EFFICIENCY OF RAILWAYS: DOES POLICY MATTER?

by

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Abstract

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Railway industry reforms, recently undertaken in dozens of developed and developing countries attracted attention of many scholars. The current study attempts to assess the results of railway reforms in some European countries by determining their impact on the technical efficiency of railroads. This paper stresses the sensitivity of such analysis to choosing the methodological tools and country-specific controls. The empirical evidence supports the hypothesized positive impact of reforms on the performance of railways only when transition countries are benchmarked against each other. In the case of the whole Europe, per capita GDP and market share were found to be the main determinants of the efficiency of railways.

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Chapter 1

INTRODUCTION

About three decades ago railways throughout the world were regarded as natural monopolies, and therefore have been state owned. Poor economic performance of railroads in most industrial countries led to a decrease of the market share in favor of other kinds of transport in both freight and passenger traffic. At the same time liberalization of trade and globalization resulted in an enormous increase in consumer demand and made the need of reforms crucial. In the early eighties some pioneer restructuring was implemented in the United States, followed by New Zealand, Sweden, United Kingdom and, further, by all Western European countries. In most countries the undertaken reforms, which primarily consisted of privatization, separation of infrastructure from services, introduction of the third party access, and reduction of government regulation, are still in progress, but even current results are impressive (see Table 1).

Table 1. Railway asset utilization (ton km+ pass km per track km [000])

	Before Restructuring	After Restructuring[1]
Argentina	567	543
Canada CN	2000	3955
Canada CP	2400	2883
Japan	9600	13618
Sweden	2000	2482
Great Britain	2800	2857
United States	5200	8643

Notes: [1]Most recent year available
Source: Kopicki and Thompson (2000)

The positive example of Europe and North America inspired other countries, and now railroad restructuring takes place in Latin America, China, Central and Eastern Europe (CEE) and Commonwealth of Independent States (CIS).

In this paper we will focus on assessment of railway reforms in CEE and CIS countries. Before the start of transition railroads played a key role among all transportation services in these countries. This was determined by a number of reasons: railway transport was dominant in the USSR, railways used domestically produced fuel, automobile roads were of low quality and the network was poorly developed, etc. After collapse of the Soviet Union, transition countries faced a huge recession that directly influenced the performance of the railway sector. Broken economic ties, enormous decline in output, and poor management stipulated for the significant fall in freight traffic: after a decade of transition it has reached, on average, only 42 percent of its 1988 level for freight traffic and 50 percent for passenger traffic (ECMT, 2001). In every country railway restructuring, as well as the overall transition process, follows its own path. Some countries, first of all EU candidates, succeeded in putting their railroads close to European standards; another ones, such as Belarus, still suffer from inefficient soviet-type railways and only start developing plans for railroad restructuring.

In the past, few scholars tried to study a statistical relationship between performance of railways and different kinds of policies applied in the industry. By now I am aware of five papers in this field: Oum and Yu (1994), Gathon and Pestieau (1995), Cantos et al (2001), Friebel et al (2003), and Friederszick et al (2003). In all cases but for Oum and Yu (1994) authors used *only* policy variables in explaining efficiency of railways and, not surprisingly, discovered that performance of railways is significantly dependant on the progress of railroad reforms in the country.

While all the previous authors looked only at developed countries, I decided to develop this trend in the field of transportation research by evaluating railroad reforms in transition countries. In particular, I assess railway performance by benchmarking railways in transition countries against each other and against railways of Western European countries by means of Data Envelopment Analysis (DEA). I use frequently quoted in the literature two-stage method of estimating efficiency: DEA efficiency scores, obtained at the first stage, are then regressed on the different environmental variables, including policy. The main contributions are as follows: i) my sample includes both developed and emerging countries; ii) I compiled a new dataset which allows using country-level data, while previous authors refer to the company-level data; iii) on the second stage of my analysis I use a fixed effects truncated regression model which accounts for country-specific effects.

