Ultimate Interoperability: Line-haul Railways as Global Corporate Citizens

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Abstract

As the railway mode enters its third century, many line-haul railways still play an indistinct role in global logistics and intelligent mobility. A corporate citizenship perspective promised rich insight into railway positioning, so the authors raised the level of discourse of their previously reported research to examine global whole-industry adaptation. They have presented an enhanced database, together with multivariate statistical analysis, that offers novel insights into line-haul railways as global corporate citizens. They found eight factors that represented actions, including passenger- and freight positioning, by which line-haul railways could develop or enhance their corporate citizenship, and six clusters that demonstrated how line-haul railways positioned themselves in particular economic-, geographic-, political-, and social settings. Implementation potential is discussed, concluding that line haul railways that leverage rail's genetic technologies, as assertive global corporate citizens, are progressing toward ultimate interoperability as they package- and deliver stakeholder expectations.

1 Introduction to the research

1.1 Business consistency and -differentiation

Globalization is transforming railways: The *Global Rail Freight Conference 2007* in New Delhi reflected that transformation in its title, and WCRR2008 reflects it in its theme *Towards a global railway.* However, as the railway mode enters its third century, many railways do not yet seem to play a clearly recognizable role in global logistics or intelligent mobility. Although fundamental changes are evident, many railways still look different from each other, and from other global service industries, and many appear not to integrate seamlessly into global logistics and intelligent mobility. To illustrate the proposition, consider an example at the other end of the globalization spectrum: Airlines have become so similar that differentiating them is challenging. Indeed, the celebrated Singapore Girl epitomized Singapore Airlines' successful brand strategy to position itself around customer service excellence, as distinct from the "airline-ness" that it unavoidably shared with other airlines.

1.2 Corporate citizenship applied to railways

The authors have reported previously on how globalization drove line-haul railways to adapt to changing settings, at WCRR 2006 [1]. Among other, they identified a Constrained Railways cluster, containing railways that had not yet started adapting to globalization, as well as several clusters that had adapted to varying degrees, namely Railways under Intense Competition, Railways under Rising Private Participation, Railways under Unreceptive Private Participation, Railways under Liberal Private Participation, and Railways in Emerging Economies. When comparing railways that had adapted to those that had not, they perceived that those that had adapted seemed to have established a modicum of consistent identity, or *corporate citizenship*. The latter is about an entity's contribution to society through its core business, social investment, and engagement in public policy: The manner in which an entity manages its economic, social, and environmental relationships, and the way it engages with its stakeholders, has an impact on its long-term success [2]. The authors argued that global logistics and intelligent mobility, being constructs that cut across all transport modes, demanded from participants business interoperability that is beyond physical interoperability, and that railways will attain such ultimate interoperability when their corporate citizenship resembles that of other global service industries, such as airlines and supply chain organizers.

1.3 Raising the level of discourse

Having perceived that a corporate citizenship perspective offered potentially rich insight into railway positioning, the authors set about raising the level of discourse of their previously reported research to that of corporate citizenship. Recognizing the World Economic Forum's definition of corporate citizenship [2], they extended, recast, and revised their statistical coverage for the present study to incorporate the essence of corporate citizenship, namely Contribution to Society, Core Business, Social Investment, and Engagement in Public Policy, as follows:

Contribution to Society was taken as the input-output conversion, from capital- and human resources deployed, to extent- and volume of service delivered. This aspect was adequately covered in their previous research, although not specifically so articulated.

Core Business was present in their previous research: The authors recast the relevant variables as Business Group. Noting that line-haul railways deploy generic information technology, to support the complex service delivery processes made possible by their Coupling genetic technology, they added a new variable *Information Technology Leverage* to this group. They also added the new variable *Road Competition*, to examine railway positioning with respect to its market[1].

Social Investment is a complex field, but in many countries, railways are, or were, vehicles for social investment: Those that are still state owned are in many instances so owned for precisely that reason. The authors have thus

[1] Measurement of air and maritime competition as well would have been ideal, but would have required access to records of modal choice decisions, which are not readily available.

taken the variable *Ownership Locus*, in the Ownership Group, as a proxy for a country's expectation of its railways' social investment.

Engagement in Public Policy was previously measured in terms of direction and strength of entity-environment initiatives by the variable *Initiative Source*. It was moved to the Contribution Group.

Rail's genetic technologies Bearing, Guiding, and Coupling, endow it with primary competitive strengths in the Heavy Haul (exploiting Bearing and Coupling), High-speed Intercity (exploiting Guiding and Coupling), and Heavy Intermodal or double-stacked containers (exploiting Bearing, Guiding, and Coupling) market spaces [1]. In addition, the low rolling resistance of steel-wheel-on-steel-rail and, at high speed, low aerodynamic drag due to close coupling, endow rail with its secondary competitive strength of high energy-efficiency. The authors examined the relevance of the latter attribute by adding the variable *Climate-change Position* to the Society Group.

