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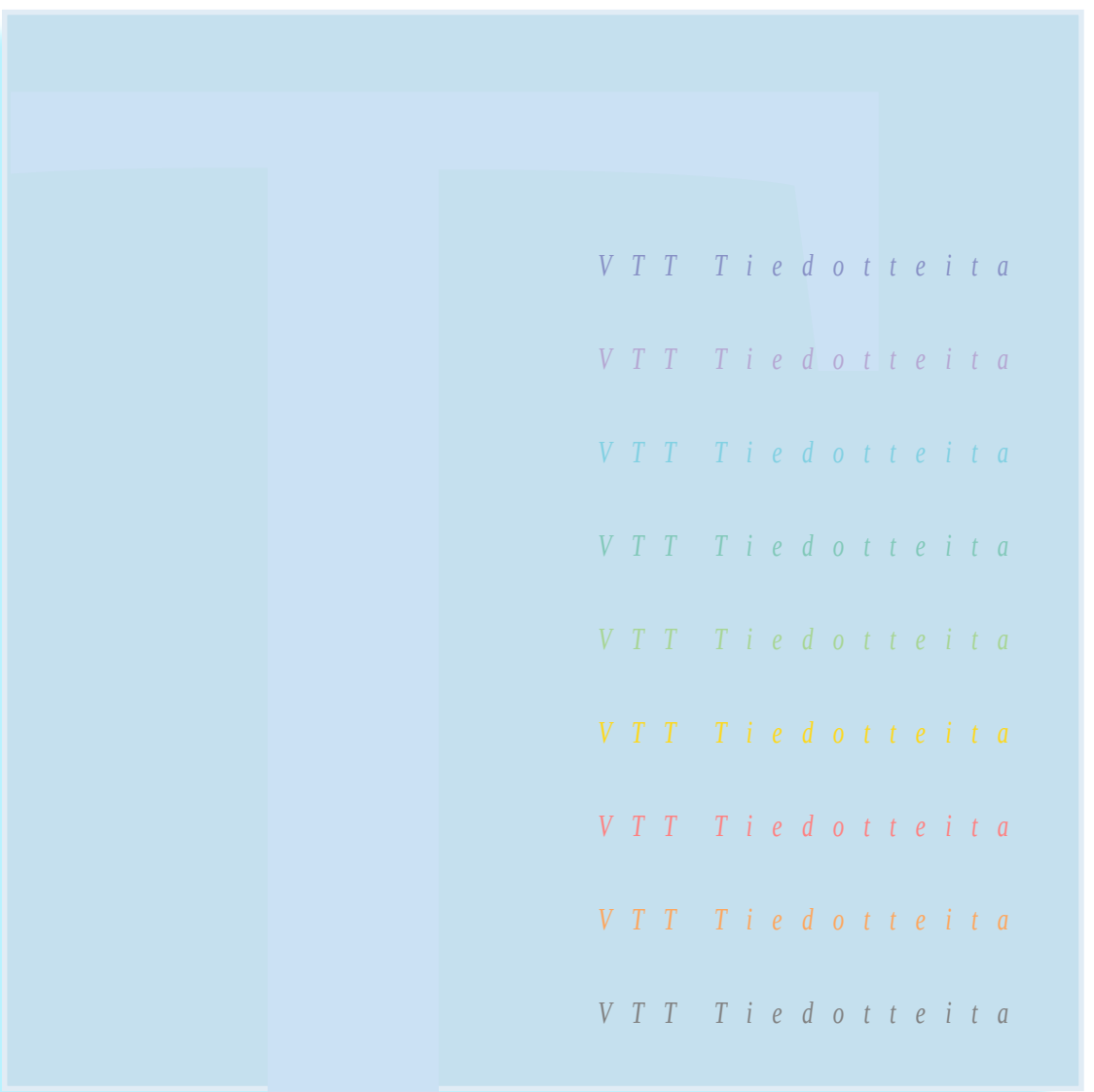
Juha Tervonen, Prianka N. Seneviratne & Heli Kilpala

Performance improvement strategies for railway enterprises



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Keywords railways, railway companies, performance evaluation, improvements, productivity, indicators, infrastructure, deregulation, logistic operations, administration, management analysis

Abstract

This report addresses the performance measurement of railway enterprises from two perspectives. First, the on-going separation process of European railway companies into infrastructure companies and operating companies allows a clearer identification of stakeholders and their expectations, according to which performance targets should consequently be set. Second, based on an extensive review of empirical research on railway productivity, a set of performance strategies likely to be meaningful in the future of European railway enterprises has been formulated.

In the past, European railway enterprises have aimed at satisfying public perceptions, policy makers and community goals. In addition, performance measurement in scientific literature has concentrated more on describing the differences in market geography, rather than pure economic efficiency. Due to the now granted managerial autonomy and exposure to competition, railway companies are formulating their business and operational strategies according to commercial lines. Therefore, there is a need for setting goals and selecting indicators for monitoring the success of these strategies. There exists a timely opportunity to adopt strategies for significantly improving railway performance. Such strategies can be formulated, e.g., based on the experiences gained from deregulation in North America.

The North American railway companies were granted more pricing freedom and the freedom to choose their markets, which they serve by government deregulation acts in both the US and Canada in the 1970s and 1980s. Such managerial autonomy resulted in abandoning unprofitable lines, mergers and exposure to competition, which resulted in significant decreases in the costs of production and prices of services. However, the impacts of deregulation are not indefinite. Other cost, pricing and market strategies are required for sustaining competitiveness.

According to the authors of this report, the performance strategies of European railway enterprises should focus more on revealing the differences in relative cost and revenue ratios of different parts of the network and on the different types of services provided. Furthermore, diversified pricing, marketing and quality-of-service strategies should be developed for capturing higher value segments in the transport markets. A set of indicators for highlighting the importance of cost, revenue and profit orientation and quality of service are proposed. Suitable long-term productivity measurement techniques are also discussed.

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Tiivistelmä

Raportissa lähestytään rautatieyhtiöiden tehokkuuden mittaamista kahdesta eri näkökulmasta. Ensinnäkin käynnissä oleva rakennemuutos, jossa liikennöinti ja radanpito erotetaan toisistaan, sallii keskeisten sidosryhmien ja niiden odotusten tunnistamisen entistä selkeämmin. Liikennöinnin ja radanpidon tehokkuutta ja tuottavuutta koskevat tavoitteet tulee asettaa näiden odotusten mukaan. Toiseksi rautatieteollisuudelle on määritelty tuottavuusstrategioita kirjallisuusanalyysin pohjalta.

Käynnissä olevaan rakennemuutokseen saakka eurooppalaiset rautatieyhtiöt ovat tähdänneet erilaisten julkisen mielipiteen ja politiikantekijöiden odotusten pohjalta määriteltyjen tavoitteiden täyttämiseen. Lisäksi tieteellinen kirjallisuus on keskittynyt lähinnä markkina-alueiden maantieteellisten erojen kuvaamiseen taloudellisen tehokkuustarkastelun sijasta. Lisääntyneen itsenäisyyden ja kilpailun vuoksi rautatieyhtiöt määrittelevät liiketoiminnalliset strategiansa vahvemmin kaupalliselta pohjalta. On siis tarve asettaa tavoitteita ja määritellä mittaamismenetelmiä (indikaattoreita) näiden strategioiden mukaisesti.

1970- ja 1980-luvuilla Pohjois-Amerikassa rautatieyhtiöiden sallittiin hinnoitella tuotteensa täysin itsenäisesti sekä valita markkina-alueensa huomattavasti vapaammin. Kannattamattomia palveluja lopetettiin, kilpailu koveni ja rautatieyhtiöitä yhdistettiin isommiksi yksiköiksi. Tämän tuloksena sekä tuotantokustannukset että palvelujen hinnat alenivat. Vaikutukset kestivät vain jonkin aikaa ja todettiin tarvittavan muita kustannus-, hinnoittelu- ja markkinastrategioita suotuisan tuottavuuskehityksen ylläpitämiseksi.

Tämän raportin mukaan eurooppalaisten radanpitäjien ja liikennöitsijöiden tulisi keskittyä enemmän kustannustason ja tulovirtojen läpinäkyvään tarkasteluun eri verkon osissa, eri tuoteryhmissä ja eri palveluluokissa. Lisäksi hinnoittelu-, markkinointi- ja laatustrategioita olisi käytettävä hyväksi haettaessa paremmin tuottavia markkinasegmenttejä arvokkaampia palveluja tarjoten. Ehdotettujen strategioiden pohjalta raportissa esitetään joukko indikaattoreita, joilla voidaan tarkastella suhteellisia kustannus-, tuotto- ja laatueroja sekä tarkastellaan pitkän aikavälin tuottavuuden mittaamismenetelmiä.

Preface

This report aims at filling a gap in railway economic research and initiating a new research area in Finland. While the authors take full responsibility for the views and possible errors contained in this report, the encouragement and support provided by various individuals and institutions are greatly appreciated. In particular, the authors are thankful for VTT Communities and Infrastructure, the Department of Civil & Environmental Engineering at Utah State University (USU), and the Department of Environment, Transport, Energy and Communication (DETEC), General Secretariat, Bureau of Transport Studies (GVF).

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Contents

1. Introduction

The allocation of resources to the competing uses of a firm is a complex process that requires the systematic assessment of prior performance with proven analytical tools. Regardless of whether the ultimate goal is to increase the firm's value, maximize profits, cut costs, minimize environmental degradation, improve safety or a combination thereof, and sound reasoning must underlie the decisions. A systematic methodology enables decision-makers to monitor progress over time or to compare performance with other firms. The measures chosen to aid decision-making must clearly reflect the outcomes of a decision as well as its sustainability.

This study focuses on the determinants and evaluation of the performance of restructured European railway companies supplying infrastructure and transport services. The restructuring of rail companies has led to new entities with new responsibilities and goals that emphasize competitiveness, cost recovery and profit making, as well as traditional public service obligations. The new companies are, or soon will be, looking to improve their production processes and their products, the efficient and effective movement of people and goods, by optimizing the use of available resources. New strategies must be sought to revitalize the competitive spirit. Consequently, the need to monitor the impacts of the new goals is growing.

For decades, governments were granting natural monopoly status to railways, and setting operational goals partly based on political beliefs. Performance evaluation focused on public perceptions, policy-maker satisfaction and community service goals, instead of concentrating on improving the competitiveness of the railways. Today, the policy-makers have acknowledged that economic growth is dependent on the speedy and seamless transportation of goods and people. Customers are concerned about availability, reliability, safety, comfort, and convenience as much as the cost of transport. To satisfy that need, governments are actively seeking to optimize the mix of transport modes without unduly affecting social well-being. Consequently, rail companies are compelled to shed antiquated practices and implement strategies to meet the new mandates and stakeholder expectations.

