$$\sum_{j=1}^{n} \lambda_j x_{ij} + l_i^- = \theta_o x_{io}$$

$$i = 1, \ldots, m$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} - l_r^+ = y_{ro}$$

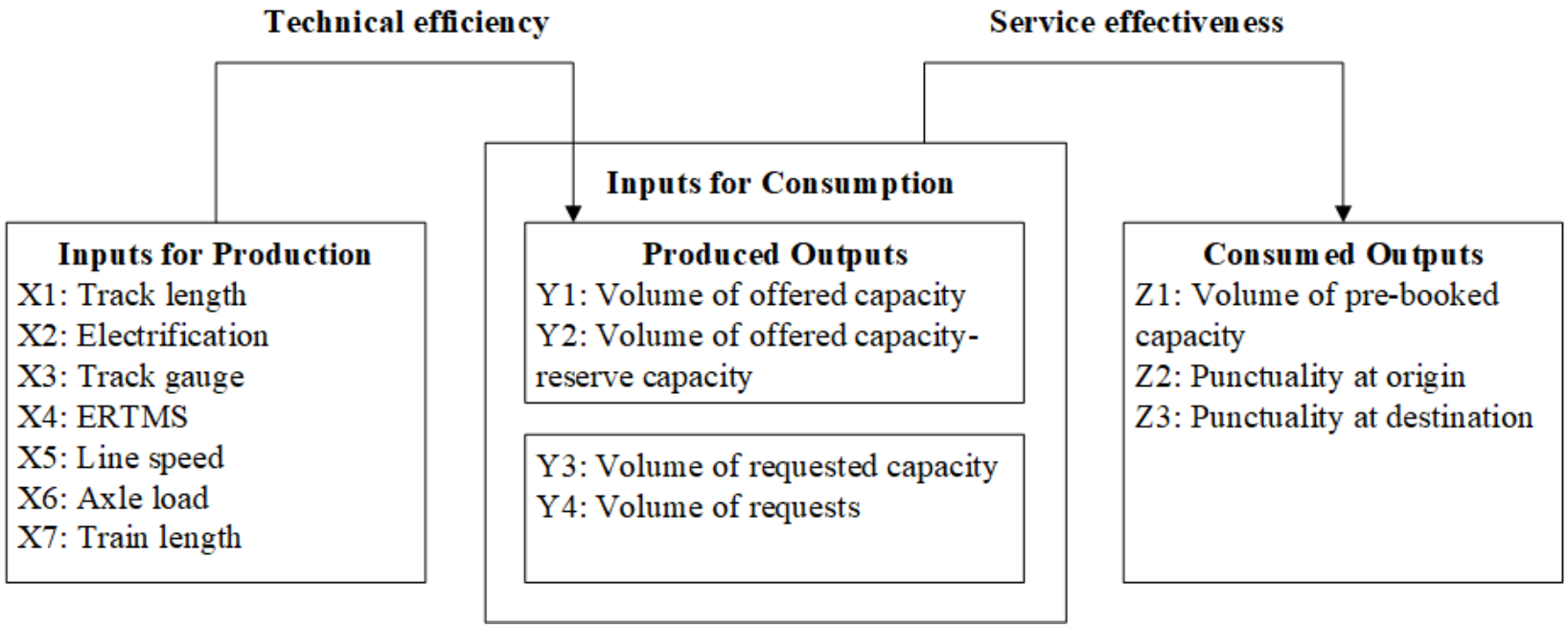
$$r = 1, \ldots, s$$

$$\lambda_j, l_i^-, l_r^+ \ge 0$$

$$i = 1, \ldots, m$$

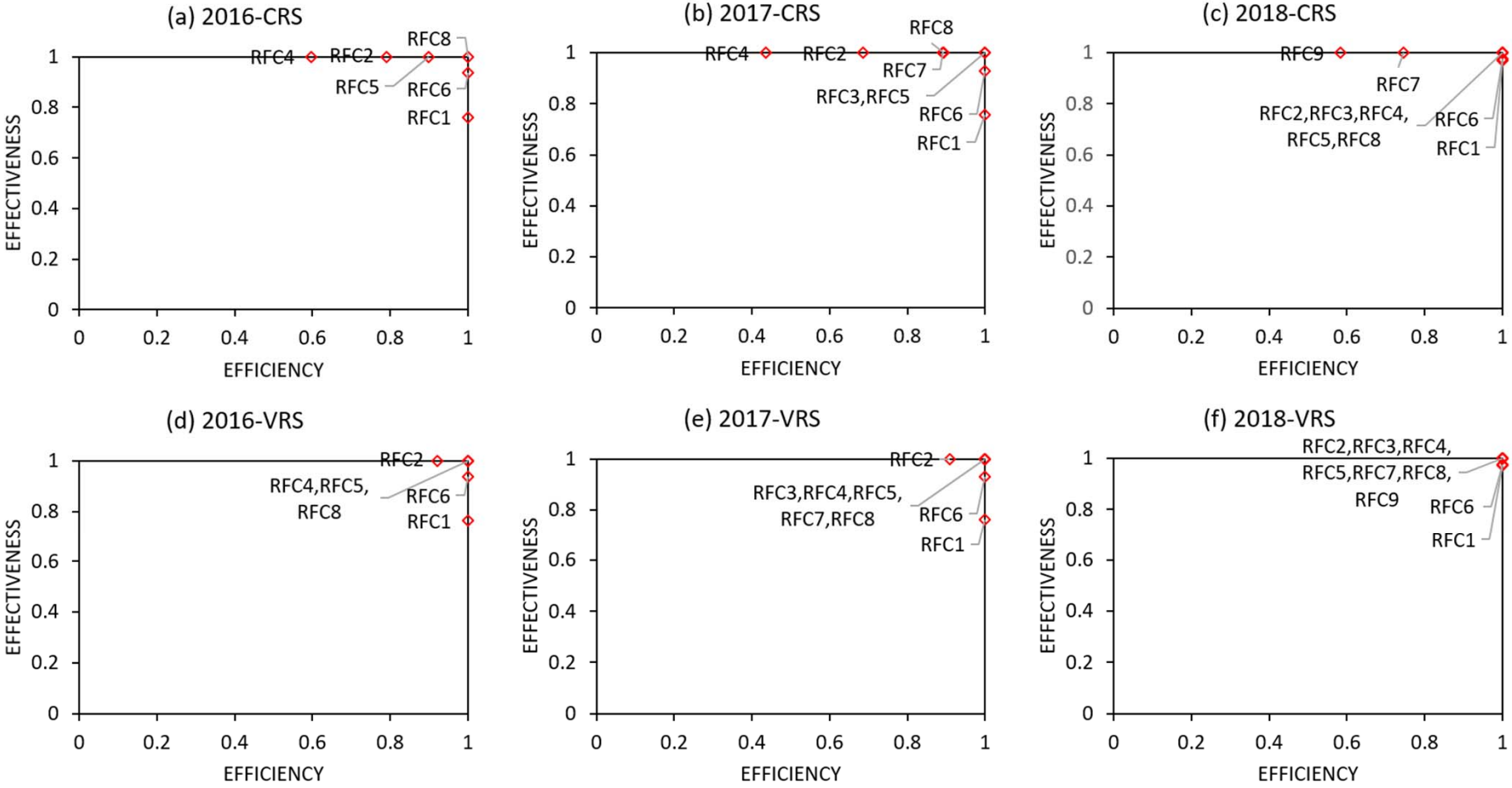
$$j = 1, \ldots, n \qquad r = 1, \ldots, s$$

Performance Measures, Technical Efficiency, and Service Effectiveness



- Measures uniformly and publicly collected by EU RFC's
- Most of these are % of route length compliant
- RFC's reported: 2016-6, 2017-8, 2018-9

Results


(a) 2016-CRS
RFC4
RFC2
RFC8
RFC5
RFC6
RFC1
(b) 2017-CRS
RFC4
RFC2
RFC8
RFC7
RFC3,RFC5
RFC6
RFC1
(c) 2018-CRS
RFC9
RFC7
RFC2,RFC3,RFC4,
RFC5,RFC8
RFC6
RFC1
(d) 2016-VRS
RFC2
RFC4,RFC5,
RFC8
RFC6
RFC1
(e) 2017-VRS
RFC2
RFC3,RFC4,RFC5,
RFC7,RFC8
RFC6
RFC1
(f) 2018-VRS
RFC2,RFC3,RFC4,
RFC5,RFC7,RFC8,
RFC9
RFC6
RFC1
EFFECTIVENESS
EFFICIENCY
0
0.2
0.4
0.6
0.8
1

Dual Analysis of 2018 Data

- CRS models:
  - RFC 7 & 9 inefficent (Eastern Europe)
  - RFC 1 & 6 ineffective (heavy road competition)
- Unclear yet if these results explain any causation

Measure	RFC7	RFC9
	Difference	Difference
Length	-1480	-2946
Electrification	-0.28	-0.58
Gauge	-0.43	-0.69
ERTMS	-0.04	-0.03
Speed	-0.20	-0.66
Axle Load	-0.21	-0.28
Train Length	-0.14	-0.20
Vol offered	0.6	1.6
Reserve	null	null