1.4 The research question and hypothesis

The authors' research question was thus: *Can one identify archetypal railway corporate citizenships within the global setting*? To unlock the requisite understanding, they hypothesized the existence of some number of underlying longitudinal, or time-dependent, relations among variables associated with line haul railways' Contribution to Society, Core Business, Social Investment, and Engagement in Public Policy, as well as resources deployed to engage with and to adapt to economic-, political-, social-, and technical issues, and to challenges and opportunities in their respective settings. The research reported in this paper explored the existence and nature of such relations.

2 Methodology

2.1 Research design

Scientific descriptive research requires a set of variables, usually the columns or fields, and a set of cases, usually the rows or instances, in a database. While pre-global railways supported comprehensive national statistics, captured by the likes of the Association of American Railroads, the International Union of Railways, the World Bank, and others, their databases appear to have sidestepped the recent deluge of disaggregated structures, new industry entrants, and disparate data. Noting the similarity between that state and human behaviour in general, the authors described and examined railway corporate citizenship from a behavioural perspective. Using a methodology developed and described previously, they extended the range of variables in their previous database [1] to support corporate citizenship research. A brief recapitulation of the methodology follows below, to render this paper self-contained, and to point out material differences from the previous research.

2.2 Selection of cases

National governments currently regulate most railways, whatever the industry structure, although exceptions do exist where railway operations crisscross transparent national boundaries, as in the North American Free Trade Agreement and the European Union. The authors therefore examined

railways by country. Note that Railway Directory [5] combined information for Senegal and Mali in 2007: To align this event with previous years, the authors aggregated all years' data for these countries. This reduced the number of cases from the previous study by one.
Some railway attributes are independent of track gauge, but the latter does drive competitiveness: There is scant evidence that track gauge less than yard/meter/3'-6'' supports sustainability: The authors thus excluded data for narrower track gauges, irrespective of gauge mix in a country. They also excluded Urban Rail once again, which they addressed in a companion WCRR2008 paper [3].

2.3 Recasting of variables

In addition to the changes mentioned in §1.3, the authors recast several previous operational definitions from a corporate citizenship perspective, without changing the associated measurements. The extended, recast and revised variables are grouped alphabetically as:

Business Group represents the way in which railways deal with their task, specifically Infrastructure Operator Diversity, Train Operator Diversity, Information Technology Leverage, Total Road Network-, Motorways-, and Paved Roads Percentage.

Competitiveness Group represents the way in which railways position themselves to compete in their chosen or allotted market spaces (*Research & Development Level, Relative Maximum Axle Load, Relative Maximum Speed, Distributed Power Presence, Heavy Haul Presence, High-speed Intercity Presence, Heavy Intermodal Presence, Motive Power Type, and Attitude to Competition*),

Contribution Group describes the railways' contribution to their society (*Network Coverage, Transport Task—Freight- and Passenger Traffic Volume, Employment Created, and Initiative Source*),

Networkability Group describes the extent and gauge of track, and the contiguous network beyond a country's borders (*Narrow-, Standard-, and Broad Gauge; Networkability; and Strategic Horizon*),

Ownership Group describes industry structure (*Infrastructure-operations Separation, Infrastructure- and Rolling Stock Ownership Locus, and Infrastructure- and Rolling Stock Commitment Horizon*),

Society Group describes the railway setting (*Country (Name), Economic Freedom, Population, Gross National Income, Physical Size, Determinism, and Climate-change Position*),

Sustainability Group describes adaptation and fit (*Infrastructure- and Rolling Stock Investment Capacity, Stakeholder Satisfaction Level, Service Reputation, Safety Reputation, Subsidy Influence*),

Time Group represents passage of time, a prerequisite for longitudinal research (*Calendar Year*).

Note that the authors used *tonnes* as a measure of freight rail contribution, because it was consistently available by country in the public domain. Open access operators tend to report *tonne-kilometers*, so a risk of double counting has crept in. This caveat serves as notice that the present methodology may have run its course. Note also that the operational definitions for the variables selected, as well as their measurement scales, cannot fit within this paper: They are available in file *WCRR2008 Line-haul Rail Operational Definitions.pdf* on the authors' website [4].

2.4 A dedicated line haul railway corporate citizenship database

The present research is predicated on the natural affinity between corporate citizenship and public domain data. Metric data was extracted from *Railway Directory* [5], *Jane's World Railways* [6], or the Internet, and non-metric data was extracted by content analysis from *International Railway Journal* and *Railway Gazette International*. The Internet was used liberally to verify data to ensure internal consistency. The longitudinal database, containing 113 line-haul railways by country, populated with data for the six years, 2002-2007, for each railway, giving a population (and sample) size of 113x6 = 678 cases, is available in file *WCRR2008 Line-haul Database.xls* on the authors' website [4].