As depicted in Figure 1, the relationships between the two main rail-sector companies, and between each company and its stakeholders are much clearer after the restructuring. The expectations of the stakeholders can be plotted and the areas of responsibility can be separated to reflect the stronger commercial thinking of the companies. They will play by the rules set by 'the Regulator'. However, setting a unifying objective function in the rail sector is an arduous task when the objectives are still evolving and the stakeholders (shareholders, customers, regulators and society) are not truly distinguishable.

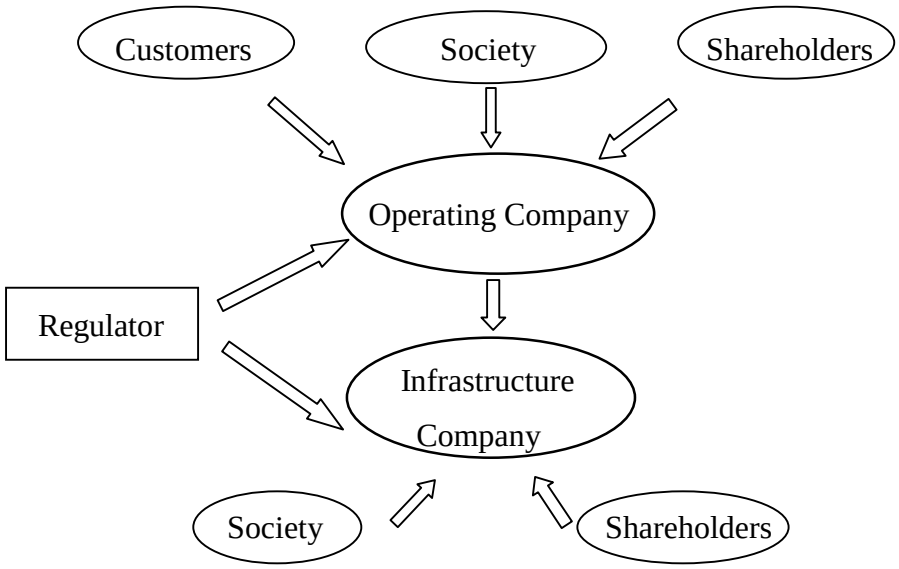

Figure 1. Principal players and stakeholders in the rail industry.

It is necessary to set unambiguous measures and corresponding targets to evaluate the success or failure of railways both in strict economic terms and in relation to socio-economic expectations. As Damodaran (1997) has stated, a unifying objective function is needed to develop cohesively over time.

This study introduces a set of new strategies for performance development in the European rail industry, as well as indicators for monitoring the impacts reflecting both economic efficiency and the principal expectations of the stakeholders. Although empirical evidence of the impacts (performance gains) of the suggested strategies exists, the magnitudes, timing or their distribution among different stakeholders are not entirely clear from previous studies. Proposed spatial partial indicators will capture the impact during a single period or temporally over several periods. Techniques for long-term productivity assessment are also proposed.

This paper is divided into six main sections. Following the introduction in Section 1, the reorganizing process of European rail enterprises is reviewed, the main stakeholders are identified along with their principal expectations and the need for performance evaluation is argued in Section 2. Section 3 is a synthesis of the principal findings of recent analyses of rail enterprise performance, aiming at identifying, among the myriad of factors found to influence performance, those factors and trends that are deemed significant if appropriately treated. Section 4 develops a framework of taking empirically proven sources of productivity into consideration at different levels of decision-making, and some indicators are proposed for monitoring the issues raised.

Section 5 gives a broad overview of the performance evaluation techniques used by researchers, officials and rail enterprises. The techniques are categorized into three groups in relation to different aspects of performance (i.e., total, partial, and a mixture of the two) that they highlight. The strengths and weaknesses of each technique are summarized and the choice of technique is discussed. Section 6 contains the conclusions and recommendations based on the overall findings. The validity of the recommendations must be reviewed by end-users and tested with empirical data.

2. Industry structure, stakeholders and performance evaluation

2.1 Changes in organizational structure

European governments have followed the same style of restructuring of rail companies, which stems from the EU Council Directives set in the 1990s aimed at separating the responsibilities of providing infrastructure and train services, as well as introducing open access to the markets and eliminating barriers, such as national borders and technical constraints (Jahanshahi, 1998). Typically, restructuring the railways has produced a train-operating company (OC) that provides passenger and freight services, and an infrastructure company (IC) providing the right-of-way (Figure 2). However, according to an eight-country survey by Leviäkangas (1997), the resultant entities have somewhat different missions, partners, and administrative structures.

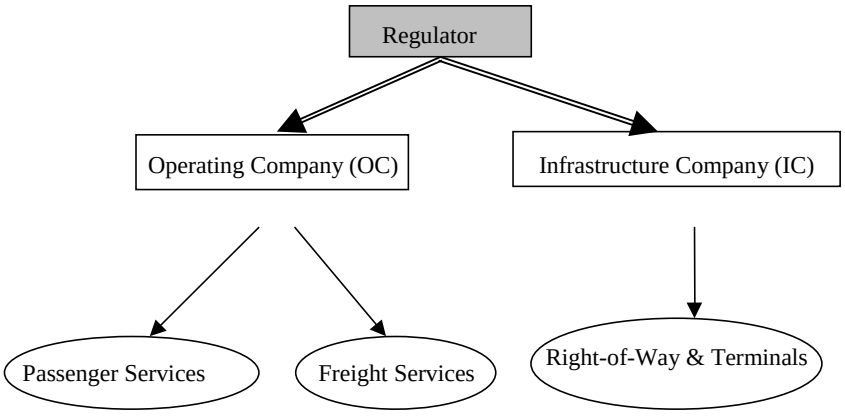

Figure 1. Elements of the diversified rail sector.

The trend, however, may be towards more diversification in service supply, i.e. the separation of passenger services from freight services, and even into long (inter-urban) and short-distance (urban) transport. According to Braeutigam et al. (1995), there is no statistically significant evidence that total operating costs will be different if freight and passenger services are provided by two entities instead of one. However, there is no extensive evidence available to fully support the claim. Passenger and freight transport differ considerably in cost structure, but especially in the regulatory environment.

The debate on the privatization of operating companies has so far led to realization only in Great Britain. Empirical evidence to date, however, does not support one or the other form of ownership as being superior. Instead, it has been concluded that deregulation,

managerial autonomy and the promotion of market competition are critical factors determining rail performance (Caves et al. 1982).

The separation process is by no means costless. Regulating the exchange processes between infrastructure companies and the operators brings about vertical transaction costs such as negotiation, formalization, data recording and mutual monitoring (Jensen, 1998). Another cost item is the complex iterative process of allocating track capacity between operators. There may also be scale disadvantages present for new operators, depending on the number of possible entrants and the characteristics of the market. These costs should not exceed the benefits, i.e. the compensatory potential of rationalization, which are gained from the separation process. The same applies to the introduction of open access.

2.2 Stakeholders under the new structure

Stakeholders are interested in or have expectations about the products offered by the different railway entities. There are at least three such stakeholder groups, which can be identified for the purposes of this study:

- Shareholders
- Customers
- Society

The need for distinction between different stakeholder expectations is apparent from annual reports and other documents describing rail company performance. Most companies appear to place stakeholder expectations in a cluster, illustrated as Stage A in Figure 3, while there is no clear distinction between which performance indicators should primarily be used for serving the stakeholders. In reality, the goals and expectations of each group are different (Stage B) and therefore must be assessed differently. Customers care for service quality and cost, but they have no direct interest on the profit-making abilities of the service provider. Shareholders, at least in the case of a fully private venture, would think just the opposite. The society with the combined role of the regulator and provider of public services, and in most cases the owner, will expect high customer satisfaction and return on investment, but also high socio-economic quality.

Naturally, there is some overlap among the expectations of the stakeholders; for example, passenger services may continue to remain partially regulated, in which case the society is not only an owner of a public corporation, but a financier of services. Passengers may pay for the services partly in the form of taxes and therefore have a

stake as shareholders besides being customers. In the case of publicly owned companies or agencies, the society's and the shareholders' roles are very much alike due to the expectations of self-supporting revenue flows and dividends. Social issues, such as the environment and safety, are nowadays of wide concern to all stakeholders, but primarily to the customers and society.

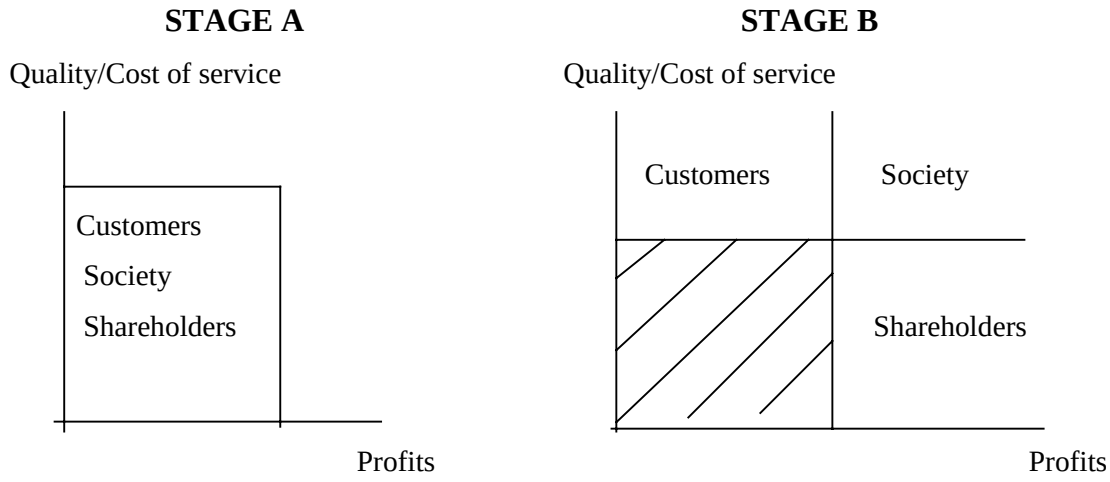

Figure 3. Distinction between stakeholder expectations.

