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Railways Regulation in Countries of the Former USSR: Reforms, Efficiency Estimation and Governance Choice

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Railways Reform in the Countries of the Former USSR: an Extended Introduction

Nadezda Negovelova

Abstract

Railways restructuring in the countries of the former USSR has practically never been studied before. Meanwhile most of these countries are implementing the same reforms as their western neighbours put in force some years earlier. In this paper, we analyse railway reform trends in these countries and discover a huge diversity of approaches and states of progress. Besides, we make an extended review of literature on railways reforms which covers empirical and institutional papers, theoretical descriptive analyses and, in particular, the reform of Russian railways. Finally, the present study gives the background necessary to learn the situation in the region in question and to understand better the two papers which follow.

1. Introduction

The latter changes in the railway infrastructure and regulation on the former Soviet territory were caused more by the break of the USSR rather than by regulatory trends in Western Europe. There was a need to reorganize former regional departments of the unified Soviet railway, i.e. to decide on their organizational structures: whether it will be a unitary public enterprise, a public body, a corporation or some other form. Only later on, for countries – candidates to the EU (Baltic states), the need to adjust the rules of their operations to the European ones emerged.

The structure of industry and purposes of restructuring are very different in these countries, especially in Russia and Asian countries, from those of Western European railways. First, there is no tough competition between railroad and road carriers, while the desire for an increase of railroad's share in transportation markets is one of the most important goals of the reform in Europe. Second, in contrast to European railroads, Russian railroads and those of some of the countries in question are profitable. Third, freight operations are much more important than passenger operations in the countries – members of the former USSR (in Europe the share of

passenger operations is about 50%) and the average distance of haul is much larger than in Europe (Guriev et al. (2003)).

The study covers the following countries:

- Russia;
- Eastern European countries: Ukraine, Belarus, Moldova;
- Baltic countries: Latvia, Lithuania, Estonia;
- Caucasus: Georgia, Armenia, Azerbaijan;
- Asian countries: Kazakhstan, Uzbekistan, Tajikistan, Turkmenistan, Kirgizstan.

The main objective of this paper is to describe the situation in the railway sector of former USSR members, put in evidence some trends common to all or some of the new railways and analyze particular reform cases. The purpose of the paper is to give a broad picture of the progress in railway reforms in the countries which were recently unified by a common railway system – with common management, planning and strategy. Besides, I will present an extended review of literature on railways reform as well, although there is very little research on former Soviet railways. While there are several papers on Eastern European railways reforms and some studies of Russian railways reform (e.g. OECD (2001)), they all, first, don't give a general picture of the situation on the territory of the former USSR; and second, they don't take into consideration the railways of Caucasian or Asian parts of the former country. That is, the actual study is motivated by the need to look at the region as a whole, to discover the main trends, or, probably, to observe a diversity of reform patterns. Another goal of the paper is to provide an extended introduction to the two papers which follow (on governance choice and efficiency estimation of Eastern European and former Soviet railways). The present paper is the first integral study of railway reform in the countries of the former USSR.

The paper is organized as follows. In the second chapter, a review of literature on railway reforms is presented. It covers empirical papers on European railway reforms, as well as some rare studies of railway reforms in transition economies. The third part describes common characteristics of the railways in questions such as share of railways in total country's transportations, transit position and so on. The fourth part is dedicated to reform approaches. The fifth part contains come case studies – the reform

experience of Russia, Ukraine, Kazakhstan, Armenia and Estonia. The sixth part concludes.

2. Review of literature

Studies of the impact of rail restructuring can be roughly divided into two broad groups: formal econometric studies and case studies – policy reviews. The latter group includes numerous country-based case studies of reform experience and is not considered in the present paper. We make an overview of empirical works on railways which took into consideration railway reforms in Europe – from efficiency estimation prospective, mentioning, however, some rare works using the institutional approach (these two approaches are used in the two papers which follow). We also consider some non-empirical studies on railway reforms.

A general analysis of railway reform and an overview of European and American experience can be found in the book of Gomez-Ibanez and de Rus (2006). They distinguish different types of reform measures – vertical separation, privatization and deregulation. However, they don't cover railway reforms in transition economies and developing countries in Europe. The authors state that the econometric evidence doesn't prove completely the statement that the separation of infrastructure from operations increases railways performance. Nash and Rivera-Trujillo (2004) also find opposite opinions about the separation of infrastructure from operations: while some authors believe that the separation of infrastructure brings advantages in efficiency, transparency, neutrality and competition, others affirm that the separation of railway infrastructure and operations have been a fundamental mistake. Overall, they say, it seems that there have been benefits from the introduction of competition into rail markets but separation of infrastructure from operations has been more problematic.

As railways reforms in Europe started in the middle of 1980s, economists began to estimate their results empirically in the beginning of 1990s. Most of them use panel data. The first important paper evaluating the reform impact was the work of Gathon and Perelman (1992). Estimating factor requirement frontier using panel data on 19 European railways over a period of 28 years and paying a particular attention to managerial autonomy, they discovered autonomy to be positively correlated with technical efficiency.

Another early paper to analyze railway reforms in Europe was the one of Oum and Yu (1994). They estimated managerial autonomy as well (applying non-parametric DEA, then Tobit regression, to a panel of 19 railways over 12 years), but added one more aspect: implications of public subsidies. The main finding of the study is that increased competition via regulatory liberalization and deregulation has improved efficiency, which is in line with the reforms that began in the middle of the 1980s and were aimed at the separation of railway operations from infrastructure and the improvement of competition and performance in the sector. This result was discovered earlier for Canadian Railways (Caves and Christensen (1980)) and proven in other succeeding papers. Gathon and Pestieau (1995) and Cantos, Pastor and Serrano (1999) show, on the samples of European railways, that autonomy increases efficiency. However, both papers attribute the increase in efficiency mostly to technical change rather than reforms. Cantos and Maudos (2001) discover that a greater financial and managerial autonomy leads to higher levels of efficiency, while a higher level of subsidies would imply a lower efficiency. However, they state that, although regulation improved productivity, financial accounts got worsened due to a strong regulatory policy which leads to non-market behavior of the railway management due to the absence of competitive pressure.

Gathon and Pestieau (1995) aimed to decompose technical inefficiency into two main parts: management inefficiency and the regulatory environment. The effects of institutional factors on the efficiency of railway companies is obtained by including an institutional autonomy index. They conclude that a railway company with a low autonomy index may increase the level of efficiency by increasing the level of managerial autonomy and reducing the level of regulation.

Costs complementarity of different railways activities (passenger and freight transportations, infrastructure management) in the framework of vertical separation is analyzed by Cantos (2001). He uses a panel of 12 railway companies over a period of 18 years emphasizing the problem of vertical integration or separation. He discovers that costs of passenger and freight operations were independent, while costs of freight operations and infrastructure management are complementary. He concludes that railway costs complementarity should be taken into consideration when taking a decision about the organizational form (vertical separation or integration). Cost complementarities were discover as well for U.S. railways (Ivaldi and McCullough (2001, 2004), Bitzan (2003)). Taking costs complementarities into

account, Preston (1996) found that the optimal size for a vertically integrated railway was that of one of the medium sized European companies such as Norway or Belgium. It appeared that splitting the larger companies into several separate companies might be worthwhile; however, this result was based entirely on vertically integrated companies, so the implications for separate infrastructure and operating companies of such splits are unclear.

Economies of scope in European railways are analyzed by Growitsch and Wetzel (2006, 2007). They apply the DEA method to a multi-input and multi-output input distance function and discover that integrated companies are relatively more efficient than vertically separated.

The sequence of reform measures (third-party access, independent regulation and the separation of infrastructure from operations) was studied by Friebel, Ivaldi and Vibes (2004). They estimate a Cobb-Douglas production frontier model on the sample of 11 European railways over the period of 21 years. They state that deregulation increases efficiency, but this effect depends on the reform sequence. The results did not show any evidence that full separation of infrastructure from operations is a necessary condition for increasing railroad efficiency. It was also found that smaller railways improved efficiency more than larger ones.

The transaction costs economics literature on railway stays apart. While the methodology of empirical estimation of governance choices is quite developed, there are very few empirical works applying transaction costs economics to railways. Some references to Coase and Williamson approach can be found in Pittman (1991, 2007), but he doesn't provide any empirical prove of his statements.

Menard and Yvrande-Billon (2005) apply transaction costs economics approach to the British rail reform and they find that transaction costs have an impact on the organizational choice. The most significant results are found for assets specificity. Yvrande-Billon (2000) finds arguments in favor of vertical integration in the case of British railways. She reveals the problems of opportunistic behavior and, again, assets specificity. In Yvrande-Billon (2003), she states that British rail reformers didn't take into consideration transaction costs. She analyses the length of contracts and discovers that, taking into account assets specificity, the length of contracts is not optimal in sense that it doesn't minimize transaction costs.

Rail freight contracting was also analyzed by Palay (1984). He confirms the statement that asset specificity bring the parties to a more sophisticated institutional structure unique to the transaction.

A broad review of literature on the reform of network industries in developing and transition economies can be found in Estache, Perelman and Trujillo (2005). Their study covers mostly Latin-American and Sub-Saharian railways, though some of the papers reviewed include other railways worldwide. They didn't mention any considerable works on Eastern European or Soviet railways. They make an overview of studies of reforms and their implications to performance, taking into account different measures of performance – because efficiency concerns were included in the design of regulation. Technically, the papers reviewed are not very different from those on developed countries in terms of methodology.

Estache, Perelman and Trujillo (2005) discover some common features of papers on railway reforms in transition economies. First, most of these papers, like those on Western European railways too, deal with two main characteristics of the railways sector: multi-output production and natural monopoly. A second interesting characteristic of this literature is that because cost minimization assumptions tend to be difficult to measure due to lack of data, most performance studies deal exclusively with physical output (freight ton-km or train-km and passenger-km) and input (employment, length of tracks (electrified or not), rolling stock and energy consumption) quantities and most are interested in production efficiency measurement only.

Those of the reviewed papers which concern Africa reveal a strong impact of political disturbances on performance. Estache, Perelman and Trujillo underline the impact of such disturbances on the railway performance of the national companies of Congo-Brazzaville (CFCO), Democratic Republic of Congo (SNCC) and Kenya (KRC). The authors of these papers point out the dramatic increase in competition from the trucking industry resulting from improved road network coverage and the poor intermodal and inter-network coordination in Africa.

The literature on railways in transition economies also offers useful insights on the impact of reforms and in particular privatization of railways services. For example, the railways of Malawi and Cameroun managed to stay in a good position close to the efficiency frontier. But the improved performance of these railways is due to strong reductions in inputs (staff

and rolling stock) rather than improvements in outputs (passenger or tons kilometer). The main problems highlighted are: organizational and management issues, maintenance problems caused by the age of equipment (rolling stock and tracks).

For two special cases, Brazil and Argentina, where vertical separation didn't take place, in both freight and passenger transportation sectors, Estache, Perelman and Trujillo mention high rates of productivity growth after the reform, 5,3% in freight and 9,8% in passengers transportations on average. And, as in the case of Brazil's privatization, this increase is mainly concentrated on the output side. Moreover, as a result of the reform in Brazil, private operators have improved performance in terms of both quantity and quality.

There is a shortage of comprehensive specialized literature evaluating the economic impact of railway reforms in the member countries of the former USSR – from theoretical, empirical or institutional point of view. Russian railways reforms and those of Eastern European countries entering the EU (or candidates) are analyzed in some but rare studies, while railways of the former Soviet republics like those of Middle Asia or Caucasus are left aside. There is no clear study which would estimate the efficiency trends of Eastern European railways and discover any relationship between regulation (especially the transfer from the planning system to market) and efficiency.

Diaconu et al. (2007) study the reform experience of Eastern European countries – candidates to the EU. The future EU membership was an incentive to implement the reform; moreover, these countries have reformed their railways structures along lines "more catholic than the Pope": full vertical separation rather than simply third-party access. However, although the reform has been implemented successfully, the private participation is still very low in practically all these countries (see Table 3).

The theoretical analysis of Russian railways reform is provided by Dementiev (2005, 2006). He develops a model of access price and tariff setting and illustrates how this model works when applying to Russian railways. He also explains why there was a need to reform Russian railways and which regulatory measures, among those suggested by regulation theory, were imposed.

One exiting detailed reform study is made in the book of Guryev (2008) "Iz tupika. Istoria odnoy reformy" (translation: "From the dead end. One reform story"). The author analyses the history of railway reform in Russia after the break of the USSR citing important persons of that period – public officers and top managers of emerging transport companies. He investigates a difficult transition to market oriented economy with which the railway reform had to be in line, while the old soviet planned mentality prevailed in minds of "reformers"; he demonstrates the development of railway legislation starting from the very early nineties.

Given the importance of railway transport in Russia, it is not surprising that railway top managers and public officers involved in regulation of the Russian railways take some attempts to develop "a railway science". The current president of RZD (since 2005) Vladimir Yakunin wrote a book called "Politologia transporta. Politicheskoe izmerenie transportnogo razvitia" (translation: "Political science of transport. Political dimension of transport development" // Moscow, 2006, 244 pages). He was convinced about the crucial role the transport plays in a country's economy, but also in its political development; he affirmed that the transport system represents an instrument of the realization of a country's geopolitical interests; especially it concerns the railway transport in Russia. The idea is that in order a country can benefit from its geopolitical position, a rational strategically oriented transport system planning is needed. Yakunin even pretended to found a scientific field, a branch of political science dedicated to the role of transport.

A considerable contribution to the analysis of Russian railways reform has been done by Pittman (Antitrust Division, US Department of Justice). He wonders whether vertical separation implemented in Western Europe is really the best reform option. He demonstrates that Russian railways are different from the European ones (reasons and goals of the reform, types of transportations, distances, institutional environment, legislative requirements, economic situation) and suggests them a model of horizontal separation taking the US or Latin American railways as an example. He states that the European wide experience didn't reveal any considerable increase of performance of separated railways in comparison to integrated; instead, some studies which he cites reveal economies of scale and scope, i.e. arguments in support of vertical integration.

The US railway model (competition between vertically integrated railway companies) and its advantages were also emphasized by Nash and Rivera-Trujillo (2004). In contrast to Western European countries, Northern American railways are oriented to the freight market rather than to the passenger one and different reasons can be given for this particular difference, partially because of long distances. For instance, in the cases of Canada and the United States, passenger airplane transportations are more convenient than railway transportations. Moreover, within a deregulated environment with high technological progress and significant competition, the air industry has been able to offer lower fares and lower travel time in comparison to rail transport. Therefore, railway passenger operations in the American continent have not been competitive. As a result, the air industry in the USA and Canada has been clearly dominant against the railways, taking the second place in the interurban transport passenger market.

Nash and Rivera-Trujillo (2004) state that in the case where there is a vertically integrated firm in each region (as in South America), there is a possibility to introduce competition, by introducing private sector participation by giving a concession which includes the infrastructure and the operations of a well-defined region for a certain period of time (as in Latin America). They state that there is competition for the market – competition for getting a concession. However, this kind of competition is very limited due to considerable sunk costs involved in each region, making necessary a significant investment. In fact, in some cases, the concessions are given for 30 or even 50 years practically eliminating the competition for the market.

Table 1 contains a summary of some important studies of railways regulation and reform in which we are interested in the context of the present paper: reform overviews, empirical works, institutional papers, studies of Russian railways reform.

Table 1: Some important studies of railways reforms worldwide

	Paper / book	Approach and/or methodology	Geographical coverage	Conclusions
Reviews of reform experience and existing empirical works	Estache, Perelman and Trujillo Infrastructure Performance and Reform in Developing and Transition Economies: Evidence from a Survey of Productivity Measures 2005	Overview of empirical papers on reforms and regulation in network industries, including railways, in developing and transition economies	Sub-Saharan Africa, East Asia, Eastern Europe, Latin America, Middle East and South Asia	In transport, private operators have tended to perform better than public operators in developing countries. There is a very strong case to push regulators in developing and transition economies toward a more systematic reliance on yardstick competition in a sector in which residual monopoly powers tend to be common.
	Gomez-Ibanez and de Rus Competition in the Railway Industry: An International Comparative Analysis 2006	Descriptive theoretical overview of the reforms in application to some railways worldwide	Great Britain, France, Spain, the USA, Latin America	The experience to date favours the introduction of competition with vertical integration rather than through vertical unbundling; competition while maintaining vertical integration has been very successful in improving railway performance.
	Diaconu, Pittman, Sip, Tomova, Wronka Competition in Freight Railways: "Above-the-rail" Operators in Central Europe and Russia 2007	Overview of the reform experience in some railways of Central and Eastern Europe and Russia	Bulgaria, Czech Republic, Slovak Republic, Hungary, Poland, Romania, Russia	EU membership is an incentive for more liberal reforms. New market entrants (independent operators), although their share is rather low, manage to catch some market segments. "Russia will always be Russia" in the sense of central control.

Empirical studies on European railways	Gathon and Perelman Measuring Technical Efficiency in European Railways: A Panel Data Approach 1992	Empirical study, panel data Factor requirement frontier estimation of technical efficiency	19 European railways 1961-1988	Institutional managerial autonomy is positively correlated with technical efficiency.
	Oum and Yu Economic Efficiency of Railways and Implications for Public Policy: A Comparative Study of the OECD Countries' Railways 1994	Empirical study, panel data DEA estimation of productive efficiency and Tobit regression as the second step	19 railways in OECD countries 1978-1989	Regulatory liberalization and deregulation has improved competition in the railway sector and, as a result, railways efficiency.
	Gathon and Pestieau Decomposing Efficiency into its Managerial and its Regulatory Components: The Case of European railways 1995	Empirical study, panel data DOLS, two-stage approach	19 European railways 1961-1988	A railway company with a low autonomy index may increase the level of efficiency by increasing the level of managerial autonomy and reducing the level of regulation.
	Cantos, Pastor and Serrano Productivity, efficiency and technical change in the European railways: A non-parametric approach 1999	Empirical study, panel data Malmquist productivity index, DEA Estimation of productivity by breaking down its growth into changes in efficiency and technical change	17 European railways 1970-1995	Most increases in productivity have occurred thanks to improvements in technology and not due to more efficient behaviour of railway companies. The degree of autonomy and professionalism in management is a key element in explaining companies' levels of efficiency.
	Friebel, Ivaldi and Vibes Railway (De)Regulation: A European Efficiency Comparison 2004	Empirical paper, panel data LISREL Production efficiency frontier	11 European railways 1980-2000	Deregulation increases efficiency, but this effect depends on the reform sequence. Full separation is not a necessary condition for improving the efficiency.