2.5 Statistical analysis

2.5.1 The methods

The authors applied multivariate analysis to the database to examine simultaneously relations among multiple variables, and multiple cases. They selected Factor Analysis, to analyze relations among a large number of variables and then to explain them in terms of a smaller number of common underlying factors, and Cluster Analysis, to group a large number of cases by within-cluster homogeneity and between-cluster heterogeneity. Statgraphics Centurion XV was used to analyze the data. They examined the communalities of all variables, and culled those that contributed more noise than insight, specifically those that appeared in the Operational Definitions file, but which are absent from Table 1. Statistical analysis stops at the Statgraphics Factor Loading Matrix and Icicle Plot: Cluster- and factor names, and the following discussion, reflect the authors' interpretation of their knowledge of the variables in the research setting.

2.5.2 Statistical significance

After culling variables with low communalities, the data set arrayed 37 variables and 678 cases. Regarding factor analysis, for >11 cases per variable, exceeded in this study, eigenvalues >1 can be considered significant. Applying that criterion yielded eight factors. For >50 cases, factor loadings >0.3 are considered significant [7], a criterion achieved by all factors. Regarding cluster analysis, which is more art than science, because researcher discretion determines the number of clusters and their interpretation, the authors did not address significance. However, significance inheres in the data set, so using the same data for both factor- and cluster analysis assured consistency of significance.

3 Findings

3.1 Factor analysis

3.1.1 The factor loading matrix

The authors' prior experience indicated the Principal Components option to extract maximum insight from the available data, and the Varimax Rotation option to clearly separate factors. The intervention extracted eight factors, shown in boldface italics in Table 1, Factor Loading Matrix, in descending order of loading of each variable onto one of the underlying factors. For convenience, upper- and lower scale poles[2] (some of them rounded), as well as the unit of measurement, for each variable, are repeated from the operational definitions in §3.1.2 onwards.

Factor analysis cannot process textual data, so one cannot identify countries. Note also that factor loading indicates association only: It cannot indicate causality. The authors constructed the scales for each variable such that positive values act in same direction: Negative loading thus indicates that a particular variable opposes other positive variables, either on the same factor, or on other factors. Note that variables that load on a particular factor are as significant as those that do not: The Varimax Rotation option maximizes the uniqueness of each factor, and minimizes the variance shared between factors. Please nevertheless refer to §3.1.9 for discussion of simple and complex variables.

3.1.2 Factor 1, Positioning Passenger Rail

The following variables loaded onto Factor 1, accounting for 29.0% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
Relative Maximum Speed, ratio	1.00	0.11
Gross National Income, US$ per capita	73 000	90
Motorways, per cent	5	0
Information Technology Leverage	Do business online	No Internet presence
High-speed Intercity Presence	Present	Absent
Economic Freedom, Heritage Foundation Index	84.0	0.0
Paved Roads, per cent	100	2
Research & Development Level	Industry leadership	Base technology
Electric Traction	Present	Absent

This factor suggested that positioning passenger railways focuses on finding a sweet spot among the mentioned variables, which, significantly, all load positively on this factor. Thus not only do high gross national income and economic freedom associate with motorways and paved roads, they also associate with high-tech railway solutions, i.e. relative maximum speed, information technology leverage, high-speed intercity presence, electric

[2] Note that there may be intermediate values between the upper and lower scale poles. Full details may be found in the Operational Definitions.

traction, and research & development level. The loading of motorways and paved roads suggested that railways benefit from road competition.