2.2.1 Infrastructure company stakeholders

a) Customers

An IC's main customers are current or future OCs. An OC would typically expect infrastructure to be available in sufficient quantity and quality. An OC may be operating different kinds of trains (freight trains, urban commuter trains, high-speed trains, scheduled/unscheduled traffic), and hence demanding different levels of track service and prices. Prices should be competitive compared to other modes of transport paying for the use of right-of-way. Therefore, the expectations of an IC's customers can be expressed as:

- ✓ Availability and accessibility
- ✓ Quality
- ✓ Price

b) Society

Society represents the public at-large. Besides the expectation towards the existence and quality of infrastructures, public interests range from environmental concerns to safety. The availability of infrastructure is an indirect concern of society that expects transport in remote areas with low demand. Some representatives of society, such as taxpayers, expect public service obligations to be satisfied by rail, subsidized if necessary. Others may expect ICs to be self-supporting in all service supply. Accordingly, the expectations of society, which the ICs must be focused on, can be summarized as:

- ✓ Size and quality of network
- ✓ Environmental impact
- ✓ Safety
- ✓ Financial performance

b) Shareholders

Although partial autonomy has been granted through legislation, the primary shareholder of ICs in most countries at present is the State. It expects ICs to efficiently and effectively serve all the needs of OCs and complement the national transportation system. At the same time, it expects ICs to be self-financing, if not profit-making, entities. In this sense, shareholder expectations seem to coincide with society's expectations. For the purposes of this study, it is assumed that the shareholder's economic expectations are similar to those of any private corporation. According to Gallamore (1999), the most important goals are:

- ➢ Recovery of infrastructure costs
- ➢ Expense reduction through improvements in asset utilization and operating cost performance
- ➢ Earnings growth from improvements in operating ratios, increases in market share and by profit acquisition strategies

Therefore, the focus is on profits and value, which may be assessed by:

- ✓ Recovery of infrastructure costs
- ✓ Return on assets

2.2.2 Operating company stakeholders

a) Customers

An OC's customers range from individuals in the case of passenger services to corporations in the case of freight services. Both groups have similar expectations in terms of:

- ✓ Availability (accessibility, hours of operation, etc.)
- ✓ Quality (speed, reliability)
- ✓ Safety
- ✓ Price

b) Shareholders

As in the case of ICs, the shares of OCs are vested in State-appointed Boards of Directors. However, the status of OCs can be expected to change faster than ICs. Managerial autonomy or private ownership, public offerings of stock, and truly commercial goals will lead to expectations of sustained revenue flows, high dividends and growth in the firm's value. These expectations are generally expressed as:

- ✓ Return on investment
- ✓ Net operating income
- ✓ Value of stock

c) Society

Traditionally, passenger transportation companies have been expected to maximize net social benefit with the available funding (Harris and Callaghan, 1997). This objective is naturally in conflict with the pure profit-making objectives of corporate shareholders. As restructuring progresses, it is possible that these conflicts will be resolved through the State's involvement in setting standards and rules of operation to safeguard the interests of the public at-large. The following aspects may reflect the views that are monitored by OCs to ensure the ethical conduct of business:

- ✓ Availability of services
- ✓ Environmental impact
- ✓ Safety
- ✓ Financial performance

2.3 The role of performance evaluation

Performance evaluation is a fundamental activity in the corporate style management of enterprises. Performance measure, in turn, is an indicator of a firm's efficiency and/or effectiveness that is directly tied to its results. Performance measures are used for assessing the progressiveness of a firm or industry or for allocating resources. A knowledge of trends in certain measures and functional relationships between those measures and key resources of an operation enables decision-makers to influence performance through either policy and/or managerial choices. The fundamental purpose of performance evaluation is to gauge progress against stated goals and objectives, presupposing that the strategic objectives are known. Performance measures can provide either a partial or a global picture of a firm.

1. Performance measures at least permit the:

2. Tracking of performance of an entire firm over time as well as understanding in sufficient detail, the real sources of gain (or loss) in performance.

3. Comparisons of a firm's performance in relation to other firms and similar industries in its own country or other countries.

4. Estimation of the impact of external influences, such as public policy regimes, regulation or ownership on performance.

5. Estimation of the impact of decisions, such as technological, managerial, operational and price changes, utilizing economies of scale and innovation, on performance.

2.4 Proposed methodology

The authors propose a systematic approach for making certain strategic policy, business and operational decisions for improving performance. The assumption is that the proposed strategies will lead to lower costs and higher revenues, which are essentially the principal expectations of the stakeholders. Accordingly, the degree to which stakeholder goals and expectations are met by implementing one or more strategies is an indicator of performance. The goals and expectations are expressed as measurable or observable indicators of various aspects of a company's products and services. Impact evaluation refers to the subsequent process of comparing the indicators with pre-established targets.

The proposed methodology, illustrated in Figure 4, consists of four basic steps:

- Identification of stakeholders and stakeholder expectations
- Identification of strategies for improving economic performance of rail companies
- Establishment of a set of indicators that would reflect the impact of the strategies on stakeholder expectations
- Analyze the impacts of strategies and develop them further

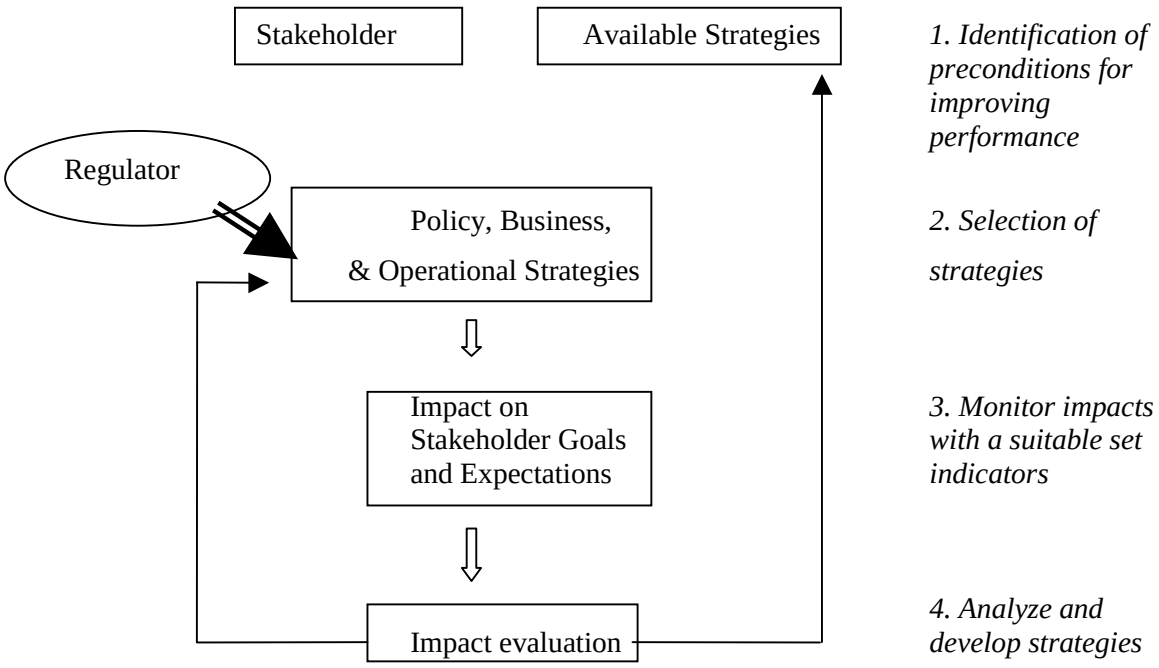

Figure 4. Proposed framework for performance evaluation.

3. Empirical evidence of performance strategies

3.1 Selection of performance strategies

Based on an extensive review of rail productivity research, the authors propose that the objectives of the restructured infrastructure and operating companies, as well as performance measurement, should focus more on relative cost, revenue and profit orientation, and quality of outputs. Consequently, an attempt is made to generalize and propose certain strategies as sources of productivity gains based on empirical evidence.

Traditional comparative examinations of the industry have focused on quantifying the physical differences in market characteristics, not market-specific or relative cost structures or revenue and profit-making. It is argued that, drawing conclusions from geographic market characteristics is misleading, and that this should not be a driver for economic examinations. Ideally, performance monitoring should enable a company to continually and simultaneously satisfy its objectives of lower costs, better service quality and higher revenues according to the transport markets it faces, not chant physical characterizations of market typography.

A host of fundamental cost-cutting strategies have been applied and tested in North America. Conversely, the effectiveness of revenue-increasing strategies is not widely published. In particular, there is a noticeable absence of details of strategies related to marketing, pricing and the quality of services. Fundamentally, cost reductions are possible through the implementation of strategies at the regulatory and organizational level. Strategies implemented by regulatory bodies impact performance through changes in the operating environment. However, they are often outside the control of OCs and ICs. These strategies are referred to here as policy choices. At the organizational level, business and operational strategies can be implemented to improve the production process and the quality of products. Rail companies in the restructured industry are expected to have the flexibility to implement a broad range of such strategies.

3.2 Policy choices

Empirical examinations have revealed the potential for major gains in productivity through policy changes. However, if strict discipline is applied to definitions, not all productivity gains due to policy changes can be considered performance improvements (i.e., changes in the efficiency of production through process changes), but increases in output due to increased resource utilization. The magnitude and sustainability of the impacts of different policy options on performance seem to vary. For instance, changes in the operational environment due to deregulation have been shown to yield dramatic

one-off type of improvements, but benefits have been found to fade with time, unless market expansions or cost decreases are achieved through other strategies to sustain the competitive edge.

3.2.1 Deregulation

Numerous studies undertaken in the recent past shed considerable light on the impacts of deregulation on performance in the US and Canada. For example, Tretheway et al. (1997) have analyzed total factor productivity of the Canadian Railways between 1956-1991. Pricing freedom provided by the Canadian National Transportation Act of 1967 led to an impressive productivity growth, catching up with and surpassing the productivity of US railroads. The US deregulation legislation in 1980, the Staggers Rail Act, went even further by giving rail companies more freedom to choose what services they supply (choice of market). The Act allowed rail companies to abandon unprofitable high-cost trackage without costly regulatory proceedings. Moreover, mergers took place and the traffic mix of the railroads was altered dramatically. As a result, unprofitable business was eliminated. Mergers, in turn, led to the reduction in the number of rail companies from 39 in 1980 to 9 in 1998 (Park et al. 1999). On average, it costs 55% less in inflation-adjusted dollars to move freight by rail in 1999 than it did in 1981 (Association of American Railroads, 1999).

However, Tretheway et al. (1997) also found that the Canadian railways were unable to sustain the productivity gains that followed pricing freedom. The principal cause was raising input prices and restrictions on the choice of markets. In cases where the volume of output cannot be significantly increased, lower input costs must be sought if productivity growth is to be sustained.

Wilson (1997) has performed a detailed analysis of the impacts of the Stagger's Rail Act of 1980 on the US Class 1 rail industry, using panel data from 1978 to 1989. He found that the initial cost savings of partial deregulation were modest, but soon the average costs were 40% lower than they would have been under regulation. Prior to deregulation, costs were decreasing at a rate of 1 to 2% per year, whereas afterwards they were falling at about 6 to 7% a year. However, by 1989, the rate of reduction in cost had eroded to the pre-deregulation levels. It is an indication that deregulation by itself is not a sustainable source of productivity gain.

Wilson (1997) found that strict regulations discourage innovative progress in developing rolling stock and blunts management incentives and initiative. Although statistics indicating the direct impact of regulation on innovation are not common, Gallamore (1999) also argues that it is apparent in the process of revitalizing railroads.