	Growitsch and Wetzel Testing for Economies of Scope in European Railways: An Efficiency Analysis 2007	Empirical study, panel data DEA super-efficiency bootstrapping model Construction of a set of virtually integrated firms	54 European railways 2000-2004	Integrated railway companies are relatively more efficient than ”virtually” integrated companies (i.e. separated) and the majority of railway companies indicate economies of scope.
Empirical studies on North-American railways	Ivaldi and McCullough Subadditivity Tests for Network Separation with an Application to U.S. Railroads 2004	Empirical study, panel data Generalized McFadden cost function, Baumol's test of costs subadditivity and operational separation test	22 U.S. railways 1978-2001	Vertical and horizontal economies of scope are discovered.
	Caves and Christensen The Relative Efficiency of Public and Private Firms in a Competitive Environment: the Case of Canadian Railroads 1980	Empirical study Total factor productivity index	2 Canadian railways 1956, 1963, 1974	No evidence of relatively higher performance of private railways (vs. publicly owned) is found. Competition has a positive impact on performance.
Institutional approach	Pittman Specific Investments, Contracts, and Opportunism: The Evolution of Railroad Sidetrack Agreements 1991	Institutional approach	U.S. freight rail contracts between carriers and shippers	In the presence of sunk, relationship-specific investments, the form of the contractual relationship between the parties makes a difference in terms of future behavior; the problem of hold-up (opportunistic behaviour) is crucial in contracting between shippers and rail forwarders.
	Pittman Make or buy on the Russian railway? Coase, Williamson, and Tsar Nicholas II 2007	Institutional approach; regulation of network industries	Russia	When taking transaction costs into account, horizontal separation may be preferred. Transactions costs analysis may support the preservation of vertical integration to create competition where that is feasible.

	Menard and Yvrande-Billon Institutional Constraints and Organizational Changes: The Case of the British Rail Reform 2005	Institutional approach, transaction costs economics	Rail contracts in Great Britain accompanying the creation of the train operating companies	Transaction costs influence the organizational choice. If the degree of specificity of assets has a direct impact on the choice of a governance structure, the choice of an organizational arrangement reciprocally influences the nature and characteristics of investments made.
Russian railways	Guriev, Pittman, Shevyakhova Competition vs. regulation: a proposal for railroad restructuring in Russia in 2006-2010 2003	Regulation of network industries on the example of Russian railways	Russia, the UK, Sweden, Mexico, the USA, Canada	The paper contains some proposal of Russian railways restructuring preserving a vertically integrated structure.
	Guryev Iz tupika. Istoria odnoy reformy 2008	Overview of the Russian railways reform	Russia	The reform (introduction of competition, separation of business activities from administrative functions) is slowed because of the resistance of old-mentality public officers.
	Dementiev Reforming Russian Railways. Introduction of Competition and New Regulatory Challenges 2005	Overview of the Russian railways reform and a simple theoretical model of competition	Russia	Russian railways are implementing the most "regulatory intensive" reform pattern, i.e. introduction of competition with railway incumbent present both in infrastructure services and operations. Russian railways faced "oil-induced internal competition" stimulated by the limited capacity of pipelines and high price of crude oil.

3. Common characteristics

This chapter contains an overview of some characteristics which are common to all railways in the countries – members of the former USSR. It is important to understand, from one side, their similarities and from the other side, the diversity of the reforms they implemented.

First, given very high volumes of raw materials transported (especially coal and oil) and relatively long distances, the crucial role of railways in the countries of the former USSR is not surprising. A high share of railways in total transportations (especially freight transportations) is a common characteristic of these railways. In Russia, the share of freight railway transportations in total freight transportations is 40-45% (in tkm), more than 50% in Ukraine, 87% in Belarus. This share is relatively low in countries isolated from international transport corridors: in Armenia this share is about 30% (RZD-Partner).

For comparison, in Western European countries (not USSR members), the share of railway transport is less than 10% both in freight and passenger transportations (Nash and Rivera-Trujillo (2004)).

Second, the countries whose railways make part of an international transport corridor have a higher share of railways due to their transit position. This means that the share of transit in total transportations of these railways is relatively high. In Ukraine, for example, in 2007, the share of transit was about 14% of total freight railway transportations. It gave 50% of total Ukrainian budget incomes. It is constantly growing (mainly railway transit to ports), but for the moment, the infrastructure is not sufficient. In Georgia, again, due to its transit sea-side position, the share of transit is even higher: 65% of total freight transportations. In Estonia, another maritime country, before recent political conflicts with Russia, railway transit accounted for 75% total freight railway transportation, but considerably decreased in 2007. Lithuanian ports are smaller and the share of railway transit is lower: about 35% (RZD-Partner). The railways of Middle Asia, realizing their geographic position, are still planning to increase their transit transportations. Turkmenistan is working on the construction of the railway which will connect Russia, Kazakhstan, Turkmenistan and Iran and open (to Turkmenistan) access to Middle-Asian and South-European ports. Tajikistan is working on the railway project from Afghanistan to China via Kirgizstan and Tajikistan.

Third, the freights transported by railways are mainly raw materials and natural resources: oil, coal and metals, although Russian railways and the railways of countries with access to the sea are diversifying freight patterns and, in particular, increasing container transportations.

As a general rule, the rail mode has a competitive advantage over road transport in carrying large quantities of goods which have a low value per unit weight – so-called "bulk" goods: grain, coal, oil, minerals and chemicals. For almost all other freight services, rail faces strong competition from the road mode. In countries which are substantial producers of bulk commodities such as Russia (as well as China and the US), the rail mode tends to have a substantially higher share of the overall freight transport market (OECD (2005)).

In Russia, coal accounts for about 20% of total freight transportations, oil for 15%. In Estonia, before political conflicts with Russia, oil transportations accounted for more than 60% of total Estonian railway freight transportations (oil transit was bringing about 6% of Estonian budget incomes), but they have to find ways of freight diversification because Russia intends to transfer all the oil transportations to Russian ports by 2015 (until 2008, about 80% of Russian exports of oil and oil products were passing by Baltic ports), which will hurt Baltic railways very much. In Latvia, the share of oil transportations is 50% (RZD-Partner).

The fourth common characteristic of the railways of the former USSR is the obsolescence of rolling stock. In Russia, 75-85% of fleet units are used after their expiry term. In 2007, the average age of freight wagons was 21,4 years old. In Ukraine, the share of obsolete rolling stock is 60-90% (RZD-Partner).

Fifth, the railways of the former USSR member countries still constitute a unique economic space, especially those of the CIS. These countries work on eliminating custom and other bureaucratic barriers to movements of freights and passengers.

Russia, Belarus and Kazakhstan are creating the Custom Union which was expected to start operating in 2008-2010. Ukrainian and Russian railways have signed some agreements on the mutual help and elimination of competition between 2 enterprises. This concerns the purchases of rails and other materials, as well as rolling stock. Ukrainian railways, together with Russian and Kazakh railways, have a common tariff system as well.

They have some agreements of the common use of rolling stock, for optimization purposes. Armenia is also working on facilitation of custom regulations with Russia.

The CIS has the Council of railways transport whose main goal is the coordination of common operation, elaboration of principles, organization of common use of rolling stock.

4. Reform

Many countries, especially developed ones, have attempted to improve the performance of their railways since 1980 by introducing or strengthening competitive or market forces. Three distinct methods have been used: vertical unbundling, privatization and deregulation. The main difference between these approaches is that unbundling requires important government involvement in the industry while deregulation and privatization reduce it considerably. If the intense competition that the railways face makes vertical unbundling less attractive, it also increases the appeal of privatization and deregulation (Gomez-Ibanez and de Rus (2006)).

In Western Europe, the general reform trend is to separate the monopolistic segment from the competitive ones. As noted by Laffont (in Pittman (2007)), vertical separation is taken to be the mainstream restructuring form of industrial structure, by default. The EU reform strategy thus is based on three pillars: a) unbundling infrastructure from operations, b) creating independent regulatory institutions for railways, and c) opening access to national railway markets for competitors ("third party access"). There is a firm belief among many policy-makers, on both EU and national levels, that these reforms ought to increase efficiency (Pittman (2007)).

Table 2 contains a comparison of reform measures in Europe and North and South America. Eastern European countries tend to implement the same reform measures as their Western neighbors.

Table 2: Western European railways vs. North and South American railways

	Western Europe	North and South America (USA, Canada, Mexico, Brazil, Argentina, Chile)
Organisation	Separation of infrastructure from operations (at least for accountancy purposes)	Regional separated (private companies and concessions of vertical integrated companies)
Market focus	Passenger oriented	Freight oriented
Ownership	Mainly public with a few exceptions (e.g. UK)	Private and concessions
Distances	Short	Long, Medium

Source: Nash and Rivera-Trujillo (2004)

The principal early reformers among Central and Eastern European countries – Hungary, Poland, the Czech and Slovak Republics, then Bulgaria and Romania – have adopted economic restructuring plans designed to convince the EU of the seriousness of their liberal reform strategies and hence their suitability as EU candidates. In these countries the vertically integrated state-owned incumbent monopoly railway has been separated into independent companies, including the infrastructure company, the freight train operator, and the passenger train operator. In addition, most of the governments have set up regulatory bodies, with varying degrees of formal independence. The market power of the incumbent operator is also controlled and regulated by competition authorities.

As a result of the reforms, in Romania, the share of private train operating companies is reached 20-25% on a ton-km basis (many of these companies either large shippers integrating upstream or former freight forwarders), more than 15% in Poland. In Czech and Slovak Republics there are few private train operating companies capturing small market shares, in Bulgaria and Hungary (and Russia) the share of such companies is even smaller (Diaconu et al. (2007)).

Tables 3 and 4 contain evaluations of private sector participation in railways. Estache, Perelman and Trujillo (2005) calculate the percentage of countries where private sector is presented, in a total of countries in the corresponding region. Diaconu et al. (2007) don't explain the methodology

of their calculations, subjectively evaluating the share of private operators in a total of freight turnover.

Table 3: How present is the private sector in railways? Share of countries in total number of countries (2004)

Developed countries	65%
Developing countries	37%
Sub-Saharan Africa	47%
East Asia	43%
Eastern Europe	20%
Latin America	56%
Middle East	20%
South Africa	17%

Source: Estache, Perelman, Trujillo (2005)

Table 4: Estimated share of private train operating companies in total rail freight

Country	Percentage of total tkm
Bulgaria	0
Hungary	0
Russia	Near 0
Slovak Republic	Less than 5%
Czech Republic	Less than 5%
Poland	15%
Romania	25%

Source: Diaconu et al. (2007)

If we now look at the reform / regulation patters of the countries – members of the former USSR, we can observe a considerable diversity of reforms implemented as well as the level of their progress. We can schematically derive 5 types of the reform measures:

- The absence or initial stage of the reform, the railway is still operating as a public administration;
- The railway is operated by a public company – a unitary state enterprise (not a joint stock company);

- The railway is commercialized (corporatized), the sale of some non-profile business or daughter companies is going on or expected;
- The railway was privatized;
- The railway is operating under concession;
- Horizontal separation of railways.

Almost in all the cases, the access to track is open for independent operators (although, in most cases, they emerge exclusively for transportation needs of some large, mainly resource-based, corporations and not for commercial operating purposes); this measure doesn't correspond exclusively to some reform models. The same is true about independent regulator: formally, railway activity is regulated by several bodies like ministries of transport, antitrust agencies and other. Actually, they are not always "independent": the decisions are still imposed by political forces and sometimes can not be justified economically.

Among economists and policy makers there is no consensus about the best reform model. Gomez-Ibanez and de Rus (2006) state that "the evidence is arguably slightly stronger for integration than for unbundling, but the jury is still out". Pittman also have serious doubts about the necessity of vertical separation, but suggest another solution: competition between vertically integrated companies (see below).

This last case, horizontal separation of railways, stays apart. It was implemented neither in the EU nor on non-EU post-soviet railways, but actively suggested by Pittman affirming that successful American (Latin American and North American) experience can suit well Russian railway realities. The European vertical separation experience, instead, didn't reveal any clear proofs that efficiency has been increased after separation (Guriev et al. (2003)).

In this section, a brief description of reform models is presented. More details can be found in case studies (section 5).

4.1. Public administration

Gomez-Ibanez and de Rus (2006) mention that the transformation of public bodies departments into commercial entities increases their productivity. In Western Europe, this process of transformation took place

much earlier and was practically completed by the beginning of the reform (separation of operations from infrastructure, open access, implementation of an independent regulatory body etc) in the late 1980s. The process is going well also in the countries of Eastern Europe: most of them operate as corporations. Newly created railway entities after the break of Yugoslavia were organized in the form of commercial enterprises. In the majority of countries of the former USSR, instead, it was not the case.

After the break of the USSR, each of new countries created its own railway administration. The first were Lithuanian, Latvian and Estonian railways in 1991 which were transformed from public administration into public enterprises in 1992. They were followed by Ukraine which created the State administration of railway transport which existed at least until the end of 2008. Middle-Asian railway were divided into separate railway administrations later, some of them were transformed into state-owned companies, some remained public administrations (Tajikistan; Azerbaijan in the Caucasus). Some were transformed in public enterprises rather late (e.g. Kirgizstan in 2005).

The largest among the former Soviet railways, the Russian railways company RZD, was created only in 2003. Before, it had been operating as a Ministry of railway transport (MPS).

4.2. Unitary public company

This is one of the two most common forms implemented in the countries – members of the former USSR. In this case, the railway is managed as a commercial entity, but represents a unitary undividable body 100% owned by the State. The railways which have adopted this model are those of Belarus, Moldova, since recently the railway of Azerbaijan, Turkmenistan, Tajikistan; probably, the Ukrainian railways will be transformed into such a unitary public company.

This form allows, from one side, to comply with reform trends (commercialization of railway public authorities), and from the other side, to protect the railway from the dissipation of shares, i.e. to protect the state from the lost of control over this strategically important capital.

This form doesn't exclude the open access for independent operators, like in Belarus and Azerbaijan.

4.3. Corporation

This is another form which is very common when implementing the railway reform. This is also the most frequently used model in European railways – Western European as well as Eastern European ones. It often assumes vertical separation. This approach, in the case of Western Europe, assumes further accounting separation of railway infrastructure from operations, probable privatization of some businesses, and open access of independent operators to the infrastructure.

Full vertical separation has the potential to enhance the resulting level of competition because it eliminates the incentive of the infrastructure owner to restrict access to certain operators. On the other hand, such vertical separation may increase the costs of production (through the loss of economies of scope) and also lead to underinvestment in infrastructure.

Many countries have accompanied mandated access to the track infrastructure with various forms of separation of the infrastructure from train operations. For most Western European countries, this takes the form of accounting separation or corporate separation. EU Directives require at least accounting separation between infrastructure and train services and the complete separation of certain key regulatory tasks (such as train path allocation) from an existing railway undertaking. Only a few countries (including the UK and Sweden) have prevented the infrastructure provider from providing all train services (OECD (2005)).

The first case of vertical separation was given by the Swedish railways, when in 1988 the infrastructure management was separated from the traffic operations (Nash and Rivera-Trujillo (2004)).

Corporatization took place in Russia, Kazakhstan, Latvia, Lithuania, Georgia and Uzbekistan. The railways are working on separation of operations and non-profile businesses in daughter companies which are usually 100% owned by the mother company. Non-profile businesses, however, will be probably sold (partially or completely) on the stock market or are listed there even now.

4.4. Privatization

Gomez-Ibanez and de Rus (2006) provide pros and contras of the privatization. Without privatization, the train-on-train competition is very slow to emerge in Europe or Australia and is unnecessary given the intense competition from other modes. Vertical separation, in the absence of privatization, complicates the coordination of train operations and infrastructure maintenance. Proponents of unbundling insist that private railways performe reasonably well outside of Britain. Privatization has sometimes proven difficult in developing countries where private railway operators and governments have become embroiled in disputes over tariffs and conditions of services (Gomez-Ibanez and de Rus (2006)).

The British experience of privatization is the best known in Europe. The original intention was to privatize the train operating companies but to leave the infrastructure company, called Railtrack, in public hands at least for 'the medium term'. In 1994, Railtrack was established as an internal division of British Rail and in 1995 it became a separate government-owned company. The idea was to establish a track authority or company to own infrastructure with separate private companies operating the train services (Gomez-Ibanez and de Rus (2006)). The main problem turned to be the underinvestment in infrastructure. Following a serious accident caused by poor infrastructure maintenance, the private infrastructure company, Railtrack, was placed in the hands of receivers and a new non-profit company, Network Rail, took its place (Nash and Rivera-Trujillo (2004)).

As there is a lack of privatization experience in Europe, few empirical works can be found studying performance of private vs. public railways, but those which exist put in evidence a positive impact of privatization on railways performance. Cowie (1999) analyzed Swiss railways and found that private railways had a significantly higher level of technical, managerial and organizational efficiency. Politt and Smith (2002) found that a privatized structure of British railways lead to significant improvements in operating efficiency, and industry outputs have risen after privatization.

Among the railways of the former USSR, only one was privatized: the Estonian railway. It was privatized in 2001: 66% of the share capital of Eesti Raudtee AS were sold to an external investor, Baltic Rail Services (BRS), in August 2001. This was the first privatization of a vertically integrated national railway in Europe. The proportion of private sector participation in the Estonian railway industry was not only the highest in

the region, but arguably the highest in Europe as a whole, even including the UK. In 2006, the Estonian railway was deprivatized. Further details are presented in the next part of the paper.

The privatization of Georgian railways is also under discussion, but there are still no formal projects.

4.5. Concession

A textbook concession example is the Latin American concession experience. The move to private provision of railway services was motivated by fiscal goals (governments were in economic difficulties), as well as by the desire to stop the decline of railways. Most railways were offered as a concession or lease of limited duration (usually 30 years for freight with 10-20 years possible extensions, passenger concessions were shorter), with the infrastructure reverting to the state at the end. Under concessions, the railways remained vertically integrated: the new concessionaires were responsible for both infrastructure and train operation in their service (or geographical) areas. The grants of access were typically selective so that the concessionaire had exclusive rights to most of his system. In Latin America, the reforms appear to have significantly improved railway performance (Gomez-Ibanez and de Rus (2006)).

Concession management is a rare case among the former Soviet railways. The only railway operating under concession is the Armenian railway. It is managed by a 100% daughter company of the Russian Railways company created especially for this purpose. The concession period covers 30 years with the possibility of extension.

The Armenian case is presented in details below.

Another railway considering the possibility of concession is the Georgian railway company. It operates in the form of Limited responsibility company. The reform would implement accounting separation, open access and even privatization of some parts of business. The concession plans assumed the management period of 89 years, the main concessionaire candidate was the British company Parkfield Investment. Finally the plans failed, and Georgian railway authorities are still considering other reform approaches.