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	No factor	Factor 8
Relative Maximum Speed	***0.78***	0.34	-0.02	0.26	0.13	-0.01	0.02	-0.03	0.21
Gross National Income	***0.76***	0.03	0.22	0.22	0.36	-0.01	0.15	-0.01	0.03
Motorways	***0.76***	0.10	0.14	0.15	0.12	0.01	0.01	-0.26	0.11
Information Technology Leverage	***0.70***	0.18	0.24	0.07	0.24	-0.01	0.20	0.06	0.10
High-speed Intercity Presence	***0.66***	0.28	0.03	-0.02	0.08	-0.10	0.04	-0.14	0.35
Country Economic Freedom	***0.64***	-0.22	0.31	-0.15	0.30	-0.11	0.18	0.21	-0.12
Paved Roads	***0.63***	0.13	-0.17	0.42	-0.04	-0.02	-0.01	0.14	0.01
Research and Development Level	***0.56***	0.46	0.37	-0.08	0.11	-0.01	0.06	-0.08	0.32
Electric Traction	***0.47***	0.42	-0.19	0.33	0.24	0.03	-0.02	0.27	-0.04
Network Coverage	0.23	***0.85***	0.27	0.03	0.20	0.02	0.02	0.08	0.11
Country Population	-0.05	***0.84***	0.12	-0.31	-0.10	0.00	0.04	-0.14	0.03
Employee Count	0.31	***0.81***	-0.02	0.28	-0.02	0.04	-0.02	0.18	0.08
Total Road Network	0.21	***0.80***	0.32	-0.13	0.19	0.04	0.06	0.04	0.02
Passenger Traffic Volume	0.60	***0.69***	0.00	0.05	0.16	-0.03	0.04	0.15	0.07
Country Physical Size	-0.35	***0.62***	0.40	-0.32	-0.01	0.01	-0.01	0.03	0.12
Freight Traffic Volume	0.39	***0.62***	0.35	0.27	0.16	0.01	0.02	0.24	0.15
Heavy Intermodal Presence	0.03	0.09	***0.82***	0.08	-0.02	0.09	0.06	-0.09	0.08
Distributed Power Presence	0.04	0.25	***0.76***	-0.01	0.00	0.04	0.05	0.04	0.16
Heavy Haul Presence	0.03	0.36	***0.73***	-0.03	-0.04	0.12	0.03	0.07	0.22
Infrastructure Ownership Locus	0.04	0.05	***0.67***	-0.29	0.31	-0.13	-0.03	0.01	-0.16
Relative Maximum Axle Load	0.15	0.09	***0.65***	0.47	0.13	0.01	-0.17	0.22	0.18
Infrastructure Operator Diversity	0.22	0.05	***0.62***	0.12	-0.11	0.01	0.03	-0.23	-0.13
Narrow Gauge	-0.09	0.20	-0.04	***-0.84***	0.05	-0.04	0.00	-0.12	0.01
Networkability	0.29	0.04	0.00	***0.76***	0.22	0.04	0.00	-0.07	-0.03
Standard Gauge	0.33	0.30	0.24	***0.49***	0.27	0.01	-0.01	-0.47	0.08
Infrastructure-operations Separation	0.29	0.12	-0.11	0.18	***0.81***	-0.05	0.07	0.04	0.18
Train Operator Diversity	0.31	0.12	-0.05	0.16	***0.80***	-0.04	0.12	-0.01	0.16
Rolling Stock Ownership Locus	0.17	0.09	0.47	-0.16	***0.68***	-0.16	0.12	-0.06	-0.03
Rolling Stock Commitment Horizon	0.00	0.00	0.09	0.01	-0.08	***0.90***	-0.01	0.02	-0.02
Infrastructure Commitment Horizon	-0.07	0.03	0.03	0.06	-0.05	***0.90***	0.01	0.06	-0.05
Calendar Year	-0.03	-0.04	-0.02	-0.01	0.07	0.05	***0.81***	-0.03	0.05
Climate-change Position	0.26	-0.04	-0.03	-0.20	0.17	0.03	***0.59***	0.23	-0.08
Rolling Stock Investment Capacity	0.18	0.41	0.17	0.21	-0.01	-0.04	***0.48***	-0.21	0.20
Infrastructure Investment Capacity	0.15	0.41	0.14	0.12	0.05	-0.18	***0.46***	-0.02	0.01
Broad Gauge	-0.02	0.23	0.00	0.13	0.02	0.09	0.04	***0.88***	0.04
Attitude to Competition	0.16	0.13	0.05	0.13	0.07	-0.17	0.14	0.03	***0.72***
Subsidy Influence	0.17	0.07	0.14	-0.12	0.13	0.08	-0.06	0.00	***0.67***

Table 1: Factor loading matrix

3.1.3 Factor 2, Exploiting Opportunities

The following variables loaded onto Factor 2, accounting for 11.9% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
Network Coverage, kilometers	266 800	76
Country Population, number	1 320 000 000	444 000
Employment Creation, employee count	1 514 000	95
Total Road Network, kilometers	6 544 000	3600
Passenger Traffic Volume, million journeys per year	16 500	0.1
Country Physical Size, square kilometers	17 075 200	2590
Freight Traffic Volume, million tonnes per year	2700	0.1

This factor suggested symbiotic relations among a country's transport infrastructure (Network Coverage and Total Road Network), its stature (Population and Physical Size), and contribution to the transport task (Employment Created, Passenger Traffic Volume, and Freight Traffic Volume). It demarcated the playing field in which Assertive-, Progressive-, and Enlightened Railways, discussed in §3.2, could exercise their corporate

citizenship. The positive loading of total road network once more suggested that railways benefit from road competition.

3.1.4 Factor 3, Positioning Freight Rail

The following variables loaded onto Factor 3, accounting for 7.8% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
Heavy Intermodal Presence	Present	Absent
Distributed Power Presence	Present	Absent
Heavy Haul Presence	Present	Absent
Infrastructure Ownership Locus	Privately owned	Publicly owned
Relative Maximum Axle Load	1.00	0.29
Infrastructure Operator Diversity	Parallel operators	Single operators

This factor suggested that competitive freight rail, manifested by heavy intermodal-, heavy haul- and distributed power presence, associated with high relative maximum axle load, privately-owned infrastructure, and diverse or competing infrastructure operators. Note that only passenger railways appeared to leverage advantage from client-facing information technology. The variable is absent from freight rail positioning, suggesting that freight rail's corporate citizenship should focus on being an efficient carrier, and that the super-ordinate role of supply chain management resides outside rail.