Therefore, restructuring has permitted rail companies to offer innovative responses to opportunities in the competing sectors. Wilson (1997) also refers to cases in the US where pricing innovations such as multi-car service rates, contract rates between shippers and carriers and priority pricing programmes have resulted in consolidated shipments and reductions in labour costs.

3.2.2 Subsidies and managerial autonomy

Oum and Yu (1994) analyzed the impacts of subsidies and managerial autonomy on the performance of passenger railway companies in the OECD countries using Data Envelopment Analysis (DEA). The data covers the period from 1978 to 1989, and the sample companies represent a variety of regulatory and operating environments. The authors computed a DEA efficiency index of two alternative outputs based on seven inputs. To determine the sensitivity of efficiency to the input variables, they were divided into controllable (strategic and managerial choices) and uncontrollable (policy choices). The uncontrollable variables included several related to service supply and demand, as well as the market characteristics of each company. The controllable variables included subsidy rates, the share of electrified network, and the degree of managerial autonomy.

The results indicated that electrification improves the performance of the railways, possibly resulting from reduced energy consumption and engine maintenance, and labour demand. Additionally, it was found that the greater the share of electrified network, the lesser the changes needed between electric and diesel locomotives, which leads to increased equipment utilization. Other findings of Oum and Yu (1994) imply that the larger the share of subsidies of operational costs, the less efficient the railway. Dependence on subsidies does not provide incentives for cost minimization. Finally, managerial autonomy in strategic and operational decisions is very important for improving efficiency. It enables quick responses to changing markets, but it also sets requirements for managerial accountability, thus providing incentives for improving efficiency.

Benjamin and Obeng (1990) found that, if public transit is considered a social service, relationships exist between subsidy and output, and between productivity and subsidy. In other words, subsidies, at least in the European context of railways, also serve a social purpose, which should be judged accordingly. Strict textbook style productivity measurement is not likely to reflect those differences adequately.

3.2.3 Size of network and scale of operations

Transport systems, railways in particular, are characteristically constrained by capacity and diminishing returns to scale with regard to increasing network size. However, economies of scale can be gained, e.g. through downsizing the network (abandoning unprofitable track) or increasing traffic density. Gains in economies of scale (or density) are strongly dependent on the ability to increase output with existing track and rolling stock capacity. There are negligible additional costs in filling empty seats and running full trains, but expanding services to new markets is costly. Norsworthy and Jang (1992) found substantial economies of scale for delivered mail on a given network, but diseconomies for network expansion. They refer to similar findings in rail transport.

Economies of scale are not only a question of network size and load factors. Global evidence from aviation and trucking industries, and the US rail industry in the 1990s, points to a major trend towards the concentration of firms. Smaller operators have been taken over by larger ones, or they have merged into alliances, but also large companies have formed mega-carriers. This trend is in conflict with past empirical research showing constant returns to scale in transport industries. According to theory, under constant returns to scale, increasing (or decreasing) the size of companies should not produce any change in relative profitability or productivity. If that is true, mergers must be explained by the will to simply gain market power. However, recent research on economies of scale has shown that the traditional scale factor, network size, does not capture the role of other operating characteristics when determining cost structures in transport companies. (Oum and Zhang, 1997)

According to Wilson (1997), rail sector economies of traffic density are much greater than economies of scale in network size. This means that utilizing the existing track and rolling stock capacity more intensively and frequently is likely to yield more output than running sparsely over a wider network. The relative density of operations can be increased by concentration, i.e. downsizing track usage while retaining the prior level of output on the remaining part of the network.

Benjamin and Obeng (1990) have shown that there is also evidence from public transit studies supporting performance gains due to concentration along corridors with high population densities. Keeler (1997) refers to some strong empirical findings on the ratio of fixed and variable cost shares of train operations with regard to traffic density. On the routes where capacity is utilized to the maximum, variable costs dominate the cost structure, and the marginal costs are below average cost. This means increasing economies of density. Furthermore, higher operational densities contribute to better service quality.

3.2.4 Exploratory approaches

Nijkamp (1995) has listed several determinants of efficient transport markets in European rail freight. Current barriers that fragment markets by national borders and traditional conceptions of modal split must be removed. If the requirements for interoperability and multi-modality of the common markets are not realized, a better competitive position compared to other freight transport modes will never be gained. Stubbs and Jegede (1998) have argued that better integrating the rail system with other modes for providing seamless services, with air transport in particular, may attract more passengers.

The increased use of advanced computerized systems and communications technologies is another approach that rail enterprises can adopt to enhance network performance and customer value. Gallamore (1999) has envisioned new systems to continually emerge for improving reliability, customer satisfaction, decision-making and capacity management. Customer service, which is the uppermost requirement for expanding rail market share, will emerge from knowledge of train and car positions, capacity management, reduced documentation, faster transit times and reduced quality failures.

Jahanshahi (1998) presents a number of means for sharing infrastructure. They have been found beneficial in the US rail industry, and may be potential sources of performance improvements once open access, competition and interoperability have been introduced to the European rail markets. Issues which European infrastructure companies and train operators may explore include trackage rights, paired/joined track arrangements, joint subsidiaries, joint facilities, pooling, and haulage and car-handling services. However, depending on the markets and the relationships within the industry, competition for bottleneck facilities may increase, which may in turn, lead to discrimination. According to Jahanshahi, under the emerging European arrangement of independent infrastructure agencies controlled by government regulators, discrimination is less likely to occur.

By the very nature of railways, they contribute on average less to environmental externalities compared to other modes of motorized transport. This has become a strong argument in favour of the rail industry. However, environmental aspects do not enter the cost function of rail companies in any other ways than regulatory pricing for the use of other publicly funded networks. If, for example, heavier charges are imposed on road users for covering environmental costs, the rail sector's relative competitiveness can be expected to improve, as evidenced by the Swiss experience. It is reported that the distance-based tax on road hauliers, which will be introduced at the beginning of 2001, has already led to modal shifts of certain commodities (e.g., petroleum and chemicals). In any case, the socio-economically beneficial environmental features of rail transport

are not likely to be measurable in productivity respects unless they prove to be a source of market expansion.

European infrastructure companies have initiated new strategies of outsourcing and tendering track maintenance and construction, with the aim of cutting costs and increasing efficiency. Contracting can have a big apparent impact on labour productivity, if not accounted for in estimation techniques. The impact on total factor productivity will depend on the change in the net cost of producing the tasks internally, or by purchases. In some countries, the limited size of the market for track maintenance and construction, and the pool of potential entrants may be a barrier for outsourcing and increasing competition. These barriers may be overcome in the EU countries by opening the market for entrants from other countries.

Brewer (1996) is reserved towards the contestability of rail markets. Fully contestable markets require, among other things, small sunk costs at entry and a pool of potential entrants. He argues that all entrants should have access to the same vintage technology, and there should be a costless exit from the market. Further, Jensen (1998) argues that a challenger must possess cost-efficient technology, which cannot be immediately copied by the defender operating in the same market. In reality, if no new superior technology is available, this means that the defender has a scale advantage in possessing a mass of the existing production capital, which is difficult to overcome for a newcomer.

3.3 Business and operational strategies

Typical strategic business choices include entering a new market (e.g., courier services), introducing new products (e.g. just-in-time delivery), providing intermodal services or merging with another firm. Operational choices include the negotiation of new labour contracts, performance-based incentives for employees, acquisition versus leasing equipment, project financing and marketing, and pricing.

3.3.1 Labour

Labour is the most explored source of productivity gains. The European railroads, just as any other public organization, have a history of being a means of increasing employment and economic activity. This resulted in considerable excess labour force, which has thereafter been gradually reduced. It is evident that, under such circumstances, labour reductions are likely to yield productivity.

As an example of historical developments, Tretheway et al. (1997) report the annual labour productivity contributions in the range of approximately 5 – 7% in Canadian rail industries in the period 1957 - 1981. These gains have been achieved more through the retrenchment of labour as opposed to systematic increases in workers' performance. Labour productivity can also be measured with very simple indicators, as in Table 1, where the total staff is compared to the train-kilometres produced.

Table 1. Labour use in European rail companies in 1994 (Nash and Shires, 1999).

Train Company	**Train-km/Staff**
Austria	2 170
Belgium	2 355
France	2 747
Germany	2 798
Great Britain	3 511
Italy	2 255
Netherlands	4 435
Portugal	2 449
Spain	3 747
Sweden	4 926
Switzerland	3 516

The authors' search for evidence of improved labour productivity through output-oriented incentives in the rail industry did not produce any results. Nevertheless, Resor and Thompson (1999) highlight the importance of skilled labour and strategic occupations, such as marketing, for producing high-quality services. Evidence from other sectors and the corporate world point to numerous opportunities for improving performance through employee-oriented incentive strategies.

3.3.2 Capital

Capital costs, the infrastructure part in particular, are a dominant and rigid component in the cost structure of railroads. Rail companies have argued for many years that three quarters of their annual costs are fixed, and would not go away even if trains stopped running. This has led to the belief that increasing traffic volumes automatically leads to reduced marginal cost. However, a closer analysis by Resor and Thompson (1999) has shown that, generally, both the fixed and variable costs of maintaining track are about 50% variable with traffic volumes. Furthermore, Resor and Thompson (1999) have shown that there is a threshold level of traffic, beyond which costs start increasing in proportion to traffic due to capacity constraints.

Nevertheless, adjusting track and rolling stock capacity is difficult due to the long lives of facilities and the uncertainty of future use. In particular, under-utilized railroad capacity is a classic problem leading to decisions about abandoning or developing facilities. The network structure also has a significant impact on cost. Double-track routes are relatively cheaper to maintain than single-track capacity. The number of switches, level crossings and sidetracks are also important cost drivers.

Table 2 presents a simple comparison of the utilization intensities of European tracks and mean trainloads. The higher the ratios are, the higher the utilization rate of track. However, this ratio does not yet tell anything of cost/revenue ratios, i.e. how economical the track utilization is, nor how many cars an average train consists of or how much wagonload they carry. Nevertheless, the expectation is that higher utilization rates are more economical and yield more revenue.

Table 2. Track use and mean train load in 1994 (Nash and Shires, 1999).

Train Company	**Train-kms/Track-km**	**Mean train loads (tons)**
Austria	23 424	162
Belgium	26 573	163
France	14 671	224
Germany	21 050	150
Great Britain	24 445	103
Italy	19 514	222
Netherlands	42 725	147
Portugal	12 779	196
Spain	12 189	151
Sweden	10 051	252
Switzerland	40 651	165

According to a traditional view, the means for modernizing and increasing capacity are very rigid. Substantial additional capacity can be gained only by building new track. However, this view is currently challenged by new network intelligence applications based on computerized train control and management systems (US Federal Railway Administration, 1999).