4.6. Horizontal separation of railways

This reform model was applied in Central and South America – and especially in the largest countries, including Brazil, Mexico and Argentina. It has left in place vertically integrated companies – typically private concessionaires – that control both infrastructure and operations. In maintaining vertically integrated companies, these countries have followed the examples of the United States and Canada, both of which have systems of vertically integrated railway companies that compete with each other to carry cargoes. The main difference between US model and Latin American model is that in the first case, railways compete parallel, while in Latin America they have some regional monopoly power, it is "geographic" or "source" competition. It is clear that geographic competition is in principle inferior to parallel competition as protection from the monopoly power of a railway line. However, this competition is sufficient to force the railway companies to offer lower rates and better service to get the customer's business.

Restructuring into competing vertically-integrated companies would be a challenge in Europe where railway companies have historically served not different routes but different national territories. The EU is seeking to develop trans-European freight routes. In one possible future development, different international freight routes (either East-West routes or North-South routes) would be owned and operated by different railway companies. One study for the European Union briefly raises the possibility of a similar structure for passenger railways (Steer Davies Gleave (2004) in OECD (2005)).

Careful restructuring of an existing rail network into separate rail companies operating separate rail paths may create effective competition, especially for freight services. This form of competition appears to be most attractive in those countries with a dense rail network which could be separated to form a number of competing operators and for which there is limited public sector expertise or experience in sophisticated regulatory arrangements required for mandated access to the track infrastructure. For these reasons the OECD recommends this approach for Russia and China (OECD (2005)).

Moreover, the model will work in cases of hinterland exportations via ports and there is a choice which port to use. If there is, instead, a need to provide internal transportations from a precise point A to a precise point B,

the model of geographical competition doesn't work in sense that it doesn't bring competition to the railway sector.

Pittman (2001) suggests that a variant of the Latin American rail reorganization system may be appropriate for Russia: the creation of a number of vertically integrated regional monopolists, connected at cities and/or large production centers to provide source competition at those points. "It is extremely doubtful that the regulatory system and the rule of law are of sufficiently high quality to enforce the option of vertical restructuring with competition, and the unlikelihood of much train competition renders the vertical separation option unattractive. A system of regional integrated monopolists seems the best outcome for the time being" (Pittman (2001)).

Long-term concessions on vertically integrated railways may help to achieve three goals simultaneously: to promote competition, to increase investments and to keep state ownership of infrastructure. Competition between concessions will be possible if there are enough "parallel" tracks. Though in the Eastern part of Russia the geographic structure of railroads makes such scheme hardly possible to implement, the Western part of the railroad network, instead, is dense enough to organize "parallel" competition (Guriev et al. (2003)).

However, in application to Russian railways, this model was rejected by ex-vice railway minister Anna Belova: "We could accept holding structure, if an isolated railway were a profit center. But our business peculiarity is that it is a network business. Some of railways are mostly loading freight, other are unloading it, some serve for transit and so on, i.e. the profit is formed across the whole network rather than on an isolated railway. This is the reason why we decided to preserve a unified commercial entity which encompasses different business divisions according to different types of activity" (Belova in Guryev (2008)).

5. Case studies

5.1. Russia

General picture

In Russia, in the end of nineties, the railways accounted for 5% of Federal Government budget and contributed 3,7% to GDP (less than 3% in

2008). The national railway company RZD is the largest state-owned monopoly in Russia with 1,3 million employees and assets amounting to 5-15% of all assets in the economy.

The Russian rail system is the second after the US Class I railroads in network size and average length of freight movement, and third in ton-km (after the USA and China). Russian railway transport accounts for 21,6% of the world railway freight ton-kilometers and 7,6% of railway passenger-kilometers (correspondingly, 71,4% and 26,4% of European railways).

Rail accounts for more than 40% (in tkm) in the freight transport market. Road haulage accounts for six times the tonnage of the railways, however, the distance is generally short. In the European Russia road haulage accounts for 40% of tkm and that share is predicted to increase in line with improvement of quality of road. However, in the Eastern part of the country, railways has almost monopolistic position in transport area (Dementiev (2005)).

The main freight commodities carried by the railway are the following. Coal accounts for the largest part of traffic (21,8% of tones carried), followed by crude oil and oil products (17,1% of tones carried). Construction materials account for 16,3%.

The average distance of transportation by railroads exceeds 1300 km (Guriev et al. (2003)).

Reform

Although first suggestions about commercialization and corporatization appeared in 1991 and were reflected in a president's order in 1992, the real Russian railways reform can date back to the year 1997 when the first regulatory document appeared – President's order №426 "Concept of structural reforms of natural monopolies". It encompassed 3 stages and assumed the completion of the reform by 2000. Even in that first document some progressive ideas could be found, such as: elimination of cross-subsidies, introduction of competition, privatization of non-core businesses, open access to infrastructure and maintenance facilities, creation of independent regulator.

The second attempt to formalize the reform was undertaken in 2000. It was the project of Conception of the structural reform on Russian railway transport, which also included 3 stages. At that time, it became clear that the

main reform measure must be the separation between administrative and commercial duties. Such issues as demonopolization, open and non-discriminatory access to infrastructure, separation between competitive and monopoly businesses were accentuated.

Having been modified, the document was approved in 2001 and also covered 3 stages, but the term of the reform completion was extended to 2010. The main goal of the reform was "to improve the efficiency of railways by means of the creation of competitive environment, increase of financial transparency and attraction of investment".

In the first phase (2001-2002), the railways were split into two separate entities, responsible for regulation and commercial operation. RZD was created in the form of corporation in July 2003, the old Ministry of railways (MPS) was dismantled in 2004 transferring its regulatory functions to the Ministry of transport; this brought a lot of confusion to the administrative functions. At the same time, in 2001, first independent operators officially got permissions to operate. In the second phase (2003-2005) daughter companies had to be created (separated from RZD), but this process went slower as supposed. Some of daughter companies were supposed to be sold out later – completely or partially. The goal of the third phase (2006-2010) was the "creation of a developed competitive railway market": newly created daughter companies had to compete with private operators on some market segments.

In general, the main trends of Russian railways reform may be summarized in the following way:

- separation between administrative and commercial functions;
- separation of businesses in the form of commercial entities;
- promotion of competition on the railway market;
- tariff deregulation.

However, complete vertical (infrastructure vs. operations) or horizontal (regional or other division) separation is still not a decided issue; the advantages of such step still have to be evaluated on the third stage of the reform (2006-2010).

That is, important measures which were undertaken are:

- Separation between administrative and commercial functions: it was done in the framework of administrative reform which assumed 3 levels of executive power: ministry – service – agency. Some of regulatory functions were moved to the Ministry of transport, other were taken by the Railway agency.
- Creation and partial selling of daughter companies in freight transportations (in passenger sector, the Federal passenger company, by the end of 2008, was approved but not created yet).
- Non-core businesses were separated.
- Several private operators appeared (or got the status of railway operating companies) and are working in passenger and freight railway segments.
- In some market segments, tariffs (wagon part of tariffs) got deregulated. Actually, in freight transportations, 15% of tariffs are deregulated (this share is planned to be brought up to 50% within next years).

However, in the new railway strategy (2008-2030) the restructuring is not among the main goals; instead, the main issue is the modernization of rolling stock and infrastructure as well as improvement of railway services.

One of the most important innovations was to delegate some activities to newly created daughter companies and thus to keep control over transportations within a holding structure which contradicts to competitive intentions of the reform.

In 2007, 15 daughter companies were created, the biggest of them is the First Freight Company (PGK), and others include 7 maintenance and repair companies, research centers and so on. Before 2007, other daughter companies were created, such as is OAO Transcontainer, OAO Refservice and OAO Transles. The total number of daughter companies in the middle of 2008 was 52. In 2007, total revenues from daughter companies were 156 milliards of roubles, which equals to 16% of RZD's revenues from its main activities. These companies got the most profitable segments, rolling stock, clients of RZD, but at the same time, they are not subject to tariff regulation. They still have some preferences in the access to infrastructure and bureaucratic procedures. It is then clear that they grow faster and have more

power than independent operators. Probably 100% of these companies will be sold off.

OAO Transcontainer was created in 2006 in the segment of container transportations. It got more than 21 thousand of fitting platforms, 47 container terminals (slightly more than 5% of total RZD terminals, but they serve more than 80% of total container turnover) and other assets. In 2007, the market share of Transcontainer (on the market of container transportations) was more than 60%. The company operates not only on the Russian market. In 2007, 15% of Transcontainer shares were sold.

The First Freight Company (PGK) was created in 2007 and operates on the market of transportation of oil and oil products (35% of its total tonnage), coal (more than 30%), cement (14%), construction materials, ferrous metals and other freights. It has agreements with leading industrial producers. In 2008, it transported 100 mln tones, which is about 7% of total freight transported on the RZD network. When created, PGK received from RZD more than 200 thousand of freight wagons which is 21% of total railway freight wagons in Russia and which is six times more that the number of wagons of its follower (N-Trans company with 35 thousand of wagons). 49% minus 2 shares are supposed to be sold.

The Second Freight Company will be created as well.

OAO Refservice was created in 2005 and began operating in 2006. It got about 6 thousand wagons. It operates on a very profitable market segment – transportations in refrigerators. Its market share in this segment is 60% and it often abuses its dominant position. 25% of its shares are planned to be sold.

On the freight transportations market, the share of RZD together with its daughter companies is now slightly more than 50% and is permanently decreasing.

Actually, more than 2000 small companies operate on the freight market (32 companies on the passenger market). In 2007, freight transported in private rolling stock accounted for 527 million tones and its share increased from 32,2% of total railway transportations in 2006 up to 35,3%. By 2010, the market share of independent operators is expected to stabilize on the level of 28%. Private operators have in total about 325 thousand freight wagons. In private wagons more than 70% of total oil products are transported, more than 60% of fertilizers, more than 50% of ferrous metals.

That is, they work in the most profitable market segments. Mostly they are companies affiliated to industrial producers transporting their freights.

The first was OOO Link Oil Spb created in 1997. In 2001, the legislation provided these companies with the status of operators. By the middle of 2002, there were 54 operating companies transporting 10% of the total freight volume. Their tariffs are out of regulation.

As for passenger transportations, soon after the creation of OAO RZD, Federal passenger direction was created and it will be transformed to the Federal passenger company later on. It will get from RZD 46 wagon depots, 332 railway stations, more than 25 thousand passenger carriages and other assets. At the end of 2008, the Ministry of transport approved the creation of the Federal passenger company in the form of RZD daughter company. Probably there will be tenders for operation franchises.

The main problem is the loss from passenger transportations. In 2004, revenues from passenger transportations covered only 2/3 of their costs. The deficit was about $1 billion. However, RZD affirms that the deficit is not very high – only 0,8 eurocent of subsidies per 1 pass-km, while in the USA it is equal to 12 eurocent, almost 14 in Canada, 2,5 in France, 6 in Germany and 4,5 in Great Britain (Guryev (2008)).

The problem to solve was whether passenger transportations should be financed by cross-subsidies from freight incomes or these should be the expenses of federal, regional or local budgets. Since 2007, federal budget compensates RZD losses in long distance passenger transportations due to regulated tariffs (10,9 billions of rubles in 2007, 16,4 in 2008, 22,6 in 2009, 24,7 in 2010). As for short-distance commuter trains, in 2009 regional budgets will compensate 50% of losses which are due to regulated tariffs, 75% in 2010 and 100% in 2011. Tariff regulation will not be abolished because of universal service obligations, as declared by Russia prime-minister V. Putin.

In passenger transportations, the first independent operator is ZAO Okdail created in 1991. In 2002, another company, ZAO TK Grand Service Express, appeared which was a challenge in passenger transportations: its main activities concerned high-class modernization of passenger carriages and VIP passenger transportations – in Russia as well as in other post-soviet countries. That is, like in freight transportations sector, in passenger transportations, independent operators caught the most profitable market segments.

5.2. Ukraine

General picture

Ukrainian railways are the second largest railways after Russia among the former USSR member countries – according to the length of track as well as to the amount of virtual tone-km transported. The share of railways in total freight turnover (without pipelines) is more than 80%, in passenger transportations they have more than 60%. Ukrainian railways have a high share of freight transportations (about 70%) due to their transit position: huge amounts of Russian freight pass by Ukrainian ports. Transit freight transportations are constantly growing and in 2007 accounted for about 20% of total freight railway transportations. Ukrainian railways are still the donor of the state budget.

However, one of the main problems to solve is the loss in passenger transportations which constantly grows (+33% in 2007, +27% in 2006, +22% in 2005). Revenues from passenger transportations cover less than 40% of costs, in local passenger transportations – not more than 15%. The main reasons of losses in passenger transportations is the obsolescence of the rolling stock and reduced tariffs for several categories of passengers (according to the communication of the Ukrainian transport minister Iosif Vinskiy, passenger tariffs in Ukraine are 5 times lower than in Poland and 2 times lower than in Russia), i.e. lower incomes don't allow to collect enough money to invest in the renewal of the rolling stock.

In 2008-2020, 19,4 mlrd euro will be invested in the renewal of the rolling stock. Its obsolescence is about 60-90%. In 2008, the investment in the modernization of the rolling stock is planned to reach 2,2 milliards Euro.

Another problem are relatively low freight tariffs: they are lower than in Russia and Belarus; tariffs in ports are 2-3 times lower than in Baltic and Russian ports as well.

Reform

By the end of 2008, Ukrainian railways have still been operating as a public body called Administration of railway transport of Ukraine. There were 2 reform projects: to transfer the administration into an integrated unitary publicly owned enterprise or to a corporation with future intention to privatize some parts of business (complete privatization is excluded, but

some businesses are expected to be sold out). The concession model is also considered possible as a form of public-private partnership in order to attract investment. However, concession legislation lacks.

In 2006, the "Conception of the state reform program for railway transport" was issued. It was aimed at corporatization and separation of operations from infrastructure. But 2 years later it was rejected. Even if the corporatization is assumed to be the most suitable reform model, it was not the right time because of the lack of corresponding circumstances (legislation, regulation etc).

In 2008, the Ministry of transport and communication announced a new reform agenda. Within the period 2008-2015, it will encompass 2 stages and will finally lead to a corporate structure.

1. On the first stage (2008-2009), the 6 Ukrainian railways and other affiliated bodies will be organized as a unitary public enterprise "Ukrainian railways" managed by the Ministry of transport and communications. The locomotive fleet will be transferred to another (unitary) division: this will be the first step to the principles of vertical structure management (holding company). The newly created enterprise will also be the owner of infrastructure.

The Railway transport authority will be created in order to separate the duties on the regulation and economic activity. The Authority will be financed from the state budget and will act within the structure of the Ministry of transport and communication.

2. The second stage (2009-2015) assumes corporatization of the unitary public enterprise and creation of daughter companies. Daughter companies will own infrastructure, locomotives and about 50% of total freight fleet.

At this stage, independent operators should appear – in freight (will own about 50% of total freight fleet) as well as passenger transportations (will own about 10-15% of total passenger fleet). In 2008, in Ukraine, the share of private wagons is about 28%.

Tariff regulation will remain in the duty of the Ministry of transport and communications.

Starting from 2009, a new Price list is in force. Its main innovation is the division of the tariff in three parts: infrastructural, locomotive and

wagon part. The first two remain subject to regulation. The wagon part is regulated only for the incumbent Ukrainian railways company, while private operators set this part by themselves.

5.3. Kazakhstan

General picture

Kazakh railways are the third largest railways after Russia and Ukraine among the former USSR member countries – according to the length of track as well as to the amount of virtual tone-km transported. The share of railways in total freight turnover (without pipelines) is more than 60%, in passenger transportations they have about 60%, too.

During the Soviet period the Kazakh railway system was operated by three regional divisions of the Soviet Ministry of railways. Because of the predominance of bulk raw materials carried over long distances, these railways were always among the most profitable in the Soviet system. Economic transition, and the disruption of trading relationships with the break of the Soviet Union, meant that by 1999 traffic had dropped to a quarter of its level in 1989. However, since then the resource boom has seen strong growth of about 40% in traffic between 1999 and 2002. Now, the share of freight in total (virtual) railway tone-km is 85%.

Resource transit is the most important type of Kazakh railways transportations. 50% of the total transit freights are Russian goods. Among them, there is Russian oil transported to Tajikistan and Kyrgyzstan, Russian wood transported to Central Asia and China, Russian metals transported to Uzbekistan. Almost 100% of wheat which passes in transit by Russia is from Kazakhstan. It is tranported to Germany, Azerbaijan, Tunisia, Turkey and Egypt. In 2007, transportations between Russia and Kazakhstan accounted for 104 million tones.

The axis Russia – Central Asia – China is a strategic axis in Kazakhstan's railway transportations. Trade turnover between Kazakhstan and China in 2007 accounted for $13,8 mlrd (+66% to 2006), but is expected to reach $15 mlrd yearly soon. China is the fourth biggest trade partner of Kazakhstan.

As practically all railways of the former USSR, Kazakh railways are obsolete. Obsolescence of rolling stock is about 75%. A 5-year investment

program which started in 2008 has a goal to reduce this share to 12-15%. In 2007-2011, $4,7 billion will be invested in the modernization of the railway network. In total, about 80 investment projects are planned until 2015 for the total cost of $30 billion which will come from different sources, public and private.

Reform

Kazakhstan is the pioneer, among former soviet railways, in the implementation of railways reform. The main objective of the reform was the creation of competition in railway operations and attraction of private investment. It's important to notice that a complete (legal) separation within a holding structure was assumed by the reform from the very beginning.

In 1991, the Ministry of transport and communications was created, while all the railway assets remained owned and operated by 3 regional railways. This important step of separation between administrative and commercial functions was done in Russia only in 2003. In January 1997, all Kazakh railways were put together within the same structure: unitary publicly owned enterprise Kazakh railways, which in March 2002 was transformed in a 100% Close Joint-Stock Company. This was the completion of the first stage of the railway reform adopted one year before with a new Railway Law. The reform assumed 3 phases:

- Phase 1 (2001-2002): commercialization and divestment of social and non-core activities;
- Phase 2 (2002-2004): competition and institutional changes;
- Phase 3 (2004-2006): privatization (partial); this phase was suspended.

There was a significant progress in implementing the first phase of the plan. All social and cultural activities had been divested by the end of 2003 and all supporting activities (for example, track and rolling stock repair workshops, telecommunications, security systems etc.) have been transformed to separate companies. Passenger operations were set up as a separate company under the Ministry of Transport and Communications in 2003. In January 2004, the freight train operations and 60 000 freight wagons were transferred to the newly-created State-owned freight operator (JSC Kazzheldortrans, in 2007 renamed into Kaztemirtrans). In 2003, the locomotives were transferred to a separate company (JSC Locomotiv).