3.1.5 Factor 4, Exploring Horizons

The following variables loaded onto Factor 4, accounting for 6.8% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
–Narrow Gauge, kilometers	24 700	0
Networkability, kilometers	327 000	0
Standard Gauge, kilometers	266 800	0

The negative loading of narrow gauge suggested that it weakened networkability, while the positive loading of Standard Gauge suggested that it reinforced networkability. Note the handicap of narrow gauge railways, which must unavoidably forego opportunities to network widely, and the opportunities that standard gauge offers network- and train operators to explore wider horizons.

3.1.6 Factor 5, Pursuing Competition

The following variables loaded onto Factor 5, accounting for 4.7% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
Infrastructure-operations Separation	Vertically separated	Vertically integrated
Train Operator Diversity	Multiple open-access	Monolithic railway
Rolling Stock Ownership Locus	Privately owned	Publicly owned

This factor revealed positive relations among infrastructure-operations separation, train operator diversity, and private rolling stock ownership. Noting that it subsumes the basic elements of liberal competition, this factor suggested pursuing on-rail competition within an open access dispensation.

3.1.7 Factor 6: Aligning Assets

The following variables loaded onto Factor 6, accounting for 4.1% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
Rolling Stock Commitment Horizon, years	60	5
Infrastructure Commitment Horizon, years	50	5

This factor suggested that railways commit infrastructure and rolling stock in unison for long periods. Railway assets are customarily long-lived, but because no other variables loaded onto this factor, it appears unrelated to railway business. This suggested that aligning assets with business, to avoid obsolescence thwarting fitness for purpose, should be an element of railway corporate citizenship.

3.1.8 Factor 7: Greening the Image

The following variables loaded onto Factor 7, accounting for 3.6% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
Calendar Year	2007	2002
Climate-change Position, Kyoto Protocol	Signed, ratified	Not signed, not ratified
Rolling Stock Investment Capacity	Expansion evidence	Withdrawal evidence
Infrastructure Investment Capacity	Expansion evidence	Withdrawal evidence

This factor showed that calendar year and climate-change position associated with infrastructure investment capacity and rolling stock investment capacity. The anchor role of time in this factor suggested that other actors, outside the railway industry, were setting the pace and that, although railways have the potential to make a valuable contribution to the climate change agenda, they do not yet leverage that potential in actualizing their corporate citizenship.

3.1.9 Factor 8, Constraining Downside

The following variables loaded onto Factor 8, accounting for 3.2% of total variance.

Variable	***Upper Scale Pole***	***Lower Scale Pole***
Attitude to Competition	Encouraged	Discouraged
Subsidy Influence	To beneficiary	To provider

This factor suggested that an encouraging attitude to competition and applying a subsidy to influence the beneficiary, could limit downside in an unsustainable situation. A country's railway industry can only be as

competitive as government will allow or encourage: Amtrak's recent infrastructure benefits following Federal funding are a case in point [8].

3.1.10 Simple and complex variables

Post factor analysis, it became evident that some factor loadings were less than ideal. Noting that a factor must consist of at least two variables, the variable Broad Gauge, which did not load on any factor, proved to be simple—that is, it measured what its operational definition stated, within the selected set of variables. The broad gauge railways of Finland and the former Soviet Union are following their own mind, witness a recent conference to fortify their 1520mm gauge [9]. Despite Varimax rotation, the variable Standard Gauge proved to be complex—that is, its highest loading was on Factor 4, but the factor loading matrix also showed significant negative loading on Broad Gauge. Thus, the factor Broad Gauge Conundrum, identified in the previous study [1], remains subliminal.

3.2 Cluster analysis

3.2.1 The icicle plot

The authors performed cluster analysis for one year only, namely 2007, to preclude cities clustering differently for one or more years of the review period, and hence to support clear interpretation. They used the Nearest Neighbour Single Linkage (Ward's) method with Squared Euclidean distance metric. The number of clusters could range from few large, relatively heterogeneous clusters, to many small, relatively homogeneous clusters: Researcher discretion determines the number selected for inter-pretation. The authors selected the smallest number that seemed reasonably interpretable, namely the following five. The Icicle Plot[3] (which is too large to include in this paper but is in file *WCRR2008 Line-haul Icicle Plot.xls* on the authors' website [4]), shows cases forming clusters: Adjacent cases are related, the shared length indicating the degree of homogeneity. The coloured bands through the icicles, in Column E, demarcate the chosen number of clusters. The cluster descriptions that follow list the countries in the same order: Note that the order does not imply ranking. Note also that recent years have seen rapid change in the global railway industry: By comparison with the previous cluster analysis of 2005 data [1], the two years intervening years have induced substantial re-clustering, although many of the fundamental distinctions of the previous clusterings remain.