Studies, such as Tretheway et al. (1997), have reported that contributions of improved capital utilization to productivity range from 0.1 to 2.0% per annum. The findings are based on a study of Canadian rail enterprises during the period 1951 to 1981. In the light of such findings, capital is not seen as a major source of performance improvement. However, the US experience of deregulation tells a different story from the abandonment of high-cost, uneconomical trackage. The contribution of downsized track cost to productivity is likely to be significant.

Resor and Thompson (1999) have provided further views on the implications of the quality of capital (referred to in greater detail in Section 4.4) and the common beliefs in the behaviour of fixed cost in relation to traffic volumes. Therefore, once the load of evident excess capacity has been eliminated, capital adjustments should be examined as much according to revenue-yielding strategies as cost-cutting strategies.

Two potential strategies, which the new generation of ICs and OCs may explore once open market entry and autonomy are introduced, are leasing and project financing. Car rental firms lease large parts of their fleets either from third parties or directly from vehicle manufacturers, and even airlines have been experimenting with leasing. Innovative financing strategies for new infrastructure involving public and private partnership are becoming increasingly popular due to increased flexibility of implementation, and reduced risk and cost.

3.3.3 Technology

One main technological change that is often discussed and publicized is the stock of locomotives and wagons. The replaced locomotives have generally used a different source of power or possessed more power as well as various safety features. Changes have also taken place in control equipment (signalling and communications), and most recently, in processing and tracking freight consignments as well as passengers using information systems. The development in maintenance techniques and track materials has considerably contributed to the durability and life span of tracks and thus yielded reductions in replacement and maintenance costs.

According to the US Federal Railway Administration (1999), a recent ITS innovation, the satellite-based train control system, is likely to bring about benefits due to increased network intelligence and information flows. The benefits include, e.g. energy savings, better utilization of track and equipment, reduced yard times and wear and tear, improved scheduling, better employee deployment and improved customer services. The findings are backed up by a study on the nationwide benefits of the Differential Global Positioning System (DGPS) by the US Federal Highway Administration (1998).

3.3.4 Quality of services

The impacts of quality changes on performance have been difficult to isolate because they are not clearly reflected in output prices, although quality change can be attributed to some clear change in the physical appearance of an input or a product or a service. Some quantitative indices have been proposed for capturing the quality of the output

dimension, also extending them to the quality of inputs. Typically it is assumed that the technical quality of the output improves when the quality of inputs improve (Norsworthy and Jang, 1992). However, service quality improvements usually require substantial investments in track capacity, rolling stock and facilities, but often also in service concepts and people to implement them. The impact of the service quality improvements can be observed as increased business and market share.

Morrison and Winston (1999) have assessed the impacts of deregulation on service innovations. They found that railroad and trucking industries have been able to tailor intermodal services to the shippers' production and inventory policies, thus achieving cost savings for their customers. Resor and Thompson (1999) argued on the contrary, suggesting that US railroads have concentrated too heavily on low-cost strategies than on service quality and revenue making. In the US the railroads, Resor and Thompson (1999) claim, have depended too heavily on bulk movement, where costs can be slashed, but profit margins are low.

Harker and Hong (1994) argued that the rail industry needs to reinvest in modern technology and restructure management practices in order to respond to present market demand for speedy, highly reliable and efficient transport services. This, in turn, demands better management of rail track resources, i.e. prioritizing high-value services before low-value services by pricing track time according to service value. This will eventually lead to diversified pricing in both passenger fares and freight rates.

Innovative marketing plans and distinguishable products are strategies whose true potential has not been explored by rail firms. The opportunities for these strategies are more open to OCs than ICs. While OCs are now offering two-class passenger services, further packaging of services, such as door-to-door services as in the case of some freight products are yet to be exploited. The OCs also lack in the intermodal service offerings.

3.3.5 Cost conceptions and profit orientation

Traditional productivity studies have not directly addressed the issues of making revenue or profit, either in absolute or relative terms. However, especially when stakeholder expectations are examined, profit-making strategies deserve attention. Resor and Thompson (1999) examined the implications of harsh cost-cutting policies on revenues, service profiles, and profit making in the US Class I railroads. They found that, following the Staggers Rail Act, the industry has shed thousands of kilometres of unneeded tracks and reduced payrolls by tens of thousands of employees. Moreover,

investment in infrastructure has shrunk, but the return on existing infrastructure has increased to competitive levels in 1996 and 1997.

The above authors also have noted that a total of USD 18 billion in annual cost reductions was achieved by the US Class I railroads between 1966 and 1995. The largest gains were achieved in track maintenance methods and materials, reduced train crew sizes and increased use of "unit trains". Despite the impressive cost savings, the industry's revenues have also fallen sharply due to price deregulation, mostly since 1983. The fall in rates has been nearly as rapid as in costs. In 1997, the railroad industry was as profitable as in 1966, but half as large in the size of operated network. Table 3 adopted from Resor and Thompson (1999) to show some key figures indicating the change from 1980 to 1997. Comparing total revenue ton-kilometres and revenue gained per ton-kilometre, railroads are nowadays carrying more goods, but relatively being paid less for it.

Table 3. Comparison of Class I Railroad Statistics, 1980–1997, prices adjusted for inflation. (Association of American Railroads, adopted by Resor and Thompson, 1999)

Category	**1980**	**1997**	**Change %**
Gross Revenues (USD 1 000)	28 254 436	32 322 291	+ 15.7
Net Railway Operating Income (USD 1 000)	1 337 266	2 857 691	+ 113.7
Return on Investment	4.25 %	8.3 %	
Employees	458 994	177 971	- 61.2
Revenue Ton-km (USD 1 000)	1 469 794	2 169 560	+ 46.8
Rev. Ton-km. Per Employee Hour	1 381	4 744	+ 243.6
Kilometres of Track Owned	447 237	276 102	-38.3
Revenue per Ton-km (cents)	1.792	1.470	-18.0
Net Ton-km. Per Train Hour	64 730	102 424	+ 58.5

According to Resor and Thompson (1999), the railroad industry has adjusted to minimizing costs and the assets required to produce the services by changing service mix, principally de-emphasizing carload freight, and moving to "unit train" operations, carrying bulk. This has left the industry with a wholesale business where prices are steadily falling. Evidently, too great an emphasis on cost cutting and too little emphasis on profit making has made the industry shy away from offering competitive high-quality services that can reap higher profit margins.

In summary, Resor and Thompson (1999) listed the principal shortcomings of the freight business strategies of the US Class I railways. They underscore the need for a new perspective on cost and quality of service in developing strategies for obtaining new business and increasing profit margins:

a) persistent belief in the too high a cost of handling carload freight, despite the revenue per ton may be higher in some commodities

b) persistent belief in greater traffic volumes always yielding declines in unit cost

c) persistent belief in the wholesale trainload role of the sector

d) elimination of sales forces

e) unwillingness to compete for new business, other than bulk movement

f) neglect of necessary investments, resulting as inadequate yard and line capacity and service breakdowns.

4. Potential improvement strategies

4.1 Archetypal strategies

The underlying premise of performance improvement is formulating a set of strategies, which will collectively and/or individually lead to the improved performance of a company. Although the 'implementability' and/or the impact of most strategies is relatively unknown, previous empirical studies have shed light on some of them. Based on these findings, the strategies with the seemingly greatest potential are grouped into three categories as defined in Table 4.

The aim here is not to provide an exhaustive pool of strategies But rather to permit a systematic procedure for screening and analyzing the impact of some empirically validated strategies with due regard to efficiency improvements and satisfying stakeholders. It is acknowledged that, despite the restructured hierarchies, not all decisions can be made in isolation, but collectively with reference to the stakeholders. There is evident overlap among the strategies in the categories, and many of the strategies are meaningful at several levels of decision-making.

Table 4. Empirically Validated Strategies.

Policy Strategies (public jurisdiction)	**Business Strategies** (company jurisdiction)	**Operational Strategies** (company jurisdiction)
o Managerial Autonomy o Deregulation o Size of Network o Subsidies o Infrastructure Pricing o Technical Standards o Interoperability	o Pricing of Services o Operation Area o Service Mix o Technology o Mergers	o Quality Of Service o Labour Cost o Capital Cost

It is assumed that the change in efficiency and stakeholder satisfaction can be measured in most cases in the short term with a set of partial indicators. Otherwise, the effectiveness of the strategies cannot be validated. However, not all the impacts of the proposed strategies can be immediately monitored with a cross-sectional indicator, but indirectly by using global indicators over a longer period. Eventually, one way or the other, all the impacts will be reflected in total factor productivity. The same global indicators may be applicable for evaluating the impact of a multitude of unconventional strategies. However, they may have to be studied further before any conclusions could

be drawn. The main emphasis is now on developing a set of indicators for monitoring short-term changes in performance expected to arise from the proposed strategies.

4.2 Policy strategies

Public policies lead directly or indirectly to performance changes by affecting important attributes of performance such as volume and quality of infrastructure (US Federal Highway Administration, 1999). Policy strategies aimed at changing institutional structures, competition among transport modes, taxation, trade regulations, technical standards, technology, and research and development are such examples. Some policies change the market environment once and for all, while others have a more sustained impact. Table 5 summarizes the most important policy issues that are likely to have an impact on the performance of the rail sector.

Allowing managerial autonomy is a significant strategy for improving the performance of rail companies. It means freedom to adapt to changes in the operational environment and markets. Autonomy also provides flexibility over the size of the network as well as the links and nodes to be maintained and developed for operating commercially viable services. It allows unprofitable and under-used parts of the network to be eliminated. Moreover, the freedom for introducing commercially oriented services and fare structures can lead to higher demand and thereby boost revenues. Once managerial autonomy is granted, the state's or the regulator's authority is limited to subsidy and infrastructure-pricing policies.

Table 5. Impacts of policy strategies.

Issue	Infrastructure company		Operating company	
	Impact	*Measurement*	*Impact*	*Measurement*
Managerial autonomy	Independent decisions on markets, pricing, investments and cutting cost	Cost indicator Revenue indicator Price indicator Quality indicator Capacity indicator	Independent decisions on markets, pricing, investments and cutting cost	Cost indicator Revenue indicator Price indicator Quality indicator Capacity indicator
Infrastructure charging	Independent source of revenue for infrastructure company	Revenue indicator	A price on the use of infrastructure	Cost indicator
Deregulation of prices	Changes in revenue Change in demand for infrastructure services	Revenue indicator Utilization indicator	Changes in cost due to payment for full cost of infrastructure use Change in the fares and demand of transport services	Cost indicator Price indicator Revenue indicator
Promoting new technology	Adoption of new technology	Quality indicator Price indicator	Adoption of new technology	Quality indicator Price indicator
Competition, open access and interoperability	Change in the number of customers Infrastructure charges change	Capacity indicator Revenue indicator	New entries and competition	Price indicator Revenue indicator Quality indicator
Change in Subsidy Levels	Change in revenue	Quality indicator Cost indicator Price indicator	Change in revenue	Quality indicator Cost indicator Price indicator
Network size	Investments and maintenance costs change	Capacity indicator Cost indicator Revenue indicator Quality indicator	Capacity constraints change	Capacity indicator Cost indicator Revenue indicator Quality indicator

Ideally, deregulation allows companies to price their products without public intervention. It also imposes pressure on the companies to lower costs in order to remain competitive. The infrastructure company will levy infrastructure charges on the operators according to the costs induced by the use of tracks. This creates a basis for making cost/revenue comparisons. The operating companies will be able to better define

their service requirements in exchange for the charges paid. Decisions on the use of track capacity will also be made on a stronger commercial basis. Although prices would be deregulated and subsidies reduced (or abolished), it is unlikely that it would lead to a net change in user prices in the short term. Changing the traditionally manipulated cost/price structures and creating fully competitive markets are not necessarily easy.