The reforms established separate roles between:

- Ministry of Transport and Communications (MOTC) which determines railway industry policy and approves access for private Train Operating Companies (TOCs) wishing to use railway infrastructure;
- KTZ which will in future remain a publicly-owned railway infrastructure company; since October it's a part of the newly created "AO National welfare foundation Samruk-Kazyn"
- KTZ's passenger business (JSC Passenger Transportations) and freight business (JSC Kaztemirtrans) which will be commercially autonomous (though publicly owned) TOCs;
- JSC Locomotiv which is assumed to provide tracking stock to independent operators on the commercial basis;
- The Regulator (the Anti-Monopoly Committee) which will approve the track access regime and track charges on the basis of non-discrimination between TOCs (whether public or private). The Anti-Monopoly Committee reports directly to the President of the country.

The market of freight transportations is competitive. In 2007, the share of privately owned fleet was 35% (more than 30 000 wagons). It is planned to increase this share up to 60% by 2010. In 2007, 180 companies had their own private wagons. The market share of private operators is about 40-50%. The operation component of the freight tariff (locomotive component and wagon component) is deregulated, while the infrastructure component will remain under state regulation.

Given that passenger transportations are not profitable, they will be subsidized. The final price (for consumers) will remain regulated. Passenger transportations were put in franchise tenders: operators requiring the least subsidies are the winners. As a result, in 2005, the firs independent private operators appeared on the market.

5.4. Armenia

General picture

Armenia has the third shortest network length among the former USSR members (after Tajikistan and Kirgizstan). Between 1989 and 1999,

Armenian railways lost about 93% in its traffic volume, and now they have the second smallest (after Kirgizstan) volume of virtual tone-km. In 2006, only 2,70 million tones of freight were transported which is 10 times less than in the soviet époque (in 2007 already 2,98 million of tones demonstrating the growth of 9,7%). It's expected to increase freight transportations up to 50 million tones of freight yearly by railways, i.e. the main goal of the reform is to give back the importance which the railway had before the break of the USSR.

The share of railways in total freight transportations is about 30%. The railways are strategically important: freight can be delivered to Armenia only by railways from Georgian ports (80% of cargoes cross Georgia reaching sea ports, then, they are transported to Russia and Ukraine). There is no other connection to European-wide railway network. International transportations account for about a third of total transportations. More than 30% of freight is ore freight.

Armenian geographical position is the weakest point. The country is isolated from international transport corridors which pass by Armenian neighbors, Turkey, Georgia and Iran. The situation will get even worse when a new railway project will be completed: Georgia, Turkey and Azerbaijan plan to build a railway excluding Armenia: Kars – Ahalkalaki – Tbilisi – Baku. As a result, Armenian railways will loose some freight transportations. The construction had to start in 2008, but was suspended because of the war. On the other hand, the projects of railway lines connecting Armenia to Iran are under discussion. The works had to start in 2009 and last up to 5 years. The line will be a strategically important in the context of Armenian isolation from the main transport corridors.

Reform

The railway operates in the form of closed joint-stock venture. But it has the unique, among the railways of the former USSR, experience of concession. The concession was found to be a solution in order to attract large investment needed for the renewal of infrastructure and rolling stock and for the recovery of railway activity, bringing railway volumes to the level of Soviet époque.

In October 2007, Armenia announced the intention to give its railway to a concessionaire for 30 years with a possibility of extension for 20 years more after the first 20 years of operation. Among the candidates to manage

the Armenian railways were some foreign railway companies, including the Russian RZD which in January 2008 was announced to be the winner.

For concession purposes, RZD created a 100% daughter company named South-Caucasian railway. Officially it began operating in June 2008. As supposed, the concession will last 30 years with a possibility of extension for extra 20 years after first 20 years. RZD will invest $400 million in infrastructure and $170 million in the rolling stock, a total of $570 million including $230 million within the first 5 years. The employees of the Armenian railways will be formally transferred to South-Caucasian railway with an increase of salary by 20%. It's expected to increase freight transportations up to 30 million tones yearly.

The goals of the concession will be not only to increase railway transportations, but also to modernize the infrastructure and to develop the collaboration with neighboring states.

5.5. Estonia

General picture

Estonian railways have productive characteristics (traffic, network length, network density etc) around average. The share of railways in total freight transportations is about 50-60%. The share of freight in total virtual tone-km is very high – more than 90%: probably because automobile passenger transport is more competitive on such short distances.

Estonian transport system is very dependent on transit transportations, especially those from Russia. Prioritized freight types are oil (more than 60% of total Estonian freight transportations) and freight in containers. About 80% of Russian oil exports pass by Baltic ports. Before political conflicts, Russia transported about 25 million tones of oil and oil products yearly through the port of Tallinn, the largest of Estonian ports. The transit of Russian oil gave to the Estonian budget about 6% of its revenues. The incomes from all types of transit on the Estonian territory give 20-25% of its GDP. Transit transportations are 75% of all transportations (-24,5% in 2007; domestic transportations increased in 2007 by 50%).

But Russia plans to cancel oil and coal transportations via Baltic ports and transfer them to Russian ports by 2015. This will particularly hurt Estonian railway: while ports have some chances to survive (container

transportations from China), the Estonian railway, which is dependent on transit, will suffer a lot.

Reform

In 1997 the state-owned enterprise Eesti Raudtee was split into a number of new entities:

- the main company became a vertically integrated joint-stock company Eesti Raudtee AS responsible for the main international lines and freight services using them, as well as for managing the infrastructure;
- predominantly domestic passenger lines in the south and east of the country were vested in a new passenger company, Edeleraudtee Ltd, which was then privatized: Edelaraudtee even now offers some passenger services on Eesti Raudtee's network under a service contract with government for which it pays track access fees to Eesti Raudtee;
- international passenger services (to/from St Petersburg and Moscow) were transferred to a train operating company, EVR Express; 51% of shares were sold to investors and 49% were retained by EVR;
- commuter trains in the Tallinn area were also transferred to a suburban train operating company, Electriraudtee Ltd., still publicly owned.

In April 2000, the Estonian privatization agency announced the sale of 66% of the share capital of Eesti Raudtee AS to a strategic investor through an international competition. Following a rather vexed competition in which an initial preferred bidder was unable to complete the transaction, majority ownership was sold to the second preferred bidder, Baltic Rail Services (BRS), in August 2001. This was the first privatization of a vertically integrated national railway in Europe. The proportion of private sector participation in the Estonian railway industry was not only the highest in the ECA region but arguably the highest in Europe as a whole, even including the UK.

However, in 2006, after several court deals, the Estonian government bought back these 66% of the Estonian railway at the price of 150 million euro (lower than the company's value). The decision was explained by the

need in a more intensive development and renewal of the railway which was not achievable under the management of BRS. Neither the state nor the private owners of Estonian Railways were happy with the piling of disputes and the non-cooperative atmosphere; the differences were mostly fueled by disagreement on infrastructure access charges and other provisions covering open access operators.

In October 2007, the minister of Economic Affairs and Communications suggested to split Eestii Raudtee vertically into 3 companies: one for infrastructure, one for operations and one for their coordination, encompassing the other two. The intension was to give more transparency to the rail sector. By January 2009, the restructuring was complete. 2 new daughter companies were created: AS EVR Infra and AS EVR Cargo.

The tariff policy is being elaborated by the Ministry of economy and communications.

As for market shares, there are 3 main railway companies on the market: Eestii Raudtee – 62,8% of market, Westgate Transport – 23,4%, Spacecom – 13,8%. There is a passenger operator Corail which, however, is not very successful: from September 2008, it closed the line Tallinn – St. Petersburg because the tariffs of using the infrastructure were too high for it. Other independent operating companies are Navirail (created in 2007) and Baltic Rail AS (created in 2008).

6. Conclusions

Worldwide experience demonstrates that vertically integrated companies tend to perform better. However, this option (to remain integrated or introduce competition between vertically integrated companies) is almost never taken into consideration by reformers – either in Western Europe or in the former USSR. The "default" trend is vertical separation – accounting or complete legal separation, although it doesn't necessary lead to higher performance.

The analysis of the former Soviet railways shows that only one of them, the Kazakh railways, has implemented the reform at the same level and dimension as it has been implemented in Western European countries. Estonian railways could also be considered as an avant-garde example due

to their privatization, but the experience turned to be not successful, and now they are implementing "traditional", evolutional measures such as vertical (accounting) separation within one publicly owned holding company. Moreover, the development of Estonian railways is very problematic for political reasons: a huge part of their transportations depend on Russian freight, which is planned to be transferred to Russian ports in near future.

There is no common trend in the reform progress among the railways in question. Instead, a great diversity can be observed: operation as a government body, unitary public company, corporation with vertical separation of infrastructure and operations, concession and, in past, even a privatization experience (however, non-core businesses are being privatized or are planned to be privatized by most railways). Horizontal separation has been discussed only at academic level, but never taken into consideration by railway policy makers.

What is common is the understanding of the need to reform: in order to modernize railways, to make them more competitive, to catch back the volumes of freight transportations of the Soviet époque (to maintain the important role of railways is the goal of most former Soviet railways), finally, to adjust to market-oriented economy.

Probably the reform is not going fast because, due to high volumes of profitable freight transportations, the railways managers have an illusion that everything is working well and don't feel the necessity to reform. A good example is the Russian railway company RZD, which until 2003 had been operating as a railway ministry.

Summarizing, we can state that the reform is being executed and the recovery of railways is going on.

The two papers which follow are dedicated to empirical estimations. First, railways performance is estimated using the SFA approach; the first step of the reform, the transformation of public bodies to commercial entities, is taken into consideration. The second paper applies transaction costs economics approach to railways and investigates the impact of governance choice, in terms of vertical separation or integration, on railways performance.

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Estimation of Technical Efficiency of Eastern European and Former Soviet Railways Using Stochastic Frontier Approach

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Abstract

This paper examines the issue of technical efficiency of Eastern European and former Soviet Railways, an issue of concern to policy makers because of the change in the organization of the railway transportation sector introduced during the last decades in these countries. The fact that railway companies exist in different institutional forms, as independent state-owned public companies and as units of the public administration, raises the issue of their relative technical efficiency.

The study is based on a panel data set for a sample of railway companies operating in Eastern Europe and in the former Soviet Republics over the period from 1991-2007. The empirical analysis is performed using a parametric input distance function with an unbalanced panel data set composed of 28 railway companies observed over 17 years, with a total of 368 observations. We apply two different models within the stochastic frontier efficiency measurement. The first model is the classical stochastic frontier model proposed by Aigner et al. (1977), whereas the second is a random coefficient stochastic frontier model. This model proposed by Greene (2005a, 2005b) is able to capture in different ways the unobserved heterogeneity of the companies.

The results of a Kruskal-Wallis test for the differences in inefficiency scores do not indicate any significant difference in the level of efficiency between companies operating with varying institutional forms. Further, no significant difference between companies operating in different geopolitical regions has been found.

1. Introduction

After the *breakdown* of the *Soviet Union* at the beginning of the 1990s several Eastern European countries and several former Soviet Republics have introduced important economic and political reforms in order to transform the old command economic system into a more market-oriented

system. During this period these countries have also introduced a reform of the organization and regulation of the railway sector with the goal to improve the efficiency and the quality of its services. Most of these reforms have introduced new regulation instruments and new institutional forms for the companies in order to provide incentive and managerial instruments for the improvement of productive efficiency. These railway reforms, either being designed or implemented, include the following elements: transformation of the institutional forms of the railway companies, tariff reform, horizontal unbundling (separating freight and passenger business lines), vertical unbundling (separating infrastructure management and operation services), competitive access of independent operators to the tracks, and improved sector regulation (setting up an independent regulator).

The majority of the railway companies operating in these countries has not been privatized and, therefore, are public. Moreover, from the institutional point of view, some of these companies are still administrative units, e.g. firms without legal status integrated directly in the public administration, whereas others have their own legal status, e.g. corporations or independent state-owned public companies with a special status. These types of public railway companies are generally more independent of political and public administration processes than companies directly included in the public administration. This mixed economy raises the interesting issue of the effects of different institutional forms on costs. Little empirical analysis has been done in the comparison of technical efficiency of these two types of institutional forms in transition countries.

In this paper we test the hypothesis that railway companies integrated directly in the public administration are less efficient than those managed as corporations or as independent state-owned public companies. This hypothesis is based on the fact that the managers of the railways integrated in the public administration are faced with more bureaucratic constraints than those in public corporations. Moreover, agency problems in the public administration are more frequent than in public corporations. This hypothesis is tested using a two-stage methodology. In the first stage the railway companies' efficiency scores are estimated using an input-distance frontier function. The estimated results are analyzed in a second stage to test for a significant difference between the two types of institutional forms.

Of course, we are aware that comparing the productive efficiency of different railway companies usually assumes that they operate under the same technology. However, there might be unobserved characteristics such as network and technological differences between the railways which influence the production process which in consequence might be labelled as inefficient. It seems obvious that this problem is even more relevant and important when it comes to comparisons of railway companies which operate in different transition countries with different political and economic systems. That is why the special focus of this paper is on the application of a stochastic input distance frontier model based on panel data which is able to capture in different ways unobserved heterogeneity. Using a random coefficients frontier model proposed by Greene (2005a, 2005b) enables us to identify firm-specific effects and, moreover, to distinguish between the heterogeneity captured by firm-specific effects and inefficiency.

The remaining part of the paper is organized in the following way: section 2 contains a brief review of literature on the efficiency estimation in the railway sector. Section 3 is dedicated to the model specification. Section 4 describes the data and econometric models used in the empirical analysis. The results are presented in section 5. Section 6 contains a statistical analysis on the impact of the institutional form on the efficiency. Conclusions are summarized in section 7.

2. Review of literature

There is a wide range of literature on the efficiency estimation in railways. We have concentrated on those papers which use a frontier function approach and/or take into account institutional environments in which railways operate. We also tried to follow chronologically the trend in railways efficiency analysis which evoked the idea of efficiency estimation of countries in transition. The summary of literature review is presented in the Table 1.

The first study using a frontier technique to analyze efficiency in the railway sector was done by Perelman and Pestieau (1988). They applied the deterministic COLS method to estimate the efficiency of public enterprises on the sample of 19 European plus Japanese National railroads over the period of 14 years (another part of analysis is devoted to postal services). They built a translog frontier production function with 2 outputs (for freight

and passenger transportations) and 4 inputs (labour, energy, rolling and fixed stock). Exogeneous factors directly incorporated in the production are: line-km per square km, percentage of electrified lines, track-km per line-km, average passenger journey and average length of haul ton.

A step forward was the introduction of public policy in the analysis. Oum and Yu (1994), besides estimating the efficiency with the DEA method on the sample of 19 OECD countries over the period of 12 years, evaluate its dependence on subsidies and managerial autonomy. Two alternative output measures are used: 1) revenue-output measures (passenger-/ton-km) and 2) available output measures (passenger/freight train-km). In order to estimate the effects of policy and other variables beyond the control of management, a Tobit regression model is applied. The main result is that increased competition via regulatory liberalization and deregulation has improved efficiency, which is in line with the reforms that began in the middle of the 1980s and were aimed at the separation of railway operations from infrastructure and the improvement of competition and performance in the sector. This result was discovered earlier for Canadian Railways (Caves and Christensen (1980)) and also proven in other succeeding papers. The impact of managerial autonomy was also analyzed by Gathon and Perelman (1992).

There are relatively few studies which extend efficiency analysis to the impact of rail restructuring. On the sample of 16 European railways over the 21-year period, Cantos and Maudos (2001) estimate cost and revenue frontier functions. They use a 2-output (passenger-km and freight-km and corresponding revenues derived from freight and passenger transportations), 3-input (operating costs for energy, labour and materials and external services) specification and discover that different measures of efficiency give different results: for most railways cost efficiency generally increased, while revenue efficiency dropped. One of the reasons may be a strong regulatory policy which leads to non-market behavior of the railway management due to the absence of competitive pressure.

Different aspects of deregulation and the sequence of the reforms were studied by Friebel, Ivaldi and Vibes (2004). They built a Cobb-Douglas production frontier model including individual fixed effects through the introduction of time and time multiplied by the deregulation dummy variable. The analysis encompasses 3 reform components: third-party access, independent regulation and separation of operations from infrastructure. The sample covers 11 European countries over the period of 21 years. The

authors also prove the statement that deregulation increases efficiency, but this effect depends on the reform sequence and full separation is not a necessary condition for improving the efficiency.

In sum, the reform (the goal of which is to induce more competition) is found to have a positive effect on the efficiency, but the econometric evidence does not completely prove the statement that the separation of infrastructure from operations increases efficiency (Gomez-Ibanez and de Rus (2006)). In recent studies, there is a trend of non-inclusion regulatory and institutional dummies into the estimated production function.

A recent study by Lan and Lin (2005) proposes various stochastic distance function models to carry out a two-stage performance evaluation for 39 railways by distinguishing the technical efficiency from the service effectiveness over the period from 1995-2002. The results show that the percentage of electrified lines, population density, per capita gross national income and line density are the main factors affecting railway technical efficiency; while per capita gross national income, population density, ratio of passenger train-kilometers to total train-kilometers and line density are the main factors affecting service effectiveness.

In recent papers, "new" econometric techniques are used. Methods called True Random Effects and True Fixed Effects were developed by Greene (2005a, 2005b) in order to resolve the problem of firm-specific heterogeneity and separate inefficiency from heterogeneity.

Farsi, Filippini and Greene (2005) apply the standard SFA models and the True Random Effects model to the estimation of a panel of 50 Swiss railway companies operating over a period of 13 years. They estimate a 2-output (passenger-km and freight ton-km, the length of network is included as an output characteristic) and 3-input (costs of labour, capital and energy) Cobb-Douglas cost frontier function. They also compare the results of different models (correlation between efficiency scores) and discover that the inefficiency estimates are substantially lower when the unobserved network effects are taken into account.

Another interesting recent study (Growitsch, Wetzel (2007)) is dedicated to the estimation of economies of scope: if integrated railways are found to be more efficient, this means that they realize the economies of scope. Based on the sample of 54 European railways (time period covers 5 years), the authors construct a set of virtually integrated firms and compare

them with those actually integrated. They apply the DEA method to a multi-input and multi-output input distance function, both for physical and monetary data. The main result is that integrated companies are slightly more efficient, which may lead to ambiguous policy implications.

There is practically no literature on Russia or Eastern European countries. Some brief reviews show that Eastern European countries are reforming their railways which still have very low productivity, are in very poor technical condition and are based on non-market principles (OECD (2001)). Besides, Lan and Lin (2004, 2005) incorporate into their studies some countries of the former USSR and of Eastern Europe, but without paying special attention to the institutional and regulatory circumstances. There is no clear study which would estimate the efficiency trends of Eastern European railways and discover any relationship between regulation (especially the transfer from the planning system to the market system) and efficiency.