For brevity, the interpretations below highlight only high- or low attributes noteworthy from a corporate citizenship perspective—those not mentioned are medium. *High* and *Low* ratings compare the average of a particular cluster to the average of the population. By inspection, deeming the range between plus or minus half a population standard deviation to be medium discriminated usefully among the clusters. Cluster averages outside that range were deemed high or low. The authors use liberal meanings for words, for example large could mean high, moderate could mean medium, and small could mean low. Note that interpretation is predicated on cluster averages: Individual members may be higher or lower than the average, and may have joined the cluster for several reasons.

[3] Contrary to nature, icicle plots show icicles in the same horizontal sense as the cases (or rows) that they represent.

3.2.2 Cluster 1: Fortuitous Railways

Twenty medium countries (Albania, Bosnia, Macedonia, Syria, Israel, Tunisia, Armenia, Kyrgyzstan, Moldova, Mongolia, Türkmenistan, Sri Lanka, Azerbaijan, Georgia, **Latvia**, Lithuania, Ireland, Mauritania, Venezuela, and Saudi Arabia), characterized by Latvia. It contains a few sub-clusters, with relative maximum axle load as the only high attribute, the rest being either moderate or low. They are standard- or broad gauge state railways whose redeeming quality was an axle load that is sufficiently high to support a modicum of competitiveness. The authors named them *Fortuitous Railways*. They lacked attributes with which to project a distinctive corporate citizenship. In the previous study [1], they generally clustered with the countries in Cluster 2 below.

3.2.3 Cluster 2: Insecure Railways

Fifty-four medium countries, (Algeria, Egypt, Morocco, Iran, Belarus, Uzbekistan, Kazakhstan, Ukraine, Bangladesh, Pakistan, Cuba, Korea Democratic People's Republic, Sudan, Iraq, Tajikistan, Zimbabwe, **Benin**, Congo Republic, Togo, Swaziland, Botswana, Namibia, Jordan, Uruguay, Guatemala, Bolivia, Cameroon, Côte d'Ivoire + Burkina Faso, Kenya, Uganda, Cambodia, Ghana, Colombia, Congo Democratic Republic, Guinea, Indonesia, Thailand, Myanmar, Vietnam, Nigeria, Tanzania, Philippines, Gabon, Madagascar, Mali + Senegal, Peru, Malawi, Mozambique, Zambia, Argentina, Malaysia, Portugal, Chile, and New Zealand), characterized by Benin. It contains several sub-clusters, has no high attributes, has generally moderate attributes, and has low competitiveness, i.e. low relative maximum speed; low distributed power-, heavy haul-, and heavy intermodal presence;, and low networkability. The authors named them *Insecure Railways* because they failed to leverage any of rail's strengths, and hence could be vulnerable to external threats or withdrawal of political support. They lacked attributes with which to project a distinctive corporate citizenship.

3.2.4 Cluster 3: Enlightened Liberal Railways

Twelve small countries, (Austria, Czech Republic, Slovakia, Netherlands, Bulgaria, **Denmark**, Norway, Hungary, Croatia, Greece, Poland, and Romania), characterized by Denmark. It contains countries that rated high on relative maximum axle load and maximum speed; electric traction, networkability, train operator diversity, information technology leverage; paved roads; infrastructure-operations separation with private participation in rolling stock; economic freedom; gross national income; and subsidy influence. All other variables were moderate, while freight technology was low—distributed power, heavy haul, and heavy intermodal were absent. They have exposed themselves to competition, taken first steps toward distancing themselves from state ownership, and leveraged rail's Guiding genetic technology for high speed, to achieve moderate sustainability. Noting their liberal position on competition through train operator diversity, infrastructure-operations separation, and private participation in rolling stock, the authors named them *Enlightened Liberal Railways*.

3.2.5 Cluster 4: Enlightened Conservative Railways

Seven small countries (Belgium, Korea Republic of, Finland, **Luxembourg**, Slovenia, Serbia, and Turkey) characterized by Luxembourg). It is closely related to Cluster 3, and contains countries with competitive railways having

comparatively high research & development level, relative maximum axle load, relative maximum speed, high-speed intercity presence, electric traction, networkability, information technology leverage, total road network, motorways, paved roads, economic freedom, gross national income, and rolling stock investment capacity. All other variables were moderate, while freight technology was low—distributed power, heavy haul, and heavy intermodal were absent. Notwithstanding competition from road transport, they have achieved comparatively high sustainability. Noting their conservative position on competition through low train operator diversity, infrastructure-operations separation, and private participation in rolling stock, as well as their lagging position on climate-change, the authors named them *Enlightened Conservative Railways*.