Cross Efficiencies
Technical Efficiency, CRS, 2018

DMU	RFC1	RFC2	RFC3	RFC4	RFC5	RFC6	RFC7	RFC8	RFC9	Mean
RFC1	1,00	0,69	0,33	0,29	0,38	0,33	0,36	0,48	0,15	0,45
RFC2	1,00	1,00	0,54	0,45	0,64	0,63	0,56	0,64	0,25	0,63
RFC3	0,44	0,40	1,00	0,25	0,16	0,26	0,26	0,67	0,20	0,40
RFC4	0,90	1,00	0,42	1,00	0,83	0,90	0,70	1,00	0,48	0,80
RFC5	0,94	1,00	0,29	0,87	1,00	0,83	0,66	0,75	0,38	0,75
RFC6	0,37	0,64	0,30	1,00	0,48	1,00	0,43	0,66	0,24	0,57
RFC7	0,71	1,00	0,39	0,91	0,95	1,00	0,74	1,00	0,39	0,79
RFC8	0,42	0,54	0,80	0,67	0,37	0,59	0,44	1,00	0,46	0,59
RFC9	0,52	0,78	0,77	0,94	0,62	1,00	0,64	1,00	0,58	0,76
Mean	0,70	0,78	0,54	0,71	0,60	0,73	0,53	0,80	0,35	

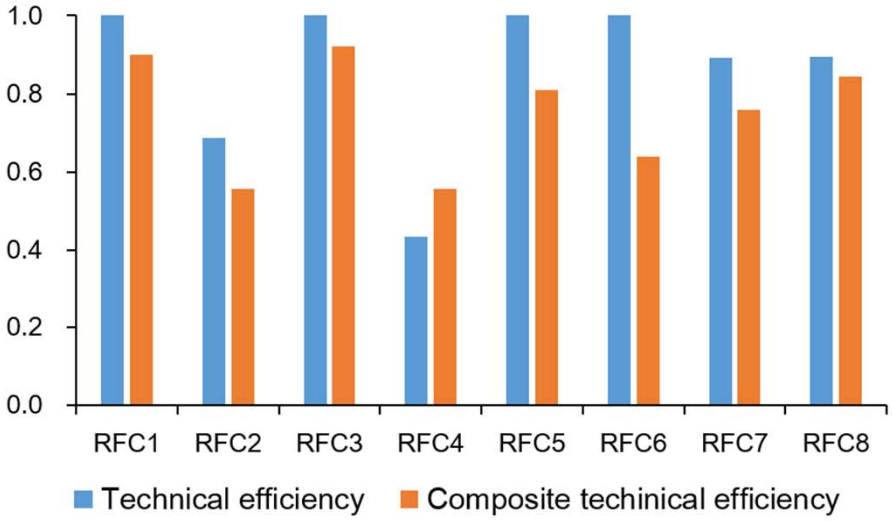
Efficiency of RFC4 inputs using RFC8 conversion factors

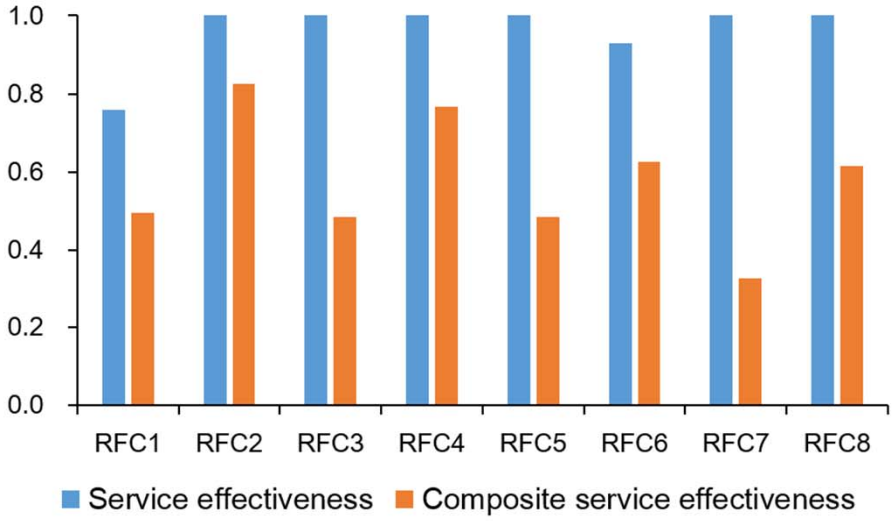
Linking Results to National Railways

- Analysis for year 2017
- Create a composite of the national railways by proportional length of the RFC
- Calculate the national efficiency scores using UIC data of line length, rolling stock fleet sizes, number of employees, and output passenger train km. and freight train km.
- National effectiveness is measured on passenger-km. and ton-km.

$$Composite\ efficiency = \sum_{k} \frac{ShareLength_k}{CorridorLength} * NationalEfficiency_k$$

National Composite Results CRS





Summary

- Centrally managed international corridors provide new data sources and evaluation possibilities
- Data is still limited and vague
- Cause and effect is difficult to define
- RFC's are significantly dependent on the qualities of the host national railways.

Thank you and “vi ses”