Table 1: Summary of the literature review

Paper	Data	Model and functional form	Methodology	Exogenous / environmental factors	Regulatory / institutional aspects
Perelman, Pestieau (1988)	19 European plus Japanese National railways, postal services, 14 year-period	Translog frontier production function with 2 outputs and 4 inputs	COLS	Line-km per square km, percentage of electrified lines, track-km per line-km, average passenger journey and average length of haul ton	No
Oum, Yu (1994)	19 OECD railways, 12 year-period	2 outputs, 7 inputs	DEA, Tobit at the second step	Passenger-km per route-km, freight km per route-km, passenger train density, freight train density, average length of passenger trip, average freight haul, average passengers load per train, average freight load per train, share of electrified lines	Managerial autonomy, ratio of subsidies to operating costs
Cantos, Maudos (2001)	16 European railways, 21-year period	Cost and revenue translog frontier function, 2 outputs, 3 inputs	SFA	No	Strong regulatory policy and a corresponding lower revenue efficiency; correlation of financial indicators with efficiency scores
Friebel, Ivaldi, Vibes (2004)	11 European railways, 21-year period	Cobb-Douglas production frontier function, 1 output, 2 inputs plus individual effects and deregulation	LISREL	No	Deregulation dummy covering 3 reform components: third-party access, independent regulation and separation of operations from infrastructure
Lan, Lin (2005)	39 worldwide railways, 8-year period	(1) Input distance function, (2) consumption distance function; (in both cases)	SFA	Gross national income per capita, population density, percentage of electrified lines, line density	No

		2 outputs and 3 inputs			
Farsi, Filippini, Greene (2005)	50 Swiss railway companies, 13-year period	Cost frontier function, 2 outputs, 3 inputs	SFA	No	No
Growitsch, Wetzel (2007)	54 European railways, 5-year period	Input distance function, 1 to 3 outputs (depending on the firm type), 3 inputs	DEA	No	Estimation of economies of scope comparing integrated vs. virtually integrated railways

3. Model specification

To measure the efficiency level of a sample of multi-output railways operating in Eastern Europe and in some former Soviet republics we decided to apply a parametric frontier input distance function.[1] Of course, another possibility would have been, as in previous studies, to estimate a multi-output cost frontier function. However, for the majority of the railway companies data on cost and input prices are not available.[2]

Measuring efficiency with an input distance function implies that the level of efficiency is improved by reducing the quantity of inputs used to produce a given exogenous level of outputs. In the railway sector the exogeneity assumption of the outputs is supported by the fact that the level of the output quantity is more or less narrowly determined by the regulator. This argument particularly applies to several incumbent railway firms which still provide almost 100 percent of the rail transport services (Growitsch, Wetzel (2007)).

The input distance function is defined for the input set as

$$d_i(x, y) = \max\{\rho : (x/\rho) \in L(y)\} \qquad (1)$$

and considers by how much the input vector may be proportionally contracted with the output vector held fixed (see Coelli, 2002) [3]; $d_i(x, y)$ will take a value which is greater than or equal to one if the input vector x is an element of the feasible input set $L(y)$. In addition, $d_i(x, y) = 1$ if x is located on the inner boundary of the input set.

As in most empirical studies, we specify a translog functional form for the input distance function.[4] For the case of M outputs and K inputs it is specified for the i_{th} firm as

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[1] For the use of parametric distance functions in the transport sector see Coelli and Perelman 2000.

[2] For a discussion on advantages and disadvantages of the use of distance functions see Coelli (2002) and Coelli and Perelman (2000).

[3] ρ represents the scalar distance, so the amount by which the input vector can be deflated. It is assumed that the technology satisfies the standard axioms: $d_i(x, y)$ is non-decreasing, positively linearly homogeneous and concave in x and increasing in y (see the properties listed in Coelli (2002) and Färe and Primont (1995)).

[4] The Cobb Douglas form in contrast is too restrictive with regard to the elasticity of substitution and scale properties.

$$\ln D_{Ii} = \alpha_0 + \sum_{m=1}^{M} \alpha_m \ln y_{mi} + \frac{1}{2} \sum_{m=1}^{M} \sum_{n=1}^{M} \alpha_{mn} \ln y_{mi} \ln y_{ni} +$$
$$+ \sum_{k=1}^{K} \beta_k \ln x_{ki} + \frac{1}{2} \sum_{k=1}^{K} \sum_{l=1}^{K} \beta_{kl} \ln x_{ki} \ln x_{li} + \quad (2)$$
$$+ \sum_{k=1}^{K} \sum_{m=1}^{M} \delta_{km} \ln x_{ki} \ln y_{mi}$$

To obtain the frontier surface (the transformation function) one would set $D_{Ii} = 1$, so the left hand side equals zero $\ln D_{Ii} = 0$ (see Coelli and Perelman (2000)). The restrictions for homogeneity of degree +1 in inputs and for symmetry are

$$\sum_{k=1}^{K} \beta_k = 1, \ \sum_{l=1}^{K} \beta_{kl} = 0 \text{ and } \sum_{k=1}^{K} \delta_{km} = 0 \quad (3)$$

The restriction for separability between inputs and outputs is fulfilled when $\delta_{km} = 0$. A convenient approach of imposing homogeneity constraints is to follow Coelli and Perelman (2000) considering that homogeneity implies that for any $w > 0$

$$d_i(wx, y) = w d_i(x, y) \quad (4)$$

Therefore, one of the inputs might be arbitrarily chosen, such as the K_{th} input and set $w = 1/X_K$. Then one obtains

$$d_i(x/X_K, y) = d_i(x, y)/X_K \quad (5)$$

For the specification of the model used in this study we considered railway companies characterized by a production process with three inputs - labor, network length and number of wagons - and two outputs - ton-kilometers and passenger-kilometers provided.

By dividing the equation (2) by an input and rearranging we defined the following input frontier translog distance function:

$$-\ln(x_W) = \alpha_0 + \alpha_T \ln y_T + \alpha_P \ln y_P + \frac{1}{2}\alpha_{TT}(\ln y_T)^2 + \frac{1}{2}\alpha_{PP}(\ln y_P)^2 +$$
$$+\alpha_{PT}(\ln y_P)(\ln y_T) + \alpha_{PN}(\ln y_P)(\ln \frac{x_N}{x_W}) + \alpha_{PL}(\ln y_P)(\ln \frac{x_L}{x_W}) +$$
$$+\alpha_{TN}(\ln y_T)(\ln \frac{x_N}{x_W}) + \alpha_{TL}(\ln y_T)(\ln \frac{x_L}{x_W}) + \alpha_N \ln \frac{x_N}{x_W} + \alpha_L \ln \frac{x_L}{x_W} + \quad (6)$$
$$+\frac{1}{2}\alpha_{NN}(\ln \frac{x_N}{x_W})^2 + \frac{1}{2}\alpha_{LL}(\ln \frac{x_L}{x_W})^2 + \alpha_{NL}(\ln \frac{x_L}{x_W})(\ln \frac{x_N}{x_W}) + + \alpha_t t - \ln D_I$$

Where x_W is the wagon measure; y_P and y_T are the numbers of passenger-kilometers and ton-kilometers respectively provided by the companies. Following the methodology attributed to Oum and Yu (1994), we decided to assume two pure supply oriented measures of the output. x_L is the indicator of labor input, x_N is the indicator of the capital input (network length in kilometers). T is a time variable which captures the shift in technology representing change in technical efficiency. Replacing the distance term $-\ln D_I$ with a composed error term v_{it} - u_{it} we obtain the standard stochastic frontier approach proposed by Aigner et al. (1977)[5]. The standard random error term vit is assumed to be distributed independent of u_{it} as i.i.d N(0, σ^2_v), whereas for the non-negative technical inefficiency term u_{it}, we assume a half-normal distribution $N^+(0, \sigma^2_u)$. A radial input-oriented measure of technical efficiency is than obtained by $TE = \frac{1}{d_i^I} = \exp(-u_{it})$.

4. Data and econometric specification

The study is based on a panel data set for a sample of railway companies operating in Eastern Europe and in the former Soviet republics over the period from 1991-2007. Due to lack of data we were obliged to exclude from the sample some small railway companies recently created in several countries.[6]

[5] For estimation purposes, the negative sign on the dependent variable can be ignored. This results in the signs of the estimated coefficient being reversed.

[6] For instance, in Poland in 2007, the independent freight operators transported only 5% of total tons of freight. In Russia in 2007, the recently created freight company, First

The data set used in the empirical part of this study includes 28 railways operating in the following 26 countries: Russia, Ukraine, Belarus, Moldova, Georgia, Armenia, Azerbaijan, Uzbekistan, Tajikistan, Turkmenistan, Kazakhstan, Kirghizstan, Latvia, Lithuania, Estonia, Czech Republic, Slovak Republic, Hungary (2 companies), Poland, Bulgaria, Romania, Albania, Macedonia, Croatia, Slovenia, Bosnia-Herzegovina (2 companies). The empirical analysis is performed with an unbalanced panel data set composed of 28 railway companies observed over 17 years, with a total number of observations of 368.

In most cases, the railway companies are historically preserved natural monopolies. In some countries, as already mentioned, there are small independent operators. For two countries we included in the data set 2 major railway companies. In the case of Bosnia and Herzegovina, the railway system is dominated by two companies, the Railways of Federation of Bosnia and Herzegovina (ZFBiH) and the Republika Srpska Railways (ZRS). In the case of Hungary, the railway system is characterized by two main companies, MAV and GYSEV. However, MAV is larger and more important than GYSEV which covers only a limited territory.

The railway companies considered in this study are quite heterogeneous. This heterogeneity is due to different environmental, topographical, technological and regulatory factors as well as different institutional frameworks. Nevertheless, the common characteristic of these companies is that they operate in countries that were under Soviet influence or control. The use of the panel data stochastic frontier approach, should, however, help to reduce the problems related to unobserved heterogeneity.

All companies included in the sample are multi-output companies which provide two services: freight and passenger transportations. Of course, the share of freight transport is generally higher than the share of the passenger transport because most of the railways under investigation are dependent on high volumes of bulk freight such as oil, coal and metals.

The data are taken from the annual reports of the UIC (Union Internationale des Chemins de Fer), from the data published by the World Bank Railways Database and from the web site of Eurostat.

Freight Company, was responsible for the transport of only 1,5% of total freight volumes.

Table 2: Sample descriptive statistics

	Network length	Number of locomotives	Number of passenger carriages	Number of freight wagons	Staff	Passenger-km	Freight tkm	Share of electrified lines	Network density
Min	220	27	17	95	1687	4	23	0	2.10
Max	86660	18066	44869	630734	1436300	172217	1858100	1	120.45
Mean	7352.24	1444.69	3181.22	49004.71	91131.90	9823.93	59195.14	0.36	36.99
Median	2313	330.5	757.5	13137	19599.5	988	7010	0.35	31.62
st. dev.	14700.34	2787.5	6881.97	101432.4	218123.05	25505.31	233152.22	0.27	28.75

From the econometric specification point of view, we should consider using stochastic frontier models for panel data. The first use of panel data models in stochastic frontier models goes back to Pitt and Lee (1981) who interpreted the panel data random effects as inefficiency rather than heterogeneity. Pitt and Lee (1981)'s model is different from the conventional RE model in that the individual specific effects are assumed to follow a half-normal distribution[7]. A major shortcoming of these models is that any unobserved, time-invariant, firm-specific heterogeneity is considered as inefficiency. In order to solve this problem using panel data, Greene (2005a,b) proposed to extend the SFA model in its original form (Aigner, Lovell and Schmidt (1977)) by adding a fixed or random individual effect in the model and/or by allowing some coefficients to be random.[8] The main model used in this paper is the random parameters (RP) stochastic frontier model proposed

[7] Schmidt and Sickles (1984) and Battese and Coelli (1992) presented variations of this model.

[8] For a successful application of these models in network industries see Farsi, Filippini and Kuenzle (2006) and Farsi, Filippini and Greene (2005).

Greene (2005b)[9]. In this model the two output coefficients and the intercept are assumed to be random variables.

The translog model is formulated in the following way:

$$
\begin{aligned}
-\ln(x_W) = {} & \alpha_i + \alpha_{Ti}\ln y_T + \alpha_{Pi}\ln y_P + \frac{1}{2}\alpha_{TT}(\ln y_T)^2 + \frac{1}{2}\alpha_{PP}(\ln y_P)^2 + \alpha_{PT}(\ln y_P)(\ln y_T) \\
& + \alpha_{PN}(\ln y_P)(\ln\frac{x_N}{x_W}) + \alpha_{PL}(\ln y_P)(\ln\frac{x_L}{x_W}) + \alpha_{TN}(\ln y_T)(\ln\frac{x_N}{x_W}) + \alpha_{TL}(\ln y_T)(\ln\frac{x_L}{x_W}) \\
& + \alpha_N \ln\frac{x_N}{x_W} + \alpha_L \ln\frac{x_L}{x_W} + \frac{1}{2}\alpha_{NN}(\ln\frac{x_N}{x_W})^2 + \frac{1}{2}\alpha_{LL}(\ln\frac{x_L}{x_W})^2 + \alpha_{NL}(\ln\frac{x_L}{x_W})(\ln\frac{x_N}{x_W}) \\
& + \alpha_t t + v_{it} - u_{it}
\end{aligned}
\tag{7}
$$

This model treats firm-specific random effects (α_i) and time-varying inefficiency (u_{it}) separately and is therefore able to distinguish between the unobserved heterogeneity and inefficiency. In this way it tries to overcome some limitations of the conventional panel data models. Moreover, in model (7) the first-order coefficients of the outputs are considered random. Therefore, in this model the two output coefficients and the intercept are assumed to be random variables with a normal distribution across companies.

The variation of the two output coefficients should capture part of the correlation of the random intercept with the corresponding variables. Therefore, within this framework we first allow firms to have different underlying production technologies with different scale economies, caused by unobserved differences in technological conditions and sizes.

For comparison purposes, we also estimated another model based on the original cost frontier model proposed by Aigner et al. (1977). A summary of the two models used in the paper is given in Table 3. Model I is a pooled frontier model in that the sample is considered a cross-section and its panel aspect is neglected. The random error term is divided into two components: a normal error term v_{it} capturing the noise and a half-normal random term u_{it} representing the inefficiency as a one-sided non-negative disturbance. The firm's inefficiency is

[9] Although similar extensions have been proposed by several previous authors, Greene (2005a, b) provides effective numerical solutions. For similar models see in particular Kumbhakar (1991) and Polachek and Yoon (1996).

estimated using the conditional mean of the inefficiency term $\mathrm{E}\left[u_{it} \left| u_{it} + v_{it} \right.\right]$, proposed by Jondrow et al. (1982).

Model II is the extension of model I that include an additional firm-specific effect (α_i) to represent the unobserved heterogeneity among firms and the two first-order coefficients of the outputs are random. In this model which is a random coefficients (RC) version of the true random effects (TRE) frontier model, it is assumed that the unobserved cost differences across firms that remain constant over time, are driven by network-related unobserved characteristics rather than inefficiency. Given the relatively long period covered in the data (up to 17 years), this is a realistic assumption. The inefficiency term is assumed to be an iid random variable with half-normal distribution.

Table 3: Econometric specification of the models employed

Model	Firm-specific component	Random error ε_{it}	Inefficiency u_{it}
Model I Pooled (ML)	None	$\varepsilon_{it} = v_{it} + u_{it}$ $u_{it} \sim \text{iid}\, N^{+}(0, \sigma_u^2)$ $v_{it} \sim \text{iid}\, N(0, \sigma_v^2)$	$E(u_{it} \left| \varepsilon_{it} \right.)$
Model II RC version of the TRE (ML)	Random (group dummies α_i)	$\varepsilon_{it} = v_{it} + u_{it}$ $u_{it} \sim \text{iid}\, N^{+}(0, \sigma_u^2)$ $v_{it} \sim \text{iid}\, N(0, \sigma_v^2)$	$E(u_{it} \left| \varepsilon_{it} \right.)$

5. Estimation results

The estimation results of the translog distance function frontier obtained by the two different models are given in Table 4. Given that all the variables are in logarithmic form, these coefficients can be directly interpreted as elasticities. For the interpretation of the empirical estimates of a distance function it is important to keep in mind, as pointed out by Färe and Primont (1995), the duality between the cost and the input distance functions. For instance, the derivative of a translog input distance function with respect to a particular input is equal to the cost share of that input. This means that the expected signs of the coefficients of the inputs should be positive. Moreover, the elasticity of a translog input distance function with respect to any

output is equal to the negative value of the cost elasticity of that output. This means that the signs of the coefficients of the outputs should be negative.

The estimated coefficients of the first-order terms have the expected signs and are statistically significant across all models. Generally, the values of the coefficients of the Pooled model differ from those of the random coefficients version of the True RE model.

Table 4: Estimated coefficients (p-values in parentheses)

	Pooled	RC version of the TRE
α_{YT}	-0.104 (0.0000)	-0.019 (0.0581)
α_{YP}	-0.501 (0.0000)	-0.163 (0.0000)
α_{YTYT}	-0.030 (0.0907)	0.002 (0.7710)
α_{YPYP}	-0.173 (0.0000)	-0.111 (0.0000)
α_{YTYP}	0.059 (0.0034)	-0.007 (0.3299)
α_{XL}	0.272 (0.0001)	0.216 (0.0000)
α_{XN}	0.694 (0.0000)	0.596 (0.0000)
α_{XLXL}	0.690 (0.0105)	0.242 (0.0043)
α_{XNXN}	-0.133 (0.5333)	0.359 (0.0000)
α_{XLXN}	-0.141 (0.5143)	-0.222 (0.0040)
α_{YTXL}	-0.357 (0.0000)	-0.127 (0.0000)
α_{YTXN}	0.185 (0.0008)	0.094 (0.0000)
α_{YPXL}	0.410 (0.0000)	0.122 (0.0000)
α_{YPXN}	-0.267 (0.0000)	-0.091 (0.0000)
α_{T}	-0.002 (0.5906)	0.012 (0.0000)
Constant	0.268 (0.0000)	-0.023 (0.2395)
Sigma	0.315 (0.000)	0.094 (0.000)

Lamda	1.215 (0.000)	1.332 (0.000)
Standard Deviation for random parameters (a)		
Costant		0.25 (0.000)
ln y_T		0.06 (0.000)
ln y_P		0.576 (0.000)

The coefficients of first-order output variables represent the cost elasticities with respect to the corresponding outputs at the sample median. The sum of the coefficients of the two output variables is approximately 0.6 for Model I and 0.18 for Model II. This result suggests the presence of economies of scale, because, ceteris paribus, by increasing both outputs by 10 percent, the total costs will increase less than 10%. Moreover, a glance at the results in the right hand column of the table (and in particular at the random parameters) indicates that there is considerable variation across railways in the impacts of both outputs on costs. This result underlines the importance of the use of a random coefficients model in this context characterized by a high degree of heterogeneity of the railway companies considered in this study.

The elasticity of the input distance function with respect to time reflects the elasticity of cost reduction and provides a dual measure of the speed of technical change. This coefficient is positive (and significant) only in the RP model. This result indicates the presence of neutral technological progress.