3.2.6 Cluster 5: Progressive Railways

Six populous countries (**France**, Italy, Spain, Japan, Germany, and United Kingdom), characterized by France. It contains countries with high research & development level, relative maximum speed, high-speed intercity presence, electric traction, attitude to competition, standard gauge (and interestingly, narrow gauge as well), train operator diversity, information technology leverage, total road network, motorways, network coverage, freight traffic volume, passenger traffic volume, employee count, economic freedom, population, gross national income, infrastructure investment capacity, and rolling stock investment capacity. This is the most extensive list of competitive attributes in this study with respect to passenger mobility, while freight technology was low—distributed power, heavy haul, and heavy intermodal were absent. All other attributes were moderate. However, they are still under government stewardship, and infrastructure operator diversity is absent, hence actualization of their corporate citizenship is circumscribed. The name speaks for itself.

3.2.7 Statistically independent countries and Assertive Railways

For n clusters, there will be at least n–1 statistically independent cases, which fall between clusters, not within them. This outcome is inherent in cluster analysis: Simply put, statistically independent countries are more individual than those in any of the clusters are. Panama, Estonia, Sweden, and Taiwan Province of China, were found to be statistically independent in this study, respectively separating Clusters 1 and 2, 2 and 3, 3 and 4, and 4 and 5, and are excluded from further discussion.

In addition to the aforementioned cases, the cluster analysis also yielded several neighbouring cases that did not cluster, but remained *statistically quasi-independent*—an unusual outcome in cluster analysis. In icicle plot order, they were Mexico, Switzerland, Australia, Canada, United States, Brazil, India, South Africa, China, and Russia. Given their large number, and the unmistakable stature of many of them, one could not simply dismiss them as different.

In their previous study [1], the authors found two clusters that contained several of the present statistically quasi-independent countries, namely Railways under Intense Competition (Canada and the United States, together with statistically independent neighbours Australia and Mexico), and Railways in Emerging Economies (Brazil, South Africa, China, India, and Russia). While

noting that most were International Heavy Haul Association members, China, Russia, and Switzerland also had significant high-speed presence. Recognizing its heterogeneity, the authors had privately wondered what held the second cluster together, and speculated whether it might fragment. The addition of two years' worth of data, and expansion of the variables to address corporate citizenship, has now induced that break. The authors therefore separated the statistically quasi-independent countries from the rest, and compared their ratings against their own mean. By counting the number of variables that rated high, and electing to examine only countries in the 50th percentile, the authors found as follows:

The United States rated high on research & development level, relative maximum axle load and -speed; distributed power-, high-speed intercity-, and heavy intermodal presence; attitude to competition, standard gauge, infrastructure operator diversity, information technology leverage, total road network, infrastructure- and rolling stock ownership locus, network coverage, freight traffic volume, economic freedom, gross national income, physical size, infrastructure investment capacity, and subsidy influence. Its blend of competitive private enterprise and technology leadership has established a formidable corporate citizenship in freight railways, a role model revered by the world.

China rated high on research & development level, relative maximum speed; distributed power-, high-speed intercity-, and heavy intermodal presence; electric traction, attitude to competition, motorways, paved roads, freight traffic volume, employee count, population, physical size; and infrastructure- and rolling stock investment capacity. Its towering corporate citizenship, and phenomenal development and growth, have become the stuff of major features in the trade press [e.g. 10].

Switzerland rated high on relative maximum speed, high-speed intercity presence, electric traction, networkability, infrastructure- and train operator diversity, information technology leverage, paved roads, motorways, rolling stock ownership locus, economic freedom, gross national income, rolling stock investment capacity, and subsidy influence. All other variables were moderate, except those that necessarily associated with a small country, while freight technology was also low—distributed power, heavy haul, and heavy intermodal were absent. While surging passenger- and freight traffic had put pressure on the network, funding for infrastructure enhancement was constrained, and freight traffic had experienced losses. Its corporate citizenship has also justified feature coverage [11].

Australia rated high on research & development level, relative maximum axle load; distributed power- and heavy intermodal presence; electric traction, train operator diversity, information technology leverage, motorways, infrastructure-operations separation, infrastructure ownership locus, rolling stock, ownership locus, infrastructure commitment horizon, economic freedom, and gross national income. Its blend of technology leadership and competitive private enterprise has established formidable corporate citizenship, particularly in freight railways with both private- and public infra-structure ownership, which has also become the stuff of major features in the trade press [e.g. 12].

Russia rated high on research & development level, relative maximum speed; distributed power- and high-speed intercity presence; electric traction, attitude to competition, broad gauge, paved roads, freight traffic volume, employee count, physical size; and infrastructure- and rolling stock investment capacity. Within an essentially state railway, it has established a substantial basis from which to compete against other modes, and given the bounded networkability of its broad gauge, has led the 1520 Strategic Partnership [9] to capture east-west long haul intercontinental business.

The multivariate statistical outcomes thus substantiate what is patently evident from the trade literature, namely that several statistically independent countries are among the pacesetters in global railways. Although they have distinct differences, they are nevertheless similar in how they leverage rail's competitive strengths. Each is indisputably successful in meeting the transport task in its own country, yet they are all sufficiently different not to cluster. They are evidently individual corporate citizens of global significance. The authors therefore named them *Assertive Railways*.