Open access is expected to bring more actors into the market and increase competition. This can be expected to bring consumer prices down and lead to specialized service suppliers. Interoperability will increase the benefits of open access in continental Europe. Mergers may lead to stronger enterprises operating in several countries.

Subsidies are considered harmful for the competitiveness of an industry. At the same time, subsidies are also a means of financing socially needed services or influencing the overall function of the transport system in a socially desirable manner. In general, the dependency on subsidies should be eliminated where possible or their use optimized. Subsidies should be used with 'smart' incentive structures for promoting social objectives efficiently, at the lowest possible cost, and not for sustaining inefficiencies. Public transport services are often tendered to the highest price bidder (lowest consumption of subsidies) or subsidized to generate demand, enhance mobility, or create social equity. Subsidies should be monitored against the benefits that are generated by them.

Network size depends on the need to maintain socially or strategically important links, required quality, and on the available budget. These needs should be examined in relation to costs and benefits. Public service obligation should be should be compared to the cost of meeting the needs using alternative, more economical means.

4.3 Business and operational strategies

The freedom to make strategic business and operational decisions depends on the level of autonomy granted to the companies. Under the current administrative structures, it can be reasonable assumed that ICs and the OCs can adopt certain business strategies with the aim of strengthening the competitive position of a company. Such strategies can be divided into:

- Cost strategies (cost cutting, investments)
- Pricing strategies (diversified pricing of services)
- Revenue/profit strategies (market segments)
- Quality strategies (service quality, socio-economic quality)
- Capacity strategies (utilization rates, market segments, social objectives)

There is a strong correlation between profit levels and the types of markets companies choose to serve. Profit levels can be improved by cost cutting, higher prices or market abandonment. Past and current railway pricing seems to be based heavily on average cost, with little emphasis on service-specific revenue/profit margins. Therefore, more information and strategies aimed at reducing marginal costs and improving marginal receipts can be expected to improve performance.

According to economic theory, charges and fares should vary according to demand and the scarcity of the product. Therefore, diversified pricing is an effective mechanism for managing capacity, generating revenue and broadening the market. It is also a way of influencing user behaviour so that demand can be controlled and costly supply peaks smoothened. The services are supplied according to the willingness of the markets to pay.

Revenue strategies aim at expanding the service mix into high-value services, both in passenger and freight movement. Improving service quality usually involves investments in capital, equipment, and skills. However, these allocations are justified when customer satisfaction is improved and new business is attracted. The outcomes can be monitored using revenue indicators in different service classes, and quality indicators based on service features considered important by customers. Improving service quality also involves partnering with other modes to supply seamless transport.

The environmental characteristics of rail transport have turned into a favourable strategic means of competition. The stronger the future emphasis is on marginal cost pricing, the stronger will be the competitive position of rail transport with regard to externalities. This should be monitored, e.g. by the environmental cost of transporting people or goods per distance unit compared to competing modes. If the true cost of transport is assigned to the user, in environmental respects, a price advantage in favour of the railways should emerge.

4.4 Impact evaluation and monitoring

It is assumed that the policy strategies described in Section 4.3 have been implemented and the companies are free to focus on business and operational strategies. The impacts of those strategies can be evaluated and monitored using several key indicators. In the present case, five such indicators are proposed:

- Cost indicators (monetary; user: company, regulator)
- Revenue/profit indicators (monetary; user: company, shareholder)
- Fare/Charge indicators (monetary; user: customer, regulator)

- Quality indicators (physical; user: customer, society)
- Capacity indicators (physical; company, regulator, society)

The set of indicators includes both physical and monetary measures that capture the impact in relation to the expectation of the different stakeholders. They will complement the traditional physical performance figures. It is emphasized that it is important to focus on indicators of profitable and competitive service provision.

The cost indicators here are intended to capture the costs of providing infrastructure or transport services, and indicate the level of utilization of assets. Emphasis is placed on distinguishing between variable and fixed costs, and assigning the cost of labour and capital to different parts of the network and for different service classes accordingly.

Fare/charge indicators monitor the impact of cost changes on customers, and regulators use them to evaluate price increases. If efficiency is improving, the infrastructure charges and fares of services should not be rising at a rate higher than the rate of inflation.

Revenue and profit data and indicators should be constructed for the same categories that are used for producing the cost indicators. This allows comparison of the cost-revenue relationships of maintaining certain parts of the network or operating certain services. These relationships, in turn, provide management with information on the aspects of networks and services that can be changed to improve financial performance.

Quality indicators monitor how the infrastructure and transport services satisfy the expectations of customers and society. Quality should also have a link to revenue generation and profit making. Capacity indicators monitor the physical efficiency of the rail system, since for the time being, decisions on investments and the size of the network require public authorization. Accordingly, society is interested in capacity indicators for formulating transport policies according to socio-economic objectives.

The outcomes of strategies are not reflected in a single indicator category, and it is likely that several strategies for performance improvement are pursued simultaneously. Therefore, changes are likely to be reflected in several indicator categories. It is also acknowledged by the authors that data may not be available for producing information on all the suggested indicators. However, it is emphasized, that these strategies are imperative for improving rail performance, and accounting systems must be developed accordingly.

Table 6 presents the indicators suggested for monitoring for performance strategies adopted by the infrastructure company. The main aim is to increase the transparency of cost differences, cost recovery ratios and the service quality of different parts of the

network and in different service classes of the track. This should allow better decisions on network size, relieving bottlenecks, adjusting cost, varying user fees, increasing cost recovery and investing in new facilities for better quality. However, under the recent proposals on marginal cost pricing of infrastructure use, it is unclear whether the infrastructure companies will be entitled to full cost recovery pricing. Under such a regime, the infrastructure companies are not likely to gain financial independence.

Table 6. Indicators for monitoring performance of the infrastructure company.

Strategy	**Indicator**	**Aim**
Cost	• Fixed and variable cost of supplying infrastructure services on different parts of the network in track service quality categories	Acknowledge the differences in infrastructure costs
Revenue/ cost recovery	• Revenue from infrastructure charges on different parts of the network	Acknowledge cost recovery ratios.
Capacity	• Potential/statistical train frequency ratio on different parts of the network • Maximum movement dimensions (speed, weight, height, width) • Maximum/statistical movement ratio on different parts of the network	Monitor for bottlenecks and investment needs.
Price	• Infrastructure charge index	Monitor for changes in infrastructure charges.
Quality	• Volume of track by service class • Track quality index • Planned traffic restrictions • Unplanned traffic restrictions and service faults • Investment for the environment and quantified gains • Investment for improving safety and quantified gains	Monitor for service quality and socio-economic impacts.

Table 7 presents the indicators suggested for monitoring for performance of the operating company. The main aim is, again, to acknowledge the heterogeneity of different services, and to increase the transparency of cost differences, revenue/profit margins and competitive advantages of the rail sector, and to formulate business strategies accordingly. The apparent physical differences in market characteristics should play a lesser role in performance evaluation, and the role of cost cutting, quality improvement and revenue-making strategies should increase.

Table 7. Indicators for monitoring performance of the operating company.

Strategy	**Indicator**	**Aim**
Cost	• Average cost of producing a ton-km or loaded wagon-km • Average cost of producing a passenger-km or passenger car-km • Cost of producing a ton-km or loaded wagon-km for different commodities on different parts of the network • Cost of producing a passenger-km or passenger car-km in different service classes, peak/low peak hours • Cost of producing a ton-km or loaded wagon-km per employee-hour in different commodity classes • Cost of producing a passenger-km or passenger car-km per employee-hour in different service classes	Acknowledge the variability of producing heterogeneous services. Reveal cost differences in peak and low peak service supply.
Revenue/ profitability	• Average revenue/profit per ton-km or loaded wagon-km • Average revenue/profit per passenger-km or passenger car-km • Revenue/profit per ton-km or loaded wagon-km from different commodities on different parts of the network • Revenue/profit per passenger-km or passenger car-km in different service classes, peak/low peak hours • Revenue/profit from a supplied ton-km or loaded wagon-km per employee-hour in different commodity classes • Revenue/profit from a passenger-km or passenger car-km per employee hour in different service classes • Cost/revenue ratios for different services • Return on investment	Acknowledge the difference in revenues and profit margins in different services on different parts of the network. Decisions on cutting costs, altering pricing and markets strategies.
Capacity	• Passenger car occupancy ratio • Freight car occupancy ratio • Locomotive service ratio	Monitor for capacity utilization.
Price	• User cost index • Subsidy ratio in the cost of producing passenger services	Monitor changes in price.
Quality	• Deviation from timetables/deliveries (monetary value) • Passenger/freight movement time on indicator links for all passenger services and high value freight • Availability of integrated connecting services • Availability of passenger services • Customer satisfaction rates based on surveys • Accidents; personal injuries according to severity, freight train accidents involving dangerous goods • Noise impact above standards, monetary value of impacts • Total emissions and emission rates per unit of movement for main emission types, monetary value of emissions	Monitor for service quality and social costs

5. Measuring the productivity impacts of performance strategies

5.1 Background

The need for temporal performance evaluation in the transport industry has led to the development of a large number of ad hoc performance measures, ratios and parameters. However, as suggested by Benjamin and Obeng (1990), the myriad of indicators has led to some confusion. Results from different data and indicator estimation techniques seem inconsistent. Some techniques require data that are difficult to obtain, while indicators produced using some techniques are unsuitable for policy formulation.

Reviews such as Diewert (1992) and Oum et al. (1992 and 1999) have explained the pros and cons of the statistical theories and assumptions underlying the indicators, as well as the results reported over the past decades. Most past researchers and industry specialists have attempted to examine and explain long-term trends in costs, market share, as well as arguments for and against regulation.

The techniques can be classified into three broad groups:

- Productivity (Aggregate Measures; Long Term)
- Efficiency and Effectiveness (Partial Measures; Short and Medium Term)
- Benchmarking (Best Practice Measures; Short Term)

Total factor productivity (TFP) is the classical indicator used to describe the change in the total cost of production in relation to the output produced, usually over a period of about a decade. TFP indicates the total change in output due to changes in major categories of inputs and their costs, as well as their respective contribution (Norsworthy and Jang, 1992). TFP serves decision-makers seeking strategies to influence the competitiveness of certain industries or even national economies.