My findings report that railroads of countries succeeding in the reforms in the field indeed seem to perform better in comparison with others.

However, not reforms but country-specific and railway-specific factors, such as income, market share, etc. are determining railway's well-being. As an example, I consider the case of Ukrainian Railway, which performs far better then railroads of many EU and EU-candidate countries despite its "C" grade for railway restructuring status. (EBRD, 2001)

Chapter 2 reviews the related literature. Chapters 3 and 4 discuss some theoretical and methodological issues concerned with Data Envelopment Analysis and specification of the regression model. Data and empirical results are presented in sections 5 and 6 accordingly. Chapter 7 focuses on situation on the Ukrainian railway, and Chapter 8 concludes.

Chapter 2

LITERATURE REVIEW

Since the beginning of the railway restructuring boom a lot of research has been done in this area. However, most papers can be regarded as descriptive: the authors analyze the process of reforms in different countries with all its advantages and weaknesses.

Kopicki and Thompson (2000) published a very detailed paper, which included theoretical concepts of railway restructuring as well as case studies of reforms in Japan, Sweden, Argentina, New Zealand, UK, USA and Canada. The theoretical part of this research discusses issues on assets, liabilities, work force restructuring; deals with the organization and design of the intermediary institutions, which carry out most of the work of restructuring; and, finally, describes railway restructuring as a management process. On the basis of several case studies the authors try to single out specific techniques and policies implemented in the selected countries and generalize them for making further restructuring trials more painless. However, the authors underline that there is no universal remedy for every railway and argue that the process is inherently situation-specific and should be developed in the context of a particular railway system.

The best way of assessment of railway reforms is to evaluate performance of railroads operating under different environments, i.e. benchmark them. A number of papers devoted to "theory of benchmarking railroads" are worth mentioning here. Nash and Shires (1999) describe the main industry specific problems that a researcher can face while comparing railroads across the countries. The main difficulty in analyzing railway activity is the multiplicity of outputs. First of all it is crucial to distinguish between passenger and freight traffic because of their different nature in terms of demand, regulation, and costs. Representing both kinds of traffic as a single unit of measurement (so-called traffic units) may lead to biased efficiency estimates if railway increases one kind of traffic by reducing the other. However, even in the two-output specification case it is very hard to find a proper unit of measurement because of different nature of the products carried. If we use freight ton-km as output measure we do not capture for different costs of transporting products of different density: to deliver a ton of pop-corn will be far more costly then a ton of steel. In passenger transport these issues refer to long and short distance traffic: suburban train will be more efficient than intercity train if we measure output only by the number of carried passengers. More on output specification problems may be found in the paper by Cantos (2000), which is described below. Measuring inputs is also not as simple as seems to be: while physical measures of route, rolling stock and other assets do not take into account quality of these assets, measuring "value of capital stock will need to allow for excess capacity and inappropriate investment" (p. 121). Moreover, railways are not always free to provide efficient policies because of government regulation and powerful trade unions in this sector. Another problem is geographical characteristics of the environment: even in most thorough benchmarking it is almost impossible to capture effects of relief, climate, complexity of network – the factors that have a considerable impact on costs. The last and the most important environmental variable is different legal framework, which has impact on the railway performance. Assessment of this impact is the primary subject of my study.

In the case of railroads relative performance can be examined by means of different techniques. The easiest way to compare several railways is just to compare their partial productivity measures (PPM), such as Train-km/staff, Train-km/Track-km, Total Cost per Train-km, Revenue/Cost and so on. This method is very simple and understandable, but it has some shortcomings: (a) PPMs reflect only one specific relationship and do not provide us with the whole picture; and (b) one PPM may be increased by means of decreasing another one that in undesirable. PPMs were used by Dodgson et al (2000) in their consulting work for British Railtrack, Preston et al (1994), and by many other authors.