Table 5 provides descriptive statistics on the cost inefficiency estimates of the railway companies obtained from Models I – II. We can observe some notable differences in the estimated cost inefficiency levels. By employing the pooled stochastic frontier model (Model I), the average efficiency is estimated to be 83%. By contrast, the average efficiency based on the random coefficients model (Model II) is estimated to be 94%. Moreover, the standard deviation of efficiency scores is much lower in this model than in the pooled model. Higher efficiency levels in comparison to Model I are expected since the random coefficients model is able to distinguish unobserved firm-specific effects from inefficiency and thus is able to treat the two effects

separately. We therefore believe that the results obtained by the RC model can be regarded as a good approximation of the general picture of the actual efficiency of Eastern European and Former Soviet Railways.

Table 5: Technical efficiency scores

	Pooled	RC version of the TRE
min	0.55	0.76
max	0.94	0.99
average	0.83	0.94
median	0.84	0.95
st.dev.	0.07	0.03

Table 6 presents the average efficiency score for every railway over the period considered in the analysis.

Table 6: Average technical efficiency scores over time

	Pooled	RC version of the TRE
Russia	0.833	0.917
Ukraine	0.882	0.943
Belarus	0.906	0.938
Moldova	0.864	0.955
Georgia	0.801	0.949
Armenia	0.722	0.939
Azerbaijan	0.711	0.943
Uzbekistan	0.722	0.937
Tajikistan	0.894	0.923
Turkmenistan	0.847	0.940
Kazakhstan	0.791	0.950
Kirghizstan	0.893	0.953
Latvia	0.862	0.951
Lithuania	0.845	0.943
Estonia	0.881	0.933
Czech Republic	0.776	0.949
Slovak Republic	0.808	0.951
Hungary GYSEV	0.866	0.941
Hungary MAV	0.825	0.940
Poland	0.788	0.936
Bulgaria	0.810	0.940
Romania	0.861	0.942
Albania	0.840	0.937

Macedonia	0.822	0.947
Croatia	0.763	0.942
Slovenia	0.901	0.946
Bosnia-Herzegovina ZBH	0.719	0.952
Bosnia-Herzegovina ZRS	0.838	0.949

6. Statistical testing

In the following, we conduct some statistical tests on the differences of efficiency levels among regions and among public companies with different institutional forms. To test these differences we adopt a Kruskal-Wallis rank test[10]. The test checks the null hypothesis that p samples do not differ and is based on the ranking of data (efficiency scores in our case). However, the test does not encompass the panel structure of the data: either it should be taken as a pool or average efficiency scores for any firm (in case of time-varying efficiency) must be calculated[11].

The results of the Kruskal-Wallis test on the differences in inefficiency scores between different groups are given in the Table 7. Most of the results do not indicate any significant difference in the level of efficiency between companies operating in different geopolitical regions and between companies operating with different institutional forms.

The Kruskal-Wallis test is applied to both models (pooled and the RC version of the TRE). The significance of the test is evaluated on the 5% significance level.

[10] There are two other alternative approaches that can be used to analyze the impact of the geopolitical and institutional factors on the level of efficiency. One aims at estimating the distance function including some dummies for the geopolitical and institutional forms. This method is free from the estimation errors incurred in the inefficiency estimates. These random errors may mask the transition between subsamples, thus may result in under-rejection (too few rejections) of the null hypothesis of similar cost-efficiencies across different types. The second assumes that these factors directly influence the degree of technical inefficiency, e.g. influence directly the inefficiency term. Our analysis (not reported in the paper) shows that both approaches lead to similar results obtained with the Kruskal-Wallis approach.

[11] Some applications of the Kruskal-Wallis test can be found, for example, in Singh, Coelli and Fleming (2001) and Farsi and Filippini (2004).

Table 7: Kruskal-Wallis test statistics

			Model I	Model II
Independent state-owned public company (288 observations)	vs	Administrative units (80 observations)	0,059	0,043
Former Soviet republics railway companies (172 observations)	vs	Companies of Eastern Europe (196 observations)	6,975*	0,018

- * statistically significant at 5% significance level.
- The statistics have a Chi-square distribution with one degree of freedom.
- The number of observations in each group is given in parantheses.

7. Conclusions

In this paper a translog inputs-outputs distance frontier function has been estimated for a panel of 28 railways companies operating in Eastern Europe and in the former Soviet republics over the period from 1991-2007. These railway companies are characterized by a high degree of heterogeneity in environmental and network characteristics. The efficiency estimates largely depend upon how the unobserved heterogeneity across companies is taken into account by the econometric model. For this purpose we have considered the estimation of two translog frontier input distance models. The first frontier model is based on the original production frontier model proposed by Aigner et al. (1977). The second model is a random coefficients frontier model proposed by Greene (2005b) that includes an additional firm-specific effect (α_i) to represent the unobserved heterogeneity among companies. This model has proved to be able to solve, at least partially, the unobserved heterogeneity problem in measuring the technical efficiency. The random coefficients frontier model provides reasonable efficiency estimates. The results of this model suggest that the median value of the technical efficiency is relatively high at 94%. It should be noted that the random coefficients frontier model's estimates do not include any persistent inefficiencies that might remain more or less constant over time. To the extent that there are certain sources of inefficiency that result in time-invariant excess costs, the estimates of this model should provide a reasonable lower bound for the companies' efficiencies. Finally, most of the results do not indicate any significant

difference in the level of efficiency between companies operating in different geopolitical regions and between companies operating with different institutional forms.

The latter result suggests that the reforms of the railway sectors introduced in several eastern European countries and in several former Soviet Union republics have not yet been as effective as expected. The reasons could be the following. First, in several countries we are still at the initial stage of reform. This implies that not all changes have been put in place. Second, the change from a command economy system to a market economy system not only requires a change of the institutions but also a change in the management culture. In several of these countries the political influence on the governance of the railway companies remains strong. It seems that in order to be effective a change in the institutional form of the railway companies should also be accompanied by a cultural change of the role of the politics in the management of these companies. Recent political conflicts between Russia and Estonia and the war between Russia and Georgia have demonstrated the vulnerability of railway operations to political decisions.

Finally, the similarity regarding the levels of efficiency of companies operating in different geopolitical regions could be explained by the fact that these countries form a unique economic space and are all economies in transition.

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Governance Choice in Railways: Applying Empirical Transaction Costs Economics to the Railways of Easter Europe and Former USSR

Nadezda Negovelova

Abstract

The performance of railways depends not only on technical parameters, but also on the organizational form of the railway: vertical integration or separation of operations from infrastructure management. Vertical separation was one of the main reforms implemented on Western European railways whose experience was transferred, some years later, to Eastern European and former Soviet railways. In this paper, transaction costs economics (TCE) is applied to analyze governance decisions of railway authorities of the former communist camp countries. The impact of transactions characteristics – frequency, uncertainty and assets specificity – in taken into account as well. We apply the Heckman method to an unbalanced panel which covers 28 railways and a period of 12 years. Our results show that vertically integrated railways perform better, and the role of transactions characteristics corresponds to TCE predictions.

1. Introduction

The Western European railway reform experience of the early nineties have been transferred, some years later, to the railways of former communist camp countries – members of the former USSR and Eastern European countries. However, the evidence of the reform success (in terms of railway performance) is still not obvious even in the EU member countries, and there could be serious doubts whether the application of the same reform measures will not deteriorate railways performance in countries of the Eastern Europe and the former USSR.

One of the most important reform measures (however, according to EU legislation, not compulsory in its extreme, complete form) was the vertical separation of operations from infrastructure management, i.e. the change of governance and organizational form. The governance decision – to remain integrated or to separate[12] – can be evaluated in

[12] We can distinguish 3 types of separation: (1) accounting separation, when the activities remain within the same company, but have separated accounts, (2) legal

several ways. We may estimate the impact of governance form on railways efficiency (e.g. Growitsch and Wetzel (2007)), we can try to analyze customers' satisfaction or contractual relationships by interviews (e.g. Palay (1984)), or we may use empirical transaction costs economics approach (TCE). The latter was rarely applied empirically to railways[13] and never to Eastern European railways.

In this paper, we analyze the organizational form decision, or governance form decision in railways, using the transaction costs economics approach. Following Williamson, the governance form is determined by the environment, or transactions characteristics – frequency of transactions, uncertainty and assets specificity. We apply so called first generation empirical tests which simply analyze the governance strategy choice, and second generation tests which account for the expected performance.

The goal of the paper is to illustrate how the governance decision in Eastern European and former Soviet railways was determined by transactions environment and to observe performance implications of the strategy choice in the framework of transaction costs economics.

The paper is organized as follows. First, a brief literature review of empirical TCE is done. Then, in the third section, the theoretical basis of TCE is presented. The fourth section contains the methodology of empirical analysis in the TCE. The fifth section explains how and why TCE may illustrate governance choices in railways. In the sixth section, we proceed with the empirical analysis applied to the data on Eastern European and former Soviet railways. The final section concludes.

2. Review of literature

Transaction costs economics (TCE) goes back to the Coase's work "The Nature of Firm" (1937), where he argued that the neoclassical picture was incomplete and not able to explain two basic

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separation, when activities are executed by separated commercial entities, and (3) ownership separation, when activities are executed by separated commercial entities which have different owners (Armstrong, Cowan and Vickers (1994)) In the present paper we deal with the stronger form of vertical separation, i.e. legal and ownership separation (the latter took place only in one case).

[13] Mainly by Yvrande-Billon; see next section for details

questions: i) the existence of firms and ii) the determinants of firm size. He investigates why the firm emerges and emphasizes the existence of transaction costs.

For about 40 years Coase's work attracted little attention, but with the development of the New Institutional Economics during the 1960s and 1970s with works of Williamson, Alchian and other economists, it became one of the most cited articles. One important question which has not been answered by Coase (1937) is: what is the source of transaction costs and contractual difficulties. This issue has been addressed by many theoretical contributions in the late 1970s and 1980s. One of the most influential authors undoubtedly is Oliver Williamson, who developed huge parts of the transaction cost theory.

Williamson (1971) criticizes the traditional simplified view that under perfect competition market exchange does not cause any costs and asks "if the costs of operating competitive markets are zero, why integrate?" He defines the "organizational failures framework" on which further discussions of transaction costs are based upon. He argues that environmental as well as human factors determine the costs of using the market or internal organization. He developed the transaction cost model (1991, 1996) where transaction costs functionally depend on three variables: the frequency of transactions, the uncertainty surrounding their organization, and the degree of specificity in the investments involved.

Williamson describes TCE as "an empirical success story" (Williamson (1996)). However, even though there exist about 1000 empirical studies analyzing the make-or-buy or contracting decisions, most of them present econometric results which leave open the door for alternative interpretations, i.e. confirming hypotheses of competing theories – resource-based view, incentive theory, incomplete contract theory (see Hamilton and Nickerson (2003)). TCE provides a discussion of the sources of transaction costs and derives propositions; econometric tests however are not conclusive. Furthermore, we get no information about the impact of contractual choices on performance.

In the empirical TCE, a common instrument are so called indirect tests which examine only the differential effect which tells us about the impact of transaction characteristics on the change of probability that one or another governance form will be chosen (see section 4 for more details) and where transaction costs are assumed to

be minimized. However, there are two interesting papers estimating structural form models instead of reduced form models.

Masten, Meehan, and Snyder (1991) investigate organizational choice in the US naval shipbuilding industry. They collected data by interviewing company officials. They tried to estimate directly the costs of organization (transaction costs) using data on the number of hours managers spend for the treatment of a particular component. They apply a two-stage Heckman method. Their results are consistent with some but not all TCE statements. Temporal specificity is found to be crucially important for organizational form decision. They also found that "The correlation between human capital specificity and the likelihood of integration […] is a consequence of a decrease in internal organization costs rather than the increase in the costs of market exchange" which contradicts the TCE predictions while supporting the resource based view of the firm.

Poppo and Zenger (1998) investigate organizational choice of information services. They measure performance, rather than governance costs, also by interviewing top executives, in the form of a qualitative measure and try to reveal directly the interdependence between performance and "exchange attributes" (transaction characteristics, in terms of Williamson). Several hypotheses are deduced taking into account competing theories of the firm (e.g. TCE, RBV, incentive theory). Estimation results of a maximum likelihood Heckman model support TCE hypotheses instead of the RBV concerning the influence of specificity (may be due to the high technological uncertainty, which makes rigid internal routines inefficient) amongst other results.

There are very few works applying TCE to the railway sector. Pittman (1991) investigates contracts of rail sidetrack construction and the break of these contracts on the sample of the US railroads. The contracts contain information about which party, railroad or shipper, pays (or furnishes) for any part of the construction. Pittman emphasizes the problem of contract uniformity, specific investment and opportunism (principal-agent problem and bargaining problem, both affecting the railroad more than the shipper). He concludes that "in the presence of sunk, relationship-specific investments, the form of the contractual relationship between the parties makes a difference in terms of future behavior". The paper doesn't contain any empirical work.

One of rare studies applying the TCE to railways is the analysis of contracts between rail freight carriers and their shippers by Palay (1984). He states that, "as investment characteristics become more transaction specific, the associated institutional structure becomes increasingly unique to the parties and transactions it supports". The paper doesn't contain empirical econometric analysis, but it is an important early example of application of the TCE to the railway sector.

Menard and Yvrande-Billon (2005) analyze the British rail reform. They use rather detailed technical data on assets specificity (types of fleet units) and redeployability, but they don't apply any sophisticated econometric technique. They discover that transaction costs influence the organizational choice. They also find that "The British experience of railways' reform illustrates that if the degree of specificity of assets has a direct impact on the choice of a governance structure, as substantiated by so many tests in transaction cost economics, the choice of an organizational arrangement reciprocally influences the nature and characteristics of investments made".

The present work differs from the literature described above and its achievements. The methodology of empirical TCE, previously applied to other industries, will now be applied to railways with the purpose of supporting or rejecting the issues developed by railway economists: among others, while citing Coase, Pittman didn't formalize the TCE statements and didn't check them empirically. Actually, no comprehensive detailed empirical TCE studies were done in railway sector. The present paper will partially fill this gap applying empirical TCE to the data on Eastern European and former Soviet railways.

3. Theoretical background

Transaction costs economics are based on the assumption that there is a cost of using the price mechanism (market) and that there is also a cost of internal organization. The choice of a certain governance form (i.e. market, hybrid, or hierarchy) is made on a comparison of the respective sum of production and transaction costs. In a world without any transaction costs, organizational choice does not matter.

Oliver Williamson formalized TCE focusing on transaction attributes (i.e. frequency, uncertainty, assets specificity) which determine transaction costs of an organizational form. Frequency has

ambiguous effects on contractual choices (Crocker and Masten (1996)): on the one hand, a high frequency may support the setup costs of specialized governance; on the other hand, it has better reputation effect properties that limit the interest of such a specialized governance structure (Williamson (1999)). A higher uncertainty usually brings the transaction inside the firm because market relationships are not guaranteed. Assets specificity refers to the degree to which a durable asset can be redeployed to alternative uses or to alternative users without sacrifice of productive value; higher assets specificity leads to higher transaction costs of market interaction, i.e. integration becomes more attractive.

Summarizing, the assets specificity increases transaction costs of the "buy" decision and correspondingly increases the probability to integrate; the same is true for uncertainty: a higher uncertainty leads to integration rather separation. As for frequency, the theory doesn't predict its clear impact on the governance form in terms of separation or integration.

Depending on the combination of uncertainty, frequency and assets specificity, the manager chooses the organizational form which optimizes expected benefits, i.e. minimizes costs – production costs as well as transaction costs affected by the transaction characteristics. There exist two pole organizational forms (market and hierarchy). On anonymous spot markets the price reflects the value of the good. Spot markets have the advantage that firms get to specialize in doing what they do best; innovation is generated by numerous sources. The opposite pole of governance is vertical integration. Vertical integration enables efficient responses to changing environments where coordinated adaptation is necessary. Organizing transactions within a hierarchy is efficient, if specialized investments have to be realized and contracts would be unavoidably incomplete. Between the two poles hybrid forms of governance, like complex contracts or partial ownership arrangements, are possible.

When testing the governance hypotheses, it is often left aside that management decisions are endogenous to their expected performance implications and not simply depend on transaction characteristics. Managers will usually choose a strategy for which they expect the highest performance resulting in the so called "self-selection bias". Here, the empirical TCE distinguishes between "first generation empirical tests" and "second generation empirical tests", the latter

attempt to correct this bias. In the next section, these two types of empirical tests are presented in details.

4. Methodological basis

The 'traditional' empirical approach in TCE, or the first generation tests, consists in evaluating the probability that contracting (market) will be chosen over alternative governance form (integrated firm) and then investigating whether the evidence is consistent with TCE predictions regarding, for instance, the benefits of long term contracting in the presence of relationship-specific investments (Masten and Saussier (2002)). Therefore, the usual econometric tests of the TCE propositions are indirect. They show that contractual choices correspond to what the theory advocates and then infer from this result that these choices are efficient (that transaction costs are minimized). But they rarely investigate "how much we lose by going from the best to the next best [contractual arrangement]" (Joskow (1991)).

In order to overcome the problem of indirect tests of reduced form models predicting only differential effects, it is necessary to relate performance values (mirroring transaction costs) directly to organizational choices. "Second generation" empirical works not only test the TCE hypothesis according to which firms' organizational choices depend on the features of their transactional environment, what we call the "first order hypothesis" of TCE, but also investigate whether deviation from TCE principles (i.e. choosing not the best strategy given certain transaction characteristics) leads to poorer performance, what we call the "misalignment hypothesis". These tests account for expected performance of the organizational form and for endogeneity between transaction characteristics, strategy choice and expected performance.

Putting it more formally, in the first generation empirical tests, in the most general form, the decision to choose a governance structure (firm vs. contracting on the market) represents a standard discrete choice problem. Transactors will choose one governance structure if the expected gains (net of transaction costs) from doing so are greater than those of organizing the transaction in some other way. The first generation of empirical tests – which have been employed in several hundreds of empirical studies – is based on indirect tests formulating the (often make-or-buy) decision as a dichotomous choice variable:

$$S^* = \begin{cases} S^C, if & \pi^C > \pi^A \\ S^A, if & \pi^C < \pi^A \end{cases},$$

where G* represents the chosen organizational form – S^C may represent contracting, S^A an alternative, and π^i is the transactor's expected performance under the respective organizational form. To test such a theory, one has to relate the expected values (i.e. benefits and costs) of alternative organizational arrangements to observable transaction attributes, which can be expressed in the form of a vector X. Hence,

$$\pi^C = \pi^C(X, \varepsilon^C)$$
$$\pi^A = \pi^A(X, \varepsilon^A)$$

with e^i being stochastic disturbances reflecting omitted variables or decision maker misperceptions about the true values of π^i. For simplicity we might assume linear relationships with $\pi^C = \beta^C X + \varepsilon^C$ and $\pi^A = \beta^A X + \varepsilon^A$ and we can define the probability that a certain contracting decision S^C is chosen:

$$\Pr(S^* = S^C) = \Pr(\pi^C > \pi^A) = \Pr(\varepsilon^A - \varepsilon^C < (\beta^A - \beta^C)X)$$

This means that for cases where the effect on the expected value of a transaction organized under governance mode "C" (beta) is larger than the expected value under the alternative governance mode "A" (alpha), the likelihood that we will observe "C" is higher. First generation empirical tests predict this differential effect (beta minus alpha) by applying qualitative economic models (e.g. probit or logit estimations with the chosen governance form as exogenous variable) and in fact can say nothing about the respective signs of these two coefficients. Here, we assume that transaction costs are minimized – the firm behaves optimally from the TCE perspective. Such binary choice models calculate coefficients in the form of $(\beta^C - \beta^A)/\sigma$ with σ^2 being the variance of the difference of the error terms ε^i.