In contrast, partial indicators are used for decision-making in the short run. They are also used in annual reports and by the media to provide a synopsis of a company's performance. Partial indicators can be divided into indicators of efficiency and effectiveness (Hensher and Daniels, 1995). Efficiency is the manner in which physical inputs of labour, energy, and maintenance materials, capital or overheads are used to produce physical services defined by, for example, either vehicle or seat-kilometres. Effectiveness has two essential components: (i) cost effectiveness - the relationship between inputs and consumed services, and (ii) service effectiveness - the relationship between produced services and consumed services.

Benchmarking can be defined as the pursuit by organizations of enhanced performance by learning from the successful practices of others (Francis et al. 1999). The mainstay of benchmarking is understanding how other organizations are able to achieve a certain level of performance, and then incorporating those ideas into one's own organization. Although treated as a separate complementary approach, benchmarking depends on partial factors of production as the basis for comparisons and strategy formulation.

5.2 Measurement of aggregate productivity changes

The majority of productivity studies in the transportation industry has used comprehensive indicators such as TFP. There are various studies, including a detailed exercise by Diewert (1992), on decomposing TFP to understand the impact of strategies, which have led to economies of scale, or shifts in production or cost functions. According to Diewert (1992), the conceptual approaches to estimating TFP fall into either non-parametric index measures or parametric statistical measures.

5.2.1 Non-parametric (index) measures (IM)

IMs are rather simple to compute using time series analyses of either the physical quantities and/or the prices of different inputs and outputs. If monetary units of measurement are used, they are inflated to a base year value for eliminating the impact of inflation in nominal prices.

Typical IMs include:

1) The ratio of the growth rate of index quantities of output and input
2) The ratio of deflated revenues and deflated cost expenditure
3) The ratio of direct output quantity and inflated expenditure index.
4) The ratio of deflated revenues and direct input quantity index
5) The ratio of output-input price
6) Change in technical coefficients

Although IMs are not generally very sensitive to the quality of primary data, they are sensitive to price inflators and output quantity indices. That, in turn, affects cross-study comparisons. The index measures of physical and monetary units are also not directly comparable. Another reason for incomparability is the degree of aggregation of the outputs.

5.2.2 Parametric statistical measures (PSM)

PSM are considered more sophisticated as they are based on the statistically validated cost or production functions of a company or an industry. PSM reflect the shifts in those functions due to technological changes, which the IMs do not. Therefore, a functional relationship with a specific form must be established between the set of inputs used and the output produced, and the parameters must be statistically estimated.

In the three most common PSMs, performance is measured in relation to the:

1) Upward shift in the production function with the costs (inputs) fixed
2) Downward shift in the cost function with the outputs fixed
3) Cost elasticity of output expressed as an output index and a cost function.

In the first two measures, either the input or output is fixed only for practical reasons and for making examinations simpler. In reality, all parameters change simultaneously. The third measure developed by Caves et al. (1980) is perhaps the most cited and applied PSM technique.

In general, IMs and PSMs do not produce the same results. IMs describe the change in performance without distinguishing among the contributing factors. Positive changes implied by IMs may merely originate from the exploitation economies of scale, which are not 'true' changes in the relative ratios of outputs and inputs. The PSMs differ in theory because, unless constant economies of scale exist, the shifts in cost and production functions are not identical.

5.3 Partial productivity measures (PPM)

Partial measures indicate the impact of a single input factor on production, such as the number of operations per hour. They are easy to compute and understand, and are ideal for processes that produce one output using one input. Despite the preference for aggregate measures among economists, PPMs are being increasingly used for day-to-day management and ex post (past performance) monitoring. Carefully defined PPMs permit an easy comparison of performance among different units of the same organization or between firms with similar operating environments. As noted earlier and described below, PPMs can be divided into efficiency measures and effectiveness measures.

5.3.1 Effectiveness indicators

Effectiveness usually measures the amount of an end-product delivered to and consumed by customers. It is a measure of demand as well as of supply. Typical effectiveness indicators include demand side measures such as passengers, passenger-miles, fare miles, load factor, or user benefits. Their purpose is to reveal the level of consumption in relation to supply. All US Class I railroads and the two major Canadian railroads periodically report four indicators (total cars on line, average train speed, average terminal dwell time, bill of lading timeliness), which reflect how well traffic moves through a railroad's system (Railroad Performance Measures, 1999). From the point of view of overall performance, relevant questions to be answered are, for example, is the company operating the optimal number of cars on particular lines, or what impact would lower average terminal dwell time have on output?

5.3.2 Efficiency indicators

Efficiency is a measure of the relationship between outputs and inputs usually expressed as a ratio of costs or revenues. Managers often use efficiency indicators such as cost per labour-hour and quantity of output per unit cost. In the transportation industry, efficiency is often indicated by supply side measures such as side cost per vehicle-mile, cost per seat-mile or cost per vehicle-hour (US Department of Transportation, 1999).

Commonly referred to as operating efficiencies, such indicators can reflect output in relation to the major types of inputs used or the cost of the output in relation to the quantity of each input. The US Department of Transportation (1999) suggests that operating efficiencies be measured in terms of the change in operating costs per vehicle service hour (or mile), change in passengers per vehicle service hour (or mile), and change in passenger miles per vehicle service hour (or mile).

It is also possible to measure some sub-categories of operating efficiencies with either dollars or physical units. For example, labour could be measured in person-hours instead of dollars. If the definition of operating efficiency involves more than one kind of resource input, however, monetary units become the only practical measure.

5.4 Benchmarking

Benchmarking serves a number of purposes such as (Glanz & Dailey, 1993):

- It enables a company to calibrate how it is delivering its products.
- It enables a company to learn from others
- It can be used to create a need for change in the current practices

Benchmarking systematically compares performance indicators of an organization for efficiency, effectiveness, or outcome of a similar process or product against the indicators of other internal or external organizations (Karlof and Ostblom, 1993).

At this point, however, one should carefully study the relevance, the applicability, and the comparability of the performance measures used. For example, if a transport operator is producing X seat-kilometres per year, what does it tell us if there is no data from other transport operators, or no indicators of the actual use of the service, etc.? Maybe the use of the service could be compared with the use of another transport mode in the same area, or with other operators of the same mode, nationally or internationally.

Benchmarking measures can be divided into qualitative and quantitative measures. Quantitative benchmarks focus on empirical measures, and qualitative benchmarks on perceptual and observation data to compare different competencies or practices.

5.5 Strengths and weaknesses of measurement techniques

5.5.1 Total measures

Following Caves et al. (1980), almost every researcher examining railway enterprise performance has used some form of TFP technique. They include non-parametric methods of TFP indices, Data Envelopment Analysis (DEA), or econometric estimates of production and cost functions. However, TFP has remained the preferred methodology for several reasons. As Benjamin and Obeng (1990) have summarized, TFP offers the advantage of examining productivity of all inputs simultaneously. Consequently, total productivity can be analyzed in response to changes in one input factor while keeping the shares and quantities of other inputs fixed. This enables decision makers to test the sensitivity of productivity to an input factor that could be influenced through changes in policies and management practices.

TFP also lends itself to be used in productivity comparisons in an organization over time and between organizations. Dodgson (1985) noted that TFP indices have been used to reach policy conclusions, particularly with regard to the relative efficiency of private versus public ownership.

Windle and Dresner (1992) have outlined some of the major problems with TFP. One of them is the serious difficulty that arises from distinguishing between the inputs and outputs of an enterprise. They found that in the airline industry, capital input was the hardest to measure correctly because of the difference between book values and economic values. Likewise, the multitude of labour categories makes aggregation into one input difficult, if not impossible. Another problem lies with the identification of an appropriate output measure, whether vehicle-kilometres, passenger-kilometres, passenger-trips or some other output should be used to describe productivity.

Closer examination reveals different theoretical concepts constituting TFP, as well as methods of computing TFP. The principal differences arise when defining the form and the input variables of cost functions, and some of the underlying assumptions. Researchers have often assumed a flexible form, which may not truly reflect the characteristics of the output, and which cause costs to vary temporally or spatially. Moreover, it is necessary to assume linear homogeneity of input prices, and symmetricity of partial elasticities of substitution. It is also important to formulate the cost function according to either total or variable cost. If firms, for some reason, are not able to optimize fully their choice of input levels, variable cost functions should be estimated. This would evidently apply to regulated industries.

5.5.2 Partial measures

Martland (1992) argues that service quality and financial performance indicators are of greater value than productivity measures to managers at all levels of an organization. Such partial measures as cost, revenue, and reliability per unit of output are easy to compile and understand. They provide the information needed for day-to-day operations, and for examining a particular aspect of the operation in detail. Compared to TFP, data requirements and assumptions for partial factor analysis are less extensive.

Unfortunately, partial measures cannot explain output development adequately, and are inadequate for indicating the true performance of a firm or industry. They are delimiting in the sense that they do not account for the substitution effects of one input for another, or the fact that an increase in one input can enhance the productivity of another input. Although the measures are computed as units of time or capital services, they do not technically represent individually or partially the contributions of labour, capital or any

other specific factor of production. Rather, they reflect the joint effect of many influences, including changes in technology, shifts in labour force composition, capital investment, level of output, and changes in the utilization of capacity.

5.5.3 Benchmarking

One of the drawbacks of benchmarking is, that if benchmarking it is used only to learn and copy what others have done and not to improve upon their performances, then benchmarking may become a vicious circle. Companies may spend their time learning from each other, without seeking innovations and developing new practices by themselves (Glanz & Dailey, 1993).

5.6 Technique of choice

The preceding sections have confirmed our hypotheses that the changing role of railways requires more flexible and goal-oriented indicators to monitor performance as well as for strategic decision-making. Moreover, empirical studies from both sides of the Atlantic seem to point in the same direction. That is:

- The precision of productivity/efficiency estimates is not always very high
- The number and diversity of outputs and inputs, as well as the level of aggregation, varies both in theory and practice
- Data problems include unavailability, errors in interpretation and measurement and the need to use proxies as default data
- Productivity is best measured as a long-term trend fluctuation
- Computational methods using panel data sets have improved the quality of index measures (Divisia-Torngvist, Caves-Christensen-Diewert or the DEA)
- Index measures (simple ratios) do not distinguish between sources of productivity, unless controlled for separately
- Cost function approach can account for the effects of all variables beyond managerial control, therefore it is recommended for measuring efficiency, rather than non-parametric index number approaches
- The translog variable cost function allows the estimation of a firm’s deviation from the efficient production frontier, as well as the various sources of productivity growth.