Another way of measuring relative performance of railways is calculating efficiency scores. According to the literature on efficiency and productivity analysis, efficiency can be estimated by a number of different techniques, however, Data Envelopment Analysis (DEA) and Stochastic Frontier Approach (SFA) seem to be the most popular ones in the field of railroad research. SFA is based on the construction of parametric frontier by specifying a concrete functional form for the technology. If we know this functional form we are supposed to obtain a precise results, but, in fact, distributional assumptions to be made in most cases are somewhat arbitrary (Cantos 2001). This issue is the main argument of supporters of the DEA approach, who estimate efficiency indicators without assuming any functional form for the technology. Some authors, however, argue that DEA approach has many weaknesses while comparing railways operating in different contexts and environments (IMPROVERAIL, 2002).

Oum and Yu (1994) were among the first who tried to explain the efficiency of railroads by policy variables. In their research authors estimated technical efficiency of 19 European railways by means of DEA. Oum and Yu argued that that the obtained efficiency scores did not reflect "true managerial efficiency" since they count for a number railway specific factors. To find this "residual efficiency", authors regressed their DEA efficiency estimates on some controllable and uncontrollable by railways variables, including traffic density, average length of passenger trip and freight haul, average passenger and freight load per train, and percentage of lines electrified. Two policy variables included in the analysis were percentage of subsidy in total operating costs and degree of managerial autonomy. The data on the latter variable was available only for a single year and was supposed to remain unchanged during the whole period under consideration (12 years). This assumption seems to be very questionable, especially when policy analysis is the main aim of the study. It's hard to believe that degree of managerial autonomy remained the same during eighties, while many European countries started active reforms in the railway sector namely at this time. Findings of Oum and Yu support theoretical ineffectiveness of regulation in the railroad industry: railway companies with lower managerial independence and higher ratio of subsidies to costs tend to be less efficient then others.

Cantos et al (2001) also used DEA for measuring railway efficiency. The list of inputs included staff, rolling stock and track size, while the output vector was specified by passenger-km and freight ton-km. The aim of this study was the evaluation of recent reforms that took place in the railway sector of the 17 European countries by means of estimation of the revenue efficiency and its further decomposition into technical and allocative parts. That decomposition was useful in explaining the reasons of inefficiency (i.e. whether it was reached due to producing low output or making a wrong product mix). After computing efficiency for the six five-year periods, the authors tried to explain its path in the recent years by different reform indicators, such as degree of separation between infrastructure and services, level of regulation of passenger traffic, degree of state influence over railway investments, and level of privatization in the industry. The reported results, in principle, coincide with theory: all four kinds of reforms were found to be in the significant positive relationship with technical efficiency. Separation of infrastructure from services had the strongest influence on railway's performance: it gave the best explanation of increases in both revenue and technical efficiency.

Another interesting aspect of Cantos' paper is the choice of output specification. Grounding his preferences Cantos refers to his previous paper (Cantos et al, 2000) solely devoted to this problem. Most authors measure output by passenger-kilometers and ton-kilometers, however, this way of measurement is optimal only when government regulation is weak. Railways, especially passenger ones, are not always profit-maximizers because of their crucial social role: very often railway companies are forced by the government to make some runs, even if they are unprofitable. In this case freight and passenger train kilometers seem to be better proxies for output. In their research the authors estimate technical efficiency of the 17 European railways (the same sample was used in Cantos, 2001) using both kinds of output measurement. The findings of this paper tell us that using different output specifications for estimation of the railway's efficiency may lead to quite different results; however, this result can be harmonized by introducing a load factor, i.e. an average ratio of the number of passengers (tons of freight) to the capacity of a carriage. The paper concludes that dealing with railways a researcher should be careful in his choice output specification and interpretation of the results.