"Second generation" empirical works try to answer a more precise, from a governance choice perspective, question: "How does the performance of a firm that adopted a particular organizational

arrangement compare with how that same firm would have performed had it adopted an alternative?"

As before, let's represent a binary organizational strategy set (S^C, S^A) corresponding to the "make or buy" issue and the respective performance outcome (π^C, π^A). Let's also suppose we observe (S^C, π^C) and (S^A, π^A). We would like to estimate what their performance might have been choosing another strategy and what is the impact of a set of exogenous variables X. That is, we want to check whether the strategy choice is "mistaken", taking into consideration the performance which could be obtained given certain transaction attributes.

We want to estimate, as before, the following equations:

$\pi^C = \beta^C X + \varepsilon^C$ and $\pi^A = \beta^A X + \varepsilon^A$.

These equations may be estimated by OLS, using the sub-samples of firms choosing both strategies only to the extent that all exogenous relevant variables are well known by the econometrician and that the set of observations is a random sample of all observations.

Nevertheless, it is usual to suppose the existence of unobservable variables that affect performance outcomes and that are also correlated with the organizational choice. And it can be obviously assumed that a firm that chose organizational choice S^C may differ from a randomly selected firm in the population of firms; we call it "self-selection bias". Following Hamilton and Nickerson (2003), the estimation approach depends on whether such unobservable variables exist and whether organizational choices are endogenous or not. If all variables that affect both performance and organizational choices are not known or organizational choices are not exogenous, then, using OLS could lead to a potential endogeneity problem. Here, we need to control for such endogenity using sophisticated econometric techniques like the Heckman procedures (see Hamilton and Nickerson (2003)). Such procedure allows to account for the impact of the transaction characteristics on performance (on the market or in the firm) while simultaneously correcting for the sample bias in the estimates.

Applying the Heckman procedure enables us to estimate the parameter values of the structural form model (i.e. alpha and beta) as well as to account for the endogeneity of organizational choice due to

self selection. At the first step, a reduced form of the organizational choice model is estimated (so called selection equation) and inverse Mills ratios are constructed. At the second step, performance equations including the inverse Mills ratio as an additional regressor are estimated using OLS. Hence, given that performance is not a strictly exogenous variable and we will have trouble with error terms which are not i.i.d. anymore, we have to construct the inverse Mills ratio for correction.

The Mills ratio is used to correct the error terms when the dependent variable (strategy choice) is a binary variable and the performance is not exogenous. It is argued that there occurs a certain "self-selection" into the strategy, where the manager expects the higher performance – like the example of a fisher and a hunter: the hunter becomes a hunter because he knows that he is better in hunting than in fishing. And this is exactly the same for a firm's decision on strategy choice (e.g. vertical integration or separation decision).

The inclusion of the inverse Mills ratio leads to expected values of the error terms equaling zero by construction; OLS estimation will result in unbiased estimates of all parameters (i.e. coefficients and sigmas). The parameter estimates of the inverse Mills ratio also have an interesting interpretation; one can discover whether positive or negative selection into the respective strategies takes place and may detect situations of comparative advantage with firms having above average performance in their chosen strategy/form of organization. We could compare the performance directly if we could observe performance of the same railway at the same time using different strategies, i.e. $\Delta = \pi_{Cit} - \pi_{Ait}$, S={A,C}. However, it's never possible because each productive entity applies only one strategy at a given period t.

How to construct Mills ratio? This issue is addressed by Hamilton and Nickerson (2003).

First, given that we have a binary variable for strategy choice, i.e. a kind of limited dependent variable, we model it as a continuous latent variable S_i^*, implying that S_1 is chosen if S_i^* passes a certain threshold, while S_0 is chosen if it doesn't. If both strategy choice and performance are continuous variables, this can be done with the use of other econometric methods, including instrumental variables, two-stage least squares, three-stage least squares (or simultaneous equations

techniques) which allow to model simultaneously numerous economic relationships.

Let's suppose that the strategy choice is a function of 3 factors: (1) the expected net benefit, what we call "performance," of implementing strategy S_1 versus S_0, (2) covariates Z_i representing factors that affect strategy choice but don't affect outcome performance directly, (3) ϑ_i which represents unobserved factors influencing the choice. Therefore the strategy choice is defined as:

$$S_i^* = \gamma(\pi_{1i} - \pi_{0i}) + Z_i\delta + \vartheta_i$$

where $S_i = 1$ if $S_i^* > 0$; $S_i = 0$ if $S_i^* \leq 0$.

The parameter γ measures the extent to which the effect of strategy on profit directly influences strategy choice. Of course, the problem in estimating this equation is that π_{1i} and π_{0i} are not observed for each firm simultaneously. Knowing that $\pi_{1i} = X_i\beta_1 + \varepsilon_{1i}$ and $\pi_{0i} = X_i\beta_0 + \varepsilon_{0i}$, we come to the reduced form model of strategy choice:

$$S_i^* = \gamma(X_i\beta_1 - X_i\beta_0) + Z_i\delta + \gamma(\varepsilon_{1i} - \varepsilon_{0i}) + \vartheta_i, \text{ or}$$

$$S_i^* = X_i\beta + Z_i\delta + \theta_i$$

where $\theta_i = \gamma(\varepsilon_{1i} - \varepsilon_{0i}) + \vartheta_i$ and $\beta = \gamma(\beta_1 - \beta_0)$.

Heckman and Lee assumed that ε_{1i}, ε_{0i} and ϑ_i are jointly normally distributed so that expressions for $E(\varepsilon_{1i} \mid S_1)$ and $E(\varepsilon_{0i} \mid S_0)$ are tractable. Endogeneity arises if $\sigma_{u1} \neq 0$ or $\sigma_{u0} \neq 0$.

$$Cov(u_i, \varepsilon_{i1}, \varepsilon_{i0}) = \begin{bmatrix} 1 & \sigma_{u1} & \sigma_{u0} \\ & \sigma_{11} & \sigma_{10} \\ & & \sigma_{00} \end{bmatrix}$$

The model assumes that $\sigma_{10} = 0$ as well, which implies that unobservables for π_{1i} are uncorrelated with unobservables for π_{0i}, because π_{1i} and π_{0i} cannot be simultaneously observed for firm i in cross-sectional data (neither in panel data if we assume that a firm

applies only one strategy at one period of time). Exogenous treatment arises if $\sigma_{u1} = \sigma_{u0} = 0$.

Under these assumptions, the expected value of the error term when choosing S_1, conditional on choosing strategy S_1, may be written as:

$$E(\varepsilon_{1i} \mid S_1) = E(\varepsilon_{1i} \mid S^* > 0) =$$
$$= -\sigma_{u1}\phi[X_i\beta + Z_i\delta] / \Phi[X_i\beta + Z_i\delta] = -\sigma_{u1}\lambda_{1i},$$

where ϕ[.] is the normal density and Φ[.] is the cumulative normal distribution. The term $\lambda = \phi[.]/\Phi[.]$ is called the inverse Mills ratio. Similarly, the expected value of the error term when choosing S_0, conditional on choosing strategy S_0, is:

$$E(\varepsilon_{0i} \mid S_0) = E(\varepsilon_{0i} \mid S^* \le 0) =$$
$$= -\sigma_{u0}\phi[X_i\beta + Z_i\delta] / (1 - \Phi[X_i\beta + Z_i\delta]) = \sigma_{u0}\lambda_{0i}.$$

If strategy choice is exogenous, so that $\sigma_{u1} = \sigma_{u0} = 0$, then the expected values of error terms are zero, and our estimations of the treatment effect are not biased. If strategy choice in endogenous, we must construct the inverse Mills ratios, which is problematic because β and δ are unknown. Fortunately, we can recover estimates of β and δ by estimating the reduced-form strategy choice equation via a probit regression. Having obtained these corrected estimates, sample selection-corrected performance equations can be estimated using OLS:

$$\pi_{1i} = X_i\beta_1 - \sigma_{u1}\phi[X_i\hat{\beta} + Z_i\hat{\delta}] / \Phi[X_i\hat{\beta} + Z_i\hat{\delta}] + e_{1i}$$

$$\pi_{0i} = X_i\beta_0 + \sigma_{u0}\phi[X_i\hat{\beta} + Z_i\hat{\delta}] / (1 - \Phi[X_i\hat{\beta} + Z_i\hat{\delta}]) + e_{0i}$$

These equations together with $S_i^* = \gamma(X_i\beta_1 - X_i\beta_0) + Z_i\delta + \gamma(\varepsilon_{1i} - \varepsilon_{0i}) + \vartheta_i$ are called "switching regression model" in labor econometrics. By construction, the expected values of the error terms e_{1i} and e_{0i} (conditional on X_i) are both zero due to the inclusion of the inverse Mills ratio terms, so that OLS estimation yields unbiased estimates of all β and δ. Before adding the Mills ratio, error terms were correlated with regressors X_i, and estimations of β were biased. Introducing an additional term into the

regression, the Mills ratio, we eliminated correlation of error terms with regressors. That is, our estimation approach proceeds in two steps. First, we estimate the reduced form strategy choice equation via probit and construct the inverse Mills ratio terms. Second, we estimate the strategy-specific equations via OLS, including the inverse Mills ratio terms as regressors along with X in order to obtain unbiased estimates of β.

The use of panel data can partially solve the problem: it may omit the need for instrumental variables or may give better information about firm's performance under different strategy regimes. However, panel data models have their own assumptions which may make an obstacle to the purposes of strategy choice evaluation. First, the unobservables that affect performance under strategy choice S_1 are assumed to be the same as those influencing performance under S_0, i.e. would have the same effect under both strategies. Second, the error term is often assumed to consist of a time-invariant, firm-specific component, and a time-varying one that is uncorrelated across periods. This can be solved by the use of fixed-effects model which allows for correlation of the firm-specific time-invariant component with control variables and strategy choices. Finally, the coefficients relating the covariates to performance for each strategy are usually restricted to be equal, i.e. the treatment effect is assumed to be homogenous across firms and the covariates have the same impact on performance for both strategies.

Even though more and more papers account for endogeneity, there are also numerous studies ignoring this issue. Hamilton and Nickerson (2003) found that "of the 421 empirical papers published in the Strategic Management Journal (out of 601) between January, 1990, and December, 2001, we identify only 27 papers that explicitly econometrically correct for potential endogeneity concerns".

5. TCE in railways

In railways, the problem arises when "steel meets steel" (Pittman (2005)). A track operator can make certain investments to improve efficiency and performance, but the realization of these benefits depends significantly on actions taken by the train operator. Correspondingly, a train operator can make certain investments to improve efficiency and performance, but the realization of these benefits depends significantly on actions taken by the track operator. The actions

in both directions are difficult to specify in a contract, difficult to observe and evaluate, and subject to shirking and opportunism. If contracting is not feasible and if the policy maker nevertheless forces the two sides to interact by contract, there is a risk of underinvestment on both sides, and economic welfare will suffer as a result. "The railways sector, then, may be a textbook example of the type of sector where the combination of relationship-specific investments, opportunistic behavior, and bounded rationality regarding a technologically complex environment would seem, under the transactions costs framework, to call for vertical integration of operations" (Pittman (2007)).

Given all this, it seems unsurprising that the worldwide experience with vertical separation and third party access in the railway sector has brought ambiguous results. There has been an increase in the transparency of operations and thus an improved ability to target infrastructure subsidies (as in Sweden), but the level of competition created on the track has not been considerably increased (as in Germany and the Netherlands) and there have been serious problems with creating the proper incentives for maintaining and improving the infrastructure. The latter created the underinvestment problems in the UK in the 2001 and finally lead to serious railways accidents. The objective of maintaining and restructuring the old infrastructure seems likely to be also especially important in Russia and CIS countries, as well as in the Eastern European countries, where infrastructure degradation over the recent past is a serious problem and where long-term government subsidies for infrastructure are generally insufficient.

It is not clear yet what is to be gained, other than transparency, from the splitting off of operations such as repair facilities, stations management and other from the main enterprise. So far there seems to be no indication that the creation of competitive conditions for these support services is a high priority (Pittman (2007)). Gomez-Ibanez and de Rus (2006) also state that there is no uncontestable evidence that vertical separation improves performance; instead, the worldwide railway reforming experience demonstrate that, in general, vertically integrated railways are found to perform better.

In this paper, we evaluate organizational decisions of Eastern European and former Soviet railways. We look at railway incumbent monopolists which were initially vertically integrated: whether they separated infrastructure management from operation or not. We don't take into consideration independent operators which own some rolling

stock. Instead, we are interested in strategic decisions of railways which had to decide about legal separation, given that it was the mainstream reform trend in Europe (even in a less strong form).

6. Empirical analysis

6.1. Methodology

We proceed in 2 steps. First, we apply probit estimation to the strategy choice equation in order to recover β and δ and to construct the inverse Mills ratio. Then, at the second step, using the results that we got at the first step, we estimate performance equations including Mills ratio for self-selection bias correction and finally answer the question what would have be the performance if the firms choosing some strategy S_i have chosen the strategy S_j.

1. The first step is analogous to so-called first-generation empirical tests. We estimate the impact of transactions characteristics (frequency, uncertainty, assets specificity) on the governance choice without taking into account the fact that the strategy is chosen in function of expected performance, i.e. we estimate only the differential effect of transaction attributes on the probability of a certain strategic decision.

We estimate a simple probit regression where the dependent variable is VERT_SEP (0 if the railway is vertically integrated, 1 if legal separation took place) and where the characteristics of transactions are proxied as will be indicated below.

2. At the second step, using the results obtained at the first step, we estimate the relationship between governance choice and performance, i.e. we answer the question what would happen if the firms applying actually the strategy "integrate" have implied the strategy "separate".

We use the methodology of Heckman and Lee described above in order to cope with the problem of endogeneity: strategy choice is not exogenous since managers rarely make decisions randomly; they take into account the expected performance. At the same time, the strategy choice depends on transaction characteristics. There are also some factors (control variables) which affect both the strategy choice and the performance. But the effect of control variables may be different across firms for 2 different samples (according to 2 different governance

choices), it is not homogenous. I.e. we assume that strategic decisions are taken taking into consideration expected benefits.

The Heckman and Lee method helps to eliminate the interdependence of error terms of the two regressions if we estimated 2 samples separately. The calculation of inverse Mills ratio and its introduction into the performance equation allows us to construct selection-corrected equations (which we will call "switching regression model") and estimate them by OLS.

6.2. Data

Our data panel covers 12 years (1996-2007) and 28 railway incumbents operating in Eastern Europe and in the former Soviet republics, 26 countries in total: Russia, Ukraine, Belarus, Moldova, Georgia, Armenia, Azerbaijan, Uzbekistan, Tajikistan, Turkmenistan, Kazakhstan, Kirghizstan, Latvia, Lithuania, Estonia, Czech Republic, Slovak Republic, Hungary (2 railway companies), Poland, Bulgaria, Romania, Albania, Macedonia, Croatia, Slovenia, Bosnia-Herzegovina (2 railway companies). The empirical analysis is performed with an unbalanced panel data, the total number of observations equals to 296.

It is worth noting that all these companies, with the exception of Estonia for a certain period of time[14], are publicly owned. Any decision is thus always taken by the single owner – the government, i.e. the internal management decision, is these cases, corresponds to government decision, which would seem to be imposed from above.

The railway companies considered in this study are quite heterogeneous. This heterogeneity is due to different environmental, topographical, technological and regulatory factors as well as different institutional and legislative frameworks. Nevertheless, the common characteristic of these companies is that they operate in countries that were under Soviet influence or control. All companies included in the sample are multi-output companies which provide two services: freight and passenger transportations.

Table 1 contains some descriptive statistics.

[14] Estonian railway was privatized and then sold back to the state because the privatization didn't bring the expected results in terms of performance and investment.

Table 1: Sample descriptive statistics

	Network length	Staff	Network density	Share of electrified lines	Virtual tkm divided by the number of wagons	Number of employees per 1 km of lines	Employee productivity	Average lead, freight	Average lead, passengers
Min	220	1794	2,09	0	0,08	3,46	19,93	0,02	19,49
Max	92217	1436300	120,45	1	11,63	21,14	3199,70	1465,90	785,07
Mean	7558,58	89097,66	33,49	0,36	1,27	9,15	461,14	299,08	100,23
Median	2322	17208	27,18	0,34	0,80	8,23	313,63	224,59	69,68
St. dev.	15959,87	229808,80	29,02	0,28	1,52	3,45	458,99	259,67	107,84
Russia (RZD)	86451,10	1242204	5,06	0,48	3,41	14,38	1347,66	1354,16	119,27
Kazakhstan (KTZ)	13738,91	119368	5,05	0,28	2,01	8,71	1235,68	701,58	566,85
Armenia (ARM)	844,40	4575	27,30	0,95	0,18	5,42	93,94	221,02	40,02
Estonia (EVR)	969,90	5360	21,48	0,14	2,20	5,51	1718,71	199,71	48,07
Poland (PKP)	21133,08	171014	66,85	0,56	1,12	8,00	446,72	295,63	71,44
Romania (CFR)	11166,17	92701	46,80	0,35	0,50	8,26	319,58	248,49	89,83
Albania (HSH)	442,42	2562	15,33	0,00	0,23	5,78	50,91	70,63	51,91

* Descriptive statistics: over the whole sample

** Country data: average across the period in question

The data are taken from the annual reports of the UIC (Union Internationale des Chemins de Fer), from the data published by the World Bank Railways Database and World Bank Governance Indicators Database (WGI). The WGI indicators contain missing values for some years; the gaps were filled by extrapolation of available data.

6.3. Variables

In order to apply so called second-generation empirical tests, we should construct 2 groups of variables:

- Transaction characteristics (frequency, uncertainty and assets specificity);
- Control variables which affect both the strategy choice and the performance.

Besides, a performance measure (dependent variable) has to be chosen.