Diewert (1992), after an extensive study of different measurement techniques, found that traditional production and cost function techniques lead to conflicting conclusions. Therefore, the technique must naturally be chosen largely according to the availability and quality of data, and the underlying assumptions. In the present case, it was decided to use a mixture of simple physical and monetary ratios as indicators. The use of simple ratios is also justified by the small size of the available data samples (due to the short histories of most new-generation rail enterprises). Of course, if the quality of input price data is better than the quality of the measured physical quantities, and given that cost minimization is the goal, cost ratios are more appropriate. In their absence, the physical ratios provide sufficient information to the various stakeholders.

The crux of the framework suggested in the present case is the evaluation component. The performance of the enterprise can be evaluated by simply comparing one or more of the suggested indicators over two time-periods. Moreover, the indicators can be compared to an established target (goal) or to a similar indicator of another firm (benchmarking). The change in the current values of indicators in relation to previous or target values will be the level of improvement or decline in performance.

6. Conclusions and recommendations

6.1 Principal findings of earlier studies

Industry experts, policy-makers, and academicians alike have examined railway companies from many different angles. Most examinations in the 1970s, e.g. Griliches (1972) and Keeler (1974), concentrated on developing single measures of productivity using input and output prices as explanatory variables. In the 1980s, when railway deregulation in North America was gathering momentum, the pioneering work of Caves et al. (1980, 1981, and 1987) contributed to overcoming certain theoretical deficiencies of the classical production function interpretations, but also essentially examined productivity changes following deregulation. As Nash and Shires (1999) have noted, the 80s' work cannot definitively indicate that productivity growth was entirely due to de-regulation, and no other contributing factors prevailed.

In the 1990s, the emphasis changed to benchmarking type approaches of performance evaluation. Oum and Yu (1994) used DEA to rank European railway companies in relation to a theoretical efficiency level. Subsequently, the ranks were examined in relation to variables reflecting the operating environment. According to Oum and Yu (1994), nine of the 19 firms examined were operating at greater than 75% efficiency in 1989. Using an alternative econometric model based on cost functions, Preston (1996) showed that operating density can be significantly increased by low-density networks, as indicated by the cost differences among different nations.

Despite the inconclusive and sometimes contradictory nature of the multitude of research findings over nearly three decades, in general they all point to the same set of strategies as the cornerstones of performance improvement. The two principal strategies can be broadly termed:

1. Deregulation
2. Extension of managerial autonomy

At the same time, it has been shown (e.g. Caves et al. 1987; Wilson, 1997) that performance gains that follow deregulation are by no means sustainable over long periods. The reasons are the limitations on the amount of labour and capital adjustments that can be made without severely impacting service quality. However, management autonomy creates much broader opportunities. Although there is no clear-cut evidence of the impacts of strategies on the performance of autonomous rail companies, there is evidence of the existence of economies of scope (network size) and advantages of scale (operating density). Therefore, as the impacts of deregulation unfold and the resultant

ICs and OCs become established, new strategies to enhance performance must be designed and tested.

6.2 Primary conclusions

Despite the lack of consistent, statistical evidence revealing the capacity to improve the performance of any particular strategy, there is strong support in favour of managerial autonomy. In deed, managerial autonomy can take many forms, and the extent of the impact of granting autonomy will depend on the permitted degree of freedom as well as the managers. It must be borne in mind that rail companies operate under physical and market constraints, which cannot be overcome entirely through managerial autonomy or, for that matter, any other strategy. In other words, massive increases in demand and revenues, and cost reductions should not be expected from innovative policy, strategic, and operational strategies. Of course, this is not to suggest that the opportunities to improve the current performance of railway companies through the commercialization of products must be overlooked. Every effort must be made to improve performance to the maximum level possible. The targets, however, must be realistic and embrace the technical, financial, and political constraints, as well as market characteristics.

We identified a set of strategies tested and advocated by previous researchers, which hold significant promise for improving performance of ICs and OCs. Additionally, we compiled an intuitively appealing set of exploratory strategies based on our own experiences. Those two sets were bundled into separate categories:

- Cost-Cutting
- Revenue Increasing
- Demand Creating
- Quality/Capacity Improvement.

It must be noted once more that we recognize the definite overlap among the categories and even among the strategies in a given bundle. Nevertheless, the aim here is to present the strategies in relation to their potential impact and select appropriate indicators describing the impacts on different stakeholders. The separation is expected to provide a basis for scanning the strategy options and comparing the alternatives prior to implementation, and subsequently monitoring the success or failure.

The impact of each category of strategies, the incidence groups (impacted stakeholders), and the quantitative indicators of the impact are given in Tables 6 and 7. With reliable data and careful analyses, the indicators should ideally provide a basis for evaluating the

spatial and temporal impacts of a set of strategies. The numbers will have to be interpreted by the decision-makers in relation to their goals.

6.3 Suggestions for further studies

The principal contribution of this study is a framework for systematically screening strategies that can potentially enhance the performance of ICs and OCs and for evaluating and monitoring improvements. While the entire process has been structured to permit decision-makers to design and test strategies specifically aimed at meeting a goal or an expectation, it is not scientifically tested and proven. Therefore, several follow-up studies may be needed to validate and fine-tune the process to mould it into a more formal framework. Among the studies that would be useful are:

- ✓ Survey the perceptions of the existing level of managerial autonomy and explore the most important constraints of autonomous decisions.

- ✓ Survey of European OCs and ICs to determine the potential and challenges pertaining to the exploratory strategies. This will include interviews with European rail company representatives.

- ✓ Analyses of strategies implemented since the restructuring in order to establish their impacts. Of particular interest would be marketing and pricing, as well as cost-cutting strategies related to maintenance, labour and capital resources.

- ✓ Identification of appropriate benchmarks for monitoring and evaluating performance. The benchmarking efforts so far have focused on traditional measures without normalizing the indicators to account for the differences in operating environments. Therefore, further research is needed to determine an appropriate procedure for standardizing performance indicators prior to benchmarking.

- ✓ Establishment of data needs for performance evaluation and monitoring. The types of data collected and the databases maintained by railway companies are evidently neither appropriate nor sufficiently detailed to permit the extraction of valuable management information. A study that can identify the types of data and formats of databases would be of value to rail companies in the long run.

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Title

Performance improvement strategies for railway enterprises

Abstract

This report addresses the performance measurement of railway enterprises from two perspectives. First, the on-going separation process of European railway companies into infrastructure companies and operating companies allows a clearer identification of stakeholders and their expectations, according to which performance targets should consequently be set. Second, based on an extensive review of empirical research on railway productivity, a set of performance strategies likely to be meaningful in the future of European railway enterprises has been formulated.

In the past, European railway enterprises have aimed at satisfying public perceptions, policy makers and community goals. In addition, performance measurement in scientific literature has concentrated more on describing the differences in market geography, rather than pure economic efficiency. Due to the now granted managerial autonomy and exposure to competition, railway companies are formulating their business and operational strategies according to commercial lines. Therefore, there is a need for setting goals and selecting indicators for monitoring the success of these strategies. There exists a timely opportunity to adopt strategies for significantly improving railway performance. Such strategies can be formulated, e.g., based on the experiences gained from deregulation in North America.

The North American railway companies were granted more pricing freedom and the freedom to choose their markets, which they serve by government deregulation acts in both the US and Canada in the 1970s and 1980s. Such managerial autonomy resulted in abandoning unprofitable lines, mergers and exposure to competition, which resulted in significant decreases in the costs of production and prices of services. However, the impacts of deregulation are not indefinite. Other cost, pricing and market strategies are required for sustaining competitiveness.

According to the authors of this report, the performance strategies of European railway enterprises should focus more on revealing the differences in relative cost and revenue ratios of different parts of the network and on the different types of services provided. Furthermore, diversified pricing, marketing and quality-of-service strategies should be developed for capturing higher value segments in the transport markets. A set of indicators for highlighting the importance of cost, revenue and profit orientation and quality of service are proposed. Suitable long-term productivity measurement techniques are also discussed.

Keywords
railways, railway companies, performance evaluation, improvements, productivity, indicators, infrastructure, deregulation, logistic operations, administration, management analysis

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Nimeke

Tuottavuuden parantamisstrategioita rautatieyhtiöille

Tiivistelmä

Raportissa lähestytään rautatieyhtiöiden tehokkuuden mittaamista kahdesta eri näkökulmasta. Ensinnäkin käynnissä oleva rakennemuutos, jossa liikennöinti ja radanpito erotetaan toisistaan, sallii keskeisten sidosryhmien ja niiden odotusten tunnistamisen entistä selkeämmin. Liikennöinnin ja radanpidon tehokkuutta ja tuottavuutta koskevat tavoitteet tulee asettaa näiden odotusten mukaan. Toiseksi rautatieteollisuudelle on määritelty tuottavuusstrategioita kirjallisuusanalyysin pohjalta.

Käynnissä olevaan rakennemuutokseen saakka eurooppalaiset rautatieyhtiöt ovat tähdänneet erilaisten julkisen mielipiteen ja politiikantekijöiden odotusten pohjalta määriteltyjen tavoitteiden täyttämiseen. Lisäksi tieteellinen kirjallisuus on keskittynyt lähinnä markkina-alueiden maantieteellisten erojen kuvaamiseen taloudellisen tehokkuus-tarkastelun sijasta. Lisääntyneen itsenäisyyden ja kilpailun vuoksi rautatieyhtiöt määrittelevät liiketoiminnalliset strategiansa vahvemmin kaupalliselta pohjalta. On siis tarve asettaa tavoitteita ja määritellä mittaamismenetelmiä (indikaattoreita) näiden strategioiden mukaisesti.

1970- ja 1980-luvuilla Pohjois-Amerikassa rautatieyhtiöiden sallittiin hinnoitella tuotteensa täysin itsenäisesti sekä valita markkina-alueensa huomattavasti vapaammin. Kannattamattomia palveluja lopetettiin, kilpailu koveni ja rautatieyhtiöitä yhdistettiin isommiksi yksiköiksi. Tämän tuloksena sekä tuotantokustannukset että palvelujen hinnat alenivat. Vaikutukset kestivät vain jonkin aikaa ja todettiin tarvittavan muita kustannus-, hinnoittelu- ja markkinastrategioita suotuisan tuottavuuskehityksen ylläpitämiseksi.

Tämän raportin mukaan eurooppalaisten radanpitäjien ja liikennöitsijöiden tulisi keskittyä enemmän kustannustason ja tulovirtojen läpinäkyvään tarkasteluun eri verkon osissa, eri tuoteryhmissä ja eri palveluluokissa. Lisäksi hinnoittelu-, markkinointi- ja laatustrategioita olisi käytettävä hyväksi haettaessa paremmin tuottavia markkina-segmenttejä arvokkaampia palveluja tarjoten. Ehdotettujen strategioiden pohjalta raportissa esitetään joukko indikaattoreita, joilla voidaan tarkastella suhteellisia kustannus-, tuotto- ja laatueroja sekä tarkastellaan pitkän aikavälin tuottavuuden mittaamismenetelmiä.

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