Besides Cantos, we can also mention some other recent papers, which studied the impact of reforms on the performance of railways. Friderizick et al (2003) by means of SFA found that state aid has a positive effect on the technical efficiency of railroads but aid intensity (aid divided by total operating costs) has a negative influence. The authors argue that state aid itself is not a cure in the case of the railway industry: for progressive reforms it should be efficiently combined with other ways of financing. Friebel et al (2003) investigated the impact of separation, government regulation and introduction of third party access on technical efficiency of 12 European railways. The main finding of the paper is that for obtaining good results railway reforms should be gradual (i.e., introducing multiple reform packages at the same time may even decrease efficiency).

As far as we can see different authors use different approaches to estimating efficiency of railways. Coelli and Perelman (1998) compared the results obtained by different methods: SFA, DEA and Corrected Ordinary Least Squares (COLS). They found that technical efficiency indicators of the 17 European railways estimated by each of the above methods are strongly positively correlated with a high level of significance. Thus, either of the techniques will provide a researcher with quite similar results. Referring to the time series forecasting literature, the authors suppose that the best estimators can be obtained by averaging the results obtained by different methods: in this case efficiency indicators are going to be more precise than those estimated by any specific technique.

Now it is time to turn east. Since most transition countries are far behind their western neighbors in restructuring railroads, we can find only few papers devoted to the railway reforms in CEE and CIS countries.

"What Role for the Railways in Eastern Europe?" (ECMT, 2001), the most substantial work in this field, consists of four reports prepared by different authors. Conclusions made by all authors can be summarized as follows:

a) Progress in railway reforms is quite different across the transition countries: CEE railways, as a rule, doing much better then CIS ones;
b) Infrastructure development in CEE countries will go along with economic growth, and even in the case of successful railway reforms trains will gradually loose part of their market share to cars, buses, trucks, planes and cargo boats;
c) In the predictable future railways will be still extremely important in CIS countries despite some decrease in traffic;

Carbajo and Sakatsume (2003) wrote a detailed paper on railway reform in several transition countries, namely Poland, Romania, Russia, Kazakhstan, and Ukraine. The authors analyze speed and scope of reforms and come up with conclusions similar to the previous paper. A great advantage of this work is a careful study and description of current legislation in the selected countries.

One more available paper on Ukrainian railway is the one published by Institute of Economic Research and Policy Consulting in Ukraine (IER) (2001). The paper is mostly devoted to tariff regulation of domestic railroad.

As one can see available papers on CEE and CIS railroads are mainly descriptive. My work will be the first one that provides some systematic analysis and evaluates railway reforms on the comparative basis.

Chapter 3

THEORY

As was already mentioned, railways in this study are benchmarked by means of Data Envelopment Analysis, the idea of which was proposed by Farrell (1957), and then extended by Charnes et. al (1978). The core of DEA consists of modeling technology as the smallest convex free disposal hull over the data (Zelenyuk, 2004). The main advantages of DEA over parametric techniques are:

a) it is not necessary to make any assumptions on functional form for the technology;
b) it is not necessary to assume cost-minimizing behavior of firms. Relaxing this assumption is especially helpful in the case of railways, which are heavily regulated;
c) DEA allows for economies of scale;
d) it is not necessary to make assumptions on the distribution of the disturbance term

DEA allows solving problems for both input and output oriented frontiers. In the former case it is assumed that a firm tries to reduce inputs for production of a fixed amount of output, while in the latter output is maximized holding inputs constant. There is no agreement among the researchers on whether railways are more consistent with the input or output oriented case. This question was highlighted by Coelli and Perelman (1999), where authors solved both problems. On one hand, a railway company can hardly manage with its inputs since its behavior is constrained by governmental control over investment and labor policy decisions. On the other hand, railway services, especially freight traffic, seem to be a demand driven industry: output of railways is an exogenous variable since a railway company produces a determined quantity of services necessary for meeting the demand. In contrast to Cantos (2001), who solves output-oriented problem, this work takes output as given. Demand side of the railway business is a very complex problem, concerned with issues of marketing, pricing, and quality of services, aimed at meeting consumers' need for railway services. Thus, this study concentrates on the supply side of the railway industry by determining how efficiently a railway company manages its inputs to produce some predetermined amount of output.