4 Discussion regarding potential implementation

The authors have shown a scientific basis for positioning railways in terms of corporate citizenship. Factor 1, Positioning Passenger Rail, and Factor 3, Positioning Freight Rail, confirm the eminent domains of third-century globalized line-haul railways to be high-speed intercity for passenger, and heavy haul and double stacking for freight. Some railways in the Fortuitous- and Insecure clusters could have the potential to implement rail's competitive strengths by transforming to one or other of the Assertive-, Progressive-, or Enlightened clusters. Railways that do not take up that challenge might well fall by the wayside. Factor 5, Pursuing Competition, and Factor 7, Greening the Image, suggest that enabling or encouraging political processes need to precede such implementation: There is however still a long way to go, as Fortuitous Railways and Insecure Railways outnumber those that have established, or are already developing, their global corporate citizenship.

Recall that rotation maximizes separation between factors. Hence, Factor 1 and Factor 3 address distinct corporate citizenships: Factor 3 revealed an interesting association of heavy freight railways and private participation, both in infrastructure and in rolling stock. Noting also the separateness of Cluster 5, Progressive Railways, and §3.2.7, Assertive Railways, while private participation in rolling stock features in both, private participation in infrastructure is more prominent in Assertive Railways than in Progressive Railways. Given the contention between freight- and passenger railway positioning, it is interesting to reflect on Europe, where sharing infrastructure between freight and passenger traffic has led to the open access dispensation of Factor 5, which excludes private participation in infrastructure. This may indicate that competitive heavy freight, such as double stacking, will elude Europe until it realizes a private-participation rail network giving priority to freight.

As with the eponymous variable in the authors' companion paper on urban rail [3], Factor 7, Greening the Image, the subject should raise concern because it is outside the railway positioning mainstream. Despite the topical climate-change melodrama, that raises green issues ever more frequently and more

stridently, the present findings showed scant correlation between the undisputed energy efficiency of railways, and a beneficial relation to their business and/or societal setting. Instead, the variable Time that loaded on Factor 7 suggested that the external environment is still setting the pace.

Although Canada missed the 50th percentile cut-off listed in §3.2.7, it came close. Canadian National, as a constituent of that "cluster"—appears to be one of the first fruits of an overtly global corporate citizenship, which seeks to capitalize on burgeoning global trade opportunities [13]. DB Logistics is another railway development that aspires to global logistics. It will be interesting to follow growth of their corporate citizenship from national railway roots into the sophisticated domain of global logistics.

5 Conclusions on line-haul rail's corporate citizenship

The authors have presented a novel approach to researching railway positioning. A high-level perspective has allowed them to bypass the myriad detail issues that obfuscate examining the transformation of railways from submissive national carriers to global corporate citizens. The cluster and factor analyses have revealed longitudinal relations that support the hypothesis stated in §1.4. These relations, among variables associated with line haul railways' Contribution to Society, Core Business, Social Investment, and Engagement in Public Policy, as well as the resources that they deploy to satisfy their dominant stakeholders, provide a platform from which to examine their global corporate citizenship. That one can interpret the present findings within a corporate citizenship frame-work establishes a plausible alternative to former lower level perspectives on railway positioning.

From Factor 1, Positioning Passenger Rail, and Factor 3, Positioning Freight Rail, the rudiments of global corporate citizenship, resting on rail's Bearing, Guiding, and Coupling genetic technologies, are already evident. Factor 2, Exploiting Opportunities, and Factor 5, Pursuing Competition, indicate the essential collaborative relation of such railways to their business milieu. Factor 4, Exploring Horizons, Factor 6, Aligning Assets, Factor 7, Greening the Image, and Factor 8, Constraining Downside, indicate the potentially symbiotic relation of railways to their societal setting. Prominent members of the global railway industry arguably do not quite have the clear corporate citizenship associated with comparable service industries that offer global business interoperability, like major airline partner-ships, and supply chain organizers like UPS, FedEx, and TNT. However, they too began modestly.

Arguably, the most significant impact of the present findings on railways will be the opportunity cost of repositioning their contribution to a country's social investment expectations. Factor 8, Constraining Downside, suggests an opportunity to liberate national railways from subservience to pursue what railways do best in the global logistics and intelligent mobility market spaces. It will mean trading off their protected, though potentially declining, present contribution against a competitive, though sustainable, future contribution.

The notion of ultimate interoperability integrates and concludes the study. Heavy haul- and heavy intermodal railways support global freight flows: High-speed railways support intelligent intercity mobility. Line haul railways, as global corporate citizens, are leveraging rail's genetic technologies to ensure

they interoperate with the business and social entities that package and deliver the aspirations of their stakeholders. Inspired by the notion of ultimate interoperability, the present research has revealed several archetypal global corporate citizens, together with an array of factors to provide clear guidance for those Fortuitous- and Insecure Railways that wish to participate in railways' third century.

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