Variables of each group are listed in the table below. Then, a discussion of the choice of variables follows.

Table 2: Variables and their predicted signs

Category and variable		Expected result	
Binary strategy variable: VERT_SEP = 1 if legal separation took place, 0 if the company is vertically integrated			
Performance variable: EMPROD (employee productivity)			
		The impact on the strategy choice	The impact on the performance
Frequency			
VTKM_WAG	Virtual tkm divided by the aggregate wagon measure	?	
Uncertainty			
REGQUAL	Quality of regulation	+	
Assets specificity			
ELECTR	Share of electrified lines	-	
NETWDENS	Network density	-	
EMPKM	Employee per km of lines	-	
Control variables			
GDP	Gross domestic product		+
USSR	Dummy variable, 1 for former USSR members, 0 otherwise		?
AVLEADF	Average lead, freight		-
AVLEADP	Average lead, passenger		+

Frequency

The theory doesn't give any clear predictions concerning the frequency of transactions (Crocker and Masten (1996)). From one hand, the more frequent transactions are, the higher is the reputation effect and the lower is the need for activity internalization. From the other hand, in the case of frequent transactions, integration may be preferred because it reduces transaction costs of market interaction (the number of interactions is high).

The frequency of transactions is difficult to instrument because it's not directly correlated with the organizational form: the decision about vertical integration or separation is usually taken by government, while the intensity of railway activity depends mostly on the demand for transportations. From the other side, we can say that for such public enterprises as railways the demand, to a certain extent, is also determined by government and its universal service obligations.

Here, the frequency of transaction is reflected by the intensity of the use of railways. A relative productive measure can be taken, such as virtual tone-km, divided either by network length or by the number of wagons. Measures normalized by the number of wagons would be preferred: thus we evaluate the frequency of transactions of an isolated railway firm because we take into account only its own wagons, we create a measure of the intensity of use of company's rolling stock providing a certain amount of virtual tkm (VTKM_WAG). In the case of open access to infrastructure, the normalization of virtual tkm of a railway by the length of total railway network in the country (used by several railway companies) doesn't make sense.

Uncertainty

The theory assumes that a more risky environment leads to a higher degree of activity internalization. Here, three of the Worldwide Governance Indicators (WGI) of the World Bank could be used: Political stability and absence of violence/terrorism, Government effectiveness and Regulatory quality.

Given that these three variables are highly correlated (pair-wise correlation more than 70%), the simultaneous inclusion of two or three of them will lead to multicollinearity, i.e. we have to choose among them the best indicator of uncertainty (or stability). We decided to use the variable "Regulatory quality" (REGQUAL) because it not only

reflects the political or economic stability in the country, but also covers the regulatory aspects, which is crucially important if we analyze railways reforms[15].

"Regulatory Quality" measures the ability of the government to implement regulatory measures and promote private sector development. Higher regulatory quality implies lower uncertainty and will lead to higher degree of vertical separation because market rules will be better established. That is, the sign is expected to be positive.

Assets specificity

Among the three transactions characteristics, asset specificity is the most difficult to measure. Investments in specific assets are defined as "durable investments that are undertaken in support of particular transactions, the opportunity cost of which investments is much lower in best alternative uses or by alternative users should the original transaction be prematurely terminated" (see Williamson (1985)). Assets specificity increases the interdependence of contracting parties. It is likely that the more specific the investments are, the more probable is the vertical integration, especially in the case of an uncertain and unstable environment.

Williamson (1983) defines five types of specificity: site specificity (assets placed in close proximity in order to minimize transportation or time costs or to benefit from complementary advantages), physical assets specificity (assets' value in alternative uses is much lower), dedicated assets (investments in assets dedicated to a certain trading partner that otherwise would not be made), human assets specificity (human capital evolving due to learning of individuals), and intangible assets (for example brands).

Among the common proxies Klein and Shelanski (1995) mention component complexity and R&D expenditure as proxies for physical asset specificity, worker-specific knowledge as a proxy for human asset specificity, and physical proximity of contracting firms as a proxy for site specificity. Other proxies, such as fixed costs or capital intensity, are rarely used. Another concern is that asset-specificity effects may be

[15] "Political Stability and Absence of Violence/Terrorism" measures the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means.
"Government Effectiveness" measures the quality of public services and their independence from political pressures, as well as the quality of public policy and the credibility of the government.

confused with market power. While specific investment may lead to bilateral monopoly, the existence of a small-numbers bargaining situation is not by itself evidence of relationship-specific investment (Klein and Shelanski (1995)).

Physical assets specificity is very important on railways because the construction of new railway lines requires huge sunk investment. The investing party faces the risk to be held up by the other party in the extent of appropriable quasi rents. The lower the extent of quasi rents the more likely is a contractual solution, the higher the extent of quasi rents the more likely is integration. Specific investments under uncertainty lead to a strong incentive to internalize transactions.

The best measure for assets specificity in railways would be the degree of assets redeployability (see Menard and Yvrande-Billon (2005)), but the data on different types of freight wagons or locomotives and the diversity of their use is not available in the sample used. We have to use some other proxies reflecting the technical aspect of the production process.

The first measure of assets specificity that we use is the share of electrified lines (ELECTR). The electrification can be considered as a huge sunk investment, the electrified lines can't be used for purposes other than circulation of electric locomotives. According to the estimations of Ukrainian railways experts, the cost of electrification of 1 km of lines is about $160 thousand. They assume that the optimal share of electrified lines is about 50-55% of total lines, while 90% of total freight transportations are made by electrified lines (RZD-Partner).

Another measure of assets specificity is the density of network (NETWDENS). The construction of the network is a sunk investment as well. This is also a measure of physical assets specificity. However, the effect may be doubtful: in the case of vertical separation and existence of several independent operators, the network may be used by all of them.

Finally, we use the indicator of the number of employees per km of lines (EMPKM). This covers the use of labor for infrastructure maintenance and rehabilitation. Low numbers indicate more intensive use of mechanical maintenance. It may be considered as a measure of assets specificity, i.e. we expect its impact on the probability of vertical separation to be negative. But from one hand, a lower number of employees per km means a higher use of mechanical inputs and sunk investment in the machinery (positive sign), while from the other hand, a higher number of employees per km means a higher investment in human assets (negative sign).

Masten, Mehan and Snyder (1991) found that "integration becomes more likely in the presence of relationship-specific human capital" and the firms are "less likely to integrate engineering-intensive activities and more likely to internalize labor-intensive ones". That is, they also predict a negative sign of the human assets specificity coefficient.

Control variables

Control variables are assumed to affect both performance and strategy choice.

GDP and USSR variables control for the importance of topographical and politico-economic situation. We may assume that countries of the former Soviet Union don't tend to implement vertical separation, instead, those of the Eastern Europe try to adjust to European rules and norms. However, we can't make definite predictions about its impact on the railway performance. As for GDP, the predicted sign is positive: the higher is the level of economic development in a country, the higher is the performance of its railway incumbent.

Freight and passenger transportations represent different markets, and different regulatory measures are applied to these different market segments. The distinction between the role of freight and passenger transportations is made by using the measures of average lead, or average journey distance (AVLEADF and AVLEADP). They are calculated as tonne-km divided by tonnes and passenger-km divided by passengers respectively, and measures the average distance that a shipment or passenger travels. This measure can significantly influence the competitive position of freight transportations by railway, as rail's competitive advantage comes into play more strongly at longer distances: organization of railway transportations in reasonable when the distance is more than ca. 500 km (Pittman (2001)) because of the time lost for loading wagons, especially in the case of intermodal transportations.

According to the president of RZD Vladimir Yakunin, the increase of AVLEADF has a negative impact on the profitability of freight transportations because it decreases the turnover of rolling stock (this means that we expect a negative impact of AVLEADF on performance), i.e. increases the need in fleet units (Yakunin, RZD-Partner). On shorter distances there is less need in rolling stock, and

even a small enterprise can operate, i.e. on shorter distances, huge incumbent railway will suffer more from competition.

For passengers, rail faces auto and bus competition for short trips and air competition at long trips. The analysis of European railway market puts in evidence that passenger railway transportations are most efficient when the travel time is about 2,5-3 hours, i.e. high-speed train services are reasonable on distances of 300 to 800 km. In such cases, railway transport is more competitive than air transport. Recent data show that, in Western Europe, about 60-85% of passengers use high-speed train services (RZD-Partner).

If the railway exhibits a relatively short length of average trip (<50 km or so), then the railway would normally be carrying a high percentage of suburban passengers. A railway with a long passenger trip length (>400 km) would typically indicate a large country in which the railway is not carrying a high proportion of suburban passengers.

Unfortunately, the data doesn't allow to distinguish between short-length commuter and regional trains (which are usually not profitable and subsidized) and long-distance trains (which are relatively more profitable). The profitability and the level of competition (intramodal, from high-speed high-class trains, and intermodal, from airlines) are different on these 2 segments. The longer is the distance, the higher is the competition, the more is the propensity to remain integrated for the incumbent in order to survive: getting high profits on long-distance segment, it can provide non-profitable short-distance transportations. At the same time, a higher average lead of passenger transportations may mean a lower share of unprofitable short-distance transportations and consequently a higher performance.

As the dependent variable which measure productivity we use the indicator of employee productivity (EMPROD) taken from the World Bank railway database. It is measures as the ratio TU/employee, where TU is the sum of passenger-km and freight tone-km. Labor costs are the largest cost item for all railways, so the output per employee is one of the fundamental measures of performance.

6.4. The model

SIMPLE PROBIT

At the first step, we estimate the equation:

Strategy = S (frequency, uncertainty, assets specificity),

The strategy in our case is a binary variable VERT_SEP which is equal to zero if the railway is vertically integrated and 1 if legal separation took place. The frequency of transactions is proxied by the variable VTKM_WAG. To model assets specificity, we used NETWDENS, EMPKM and ELECTR. For uncertainty (or stability in our case), we use the variable REGQUAL. I.e. we estimate the equation:

$$VERT\_SEP_{it} = \beta_0 + \beta_1 REGQUAL_{it} + \beta_2 EMPKM_{it} + \beta_3 ELECTR_{it} + \\ + \beta_4 NETWDENS_{it} + \beta_5 VTKM\_WAG_{it} + \varepsilon_{it}$$

SECOND GENERATION TESTS

Here, we relate performance values directly to organizational choices. We assume that the manager (the government in our case), when choosing a strategy, takes into account the expected performance which depends on the strategy choice. We have to estimate 2 equations:

Strategy = S (frequency, uncertainty, assets specificity),

Performance = Π (strategy, control variables)

Transaction characteristics (frequency, uncertainty, assets specificity) are defined as at the previous step. As for control variables, we use the following measures: AVLEADF, AVLEADP, USSR and GDP, and EMPROD as a measure of performance. We use the inverse Mills-ratio methodology described above. I.e. we estimate the equations:

$$VERT\_SEP_{it} = \beta_0 + \beta_1 REGQUAL_{it} + \beta_2 EMPKM_{it} + \beta_3 ELECTR_{it} + \\ + \beta_4 NETWDENS_{it} + \beta_5 VTKM\_WAG_{it} + \varepsilon_{it}$$

$$EMPROD_{it} = \alpha_0 + \alpha_1 VERT\_SEP_{it} + \alpha_2 AVLEADF_{it} + \alpha_3 AVLEADP_{it} + \\ + \alpha_4 USSR_{it} + \alpha_5 GDP_{it} + \zeta_{it}$$

6.5. Results

First-step estimation results, when the performance doesn't come into play, are shown in Table 3. The table contains 3 possible specifications, they all could be acceptable, but the third one (M3) seems to be the most reasonable. However, they are persistent to these small

modifications: the all give very similar results for coefficients and their significance.

Table 3: Results of the first step (p-values in parentheses)

	Variables	M1	M2	M3
Uncertainty	REGQUAL	2,805 (0,001)	3,240 (0,000)	2,734 (0,000)
Assets specificity	EMPKM	-0,764 (0,000)	-0,699 (0,000)	-0,679 (0,000)
	ELECTR	2,936 (0,137)	2,975 (0,119)	-
	NETWDENS	0,022 (0,210)	-	-
Frequency	VTKM_WAG	-0,179 (0,508)	-0,263 (0,310)	-0,171 (0,496)
Pseudo R^2		0,44	0,43	0,42

As expected, in a more certain environment (REGQUAL is an inverse measure of uncertainty) vertical separation is more probable. The frequency of transactions, instead, reduces the intention to keep a vertically integrated structure, probably because of the reputation effect and well functioning interconnections. But the variable reflecting frequency (VTKM_WAG) didn't brought significant results in any of the three model specifications, i.e. it doesn't really matter when choosing the governance form. The sign of human assets specificity (EMPKM) also corresponds to the one predicted by the theory: the more specific are the assets, the less probable is vertical integration. However, in the case of physical assets, the data doesn't reveal any highly significant dependence, and the positive signs of the ELECTR and NETWDENS variables, even if only slightly significant, contradict to the theory.

The non-significant coefficient of the ELECTR variable reveals an interesting fact: the investment in electrification, although considerable, is not specific to some type of railway transportations; moreover, it's not specific to railway activity in general. For instance, the communications constructed for railway purposes can be later used for telephony or internet: it's much cheaper and easier to put new cables (e.g. for telecom) on the already existing ways instead of creating a new line in the middle of wood, mountains or even a city landscape.

A similar explanation can be provided for the positive coefficient of the NETWDENS variable: the denser is the network, the larger are

the possibilities of its alternative use, that is, the less is the risk of a hold-up and the less is the intention to remain integrated.

If we look at outliers (the observations for which $|\hat{VERT\_SEP} - VERT\_SEP|$ is maximal), we discover among them the following railways: the Romanian railway, the ZBH of Bosnia-Herzegovina, the MAV of Hungary, the Estonian railway, the Latvian railway and the Slovenian railway. I.e. these are the railways which have probably adopted the "wrong" strategy from the point of view of transaction costs economics, which haven't taken into account the institutional environment in terms of uncertainty, frequency of transactions and assets specificity. In the case of Romania and Estonia it could be, as mentioned by Diaconu et al. (2007), "more catholic than the Pope": they went too far and too fast in their desire to implement legal separation.

The second step was to take into account the expected performance and, using the results of the first step, to construct the inverse Mills ratios for self-selection bias correction, to answer the questions whether there is a positive or negative self-selection among the firms choosing a certain strategy. We present here the results for all the three model specifications (M1, M2 and M3) and, again, find them persistent independently of the specification.

Table 4: Results of the second step (p-values in parentheses)

Variables	Strategy 1 (legal separation)	Strategy 0 (vertical integration)
M1		
GDP	0,053 (0,031)	0,079 (0,000)
USSR	1801,227 (0,000)	237,983 (0,005)
AVLEADF	-1,931 (0,161)	0,351 (0,000)
AVLEADP	7,825 (0,034)	2,288 (0,000)
Mills ratio	32,121 (0,507)	-90,469 (0,048)
σ_U	240,593	180,713
R-squared within between overall	 0,184 0,881 0,794	 0,592 0,599 0,638
M2		
GDP	0,050	0,082

	(0,041)	(0,000)
USSR	1806,744 (0,000)	237,830 (0,004)
AVLEADF	-1,958 (0,157)	0,351 (0,000)
AVLEADP	7,967 (0,032)	2,280 (0,000)
Mills ratio	40,231 (0,412)	-90,469 (0,015)
σ_U	242,918	180,537
R-squared within between overall	 0,186 0,883 0,797	 0,595 0,604 0,642
M3		
GDP	0,049 (0,050)	0,081 (0,000)
USSR	1808,452 (0,000)	238,185 (0,005)
AVLEADF	-2,066 (0,128)	0,352 (0,000)
AVLEADP	8,093 (0,027)	2,287 (0,000)
Mills ratio	44,639 (0,394)	-81,018 (0,028)
σ_U	232,414	181,991
R-squared within between overall	 0,184 0,885 0,799	 0,594 0,602 0,640

We talk about self-selection bias if the coefficients of Mills ratio are significantly different from 0. If the coefficient for S_0 (vertical integration) is significantly negative, this means that firms tend to choose S_0 when unobserved conditions are such that choosing this strategy brings them higher performance; instead, these unobservable characteristics would have lead to a lower performance if they have chosen S_1 (legal separation). Correspondingly, firms self-select in a rational way, following unobserved conditions, when the difference of Mills ratio coefficients Mills0-Mills1<0, as we can observe in our case, whatever is the model chosen (M1, M2 or M3). I.e., if we take into consideration unobserved conditions, the firms try to choose the solution which will allow them to obtain the highest performance if this difference is negative. In our case, we have a self-selection bias, from the point of view of unobservables, in favour of S_0, i.e. vertically integrated companies.

The sigmas tell us about comparative advantages. In all of the three models, we have $\sigma_{u1} > 0$ which means that there is negative selection into strategy, i.e. firms choosing S1 (legal separation) have below average performance. In the case $\sigma_{u0} > 0$ we have positive selection into strategy S_0 (vertical integration). Putting together, the S_0 firms possess the absolute advantage: firms choosing S_0 have above average performance regardless of the strategy chosen, i.e. even if this sub-sample of firms had chosen S_1, they would still perform better.

If we now look at control variables, we can observe different signs and different levels of significance of coefficients, which proves theoretical assumptions of the TCE that strategy choices of the two groups are affected by different factors. For instance, in both samples we note a higher performance of former Soviet railways and a higher performance of more developed countries (higher GDP per capita). Average lead in freight transportations, instead, has different signs in the two samples: it is negative, as predicted, and weakly significant for separated railways and positive and significant for integrated ones, i.e. competitive advantages of railways at long distances are remarkable only for vertically integrated railways, while vertically separated railways loose their performance on longer distances. The positive sign of average lead in passenger transportations supports the statement about non-profitable short-distance (commuter or regional) transportations: when short-distance transportations prevail, the performance is relatively lower, and it's true for both sub-samples.

7. Conclusions

In this paper, the basic statements of transaction costs economics have been empirically tested on the sample of Eastern European and former Soviet railways. The idea was to investigate how the transactions characteristics – frequency, uncertainty and assets specificity – determine the governance form, i.e. how they impact the decision to separate or keep integrated initially vertically integrated railway incumbents. Another aspect to cover was to take into account the expected performance when taking a governance decision and detect whether there is a self-selection bias in strategy choices of vertically integrated or vertically separated railways. For this purpose, so called "second generation tests" of the transaction costs economics were applied.

The results in general correspond to theory predictions. Uncertainty and assets specificity have the predicted signs, while the

frequency is found to be not significant (probably this is due to the lack of good instruments). If we take into account the expected performance depending on governance structure, we discover, first, that the results differ for two samples (vertically integrated vs. separated railways), and second, that integrated firms are absolutely advantageous: firms which were in the strategy sample "to remain integrated" have above average performance regardless anyway, even if they would have chosen the strategy "to separate".

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