To start the theoretical analysis of the problem we need to impose some assumptions on the production process of railways. In general, all the firms under consideration are assumed to operate on some technology set T[1], which can be defined as

$$T \equiv \{(x, y) \in R_+^N \times R_+^M : \mathrm{x} \in R_+^N \text{ can produce } y \in R_+^M \}. \qquad (1)$$

Technology can also be characterized by either the input requirement set or the output set. Output set is a multitude of all possible combinations of outputs *y* for any given input vector *x:*

$$P(x) = \{ y \in R_+^M : x \in R_+^N \text{ can produce } y \in R_+^M \} \qquad (2)$$

[1] To be more precise, all firms may not possess the same technology. However, we assume that all firms have access to the same technology

Alternatively, for any given output vector *y* there is a number of all possible combinations of inputs *x* which make an input requirement set:

$$L(y) = \{x \in R_+^N : x \in R_+^N \text{can produce } y \in R_+^M\} \qquad (3)$$

Technology, which can be equivalently characterized by any of the three sets, is assumed to satisfy basic axioms of the production theory (Fare and Primont, 1995):

1) $0_M \in P(x), \text{for } \forall x \in R_+^N$: producing nothing is possible;

2) $y \notin P(0_N), \forall y \geq 0_M$: any positive amount of output cannot be produced out of zero amount of inputs;

3) $x^0 \in L(y) \Rightarrow x \in L(y), \forall x \geq x^0, y \in R_+^M$: if a firm can produce some amount of output *y* from x^0 amount of input, it should produce at least the same *y* after increase in any of inputs[1]

4) $y^0 \in P(x) \Rightarrow y \in P(x), \forall y \leq y^0, x \in R_+^N$: if some amount of inputs *x* is used for producing *y,* it can be still used for producing any lower amount of output $y^0 < y$

5) P(x) and L(y) are closed sets

6) P(x) is bounded: unlimited levels of output cannot be produced from a given set of inputs

[1] By imposing this assumption ("Strong Disposability of Inputs") we are ignoring congestion: in the real world a solid increase in rolling stock may lead to a fall in output, because capacity of rail network is fixed

Technical efficiency concept, a simple case of which is illustrated on Figure 1, was introduced by Farrell (1957). In this example under assumption of constant returns to scale efficiency of the firm P is determined by ratio 0Q/0P – the radial decrease in inputs necessary for reaching the frontier SS'. At point Q this firm needs minimal amount of inputs to produce the same level output.

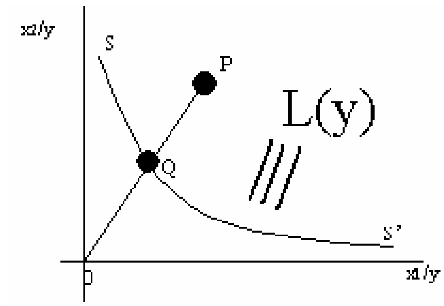

Figure 1. Technical Efficiency for Input Oriented Problem

In general case input oriented Farrell technical efficiency is defined as

$$T\hat{E}_i(x^j, y^j) = \min_{\theta, z_1 \dots, z_n} \{\theta : (\theta x^j, y^j) \in \hat{T}_i\}. \qquad (4)$$

The technology T_i may be estimated may be estimated by a number of techniques including DEA. The following linear programming model describes a general DEA problem:

$$\begin{aligned} & T\hat{E}_i(x^j, y^j) = \min_{\theta, z_1 \dots, z_n} \{\theta : (\theta x^j, y^j) \in \hat{T}_l\}., \\ & st \\ & -y_m^j + \sum_{k=1}^{N} z^k y_m^k \geq 0, \quad m = 1, \dots, M \\ & \theta x_i^j - \sum_{k=1}^{N} z^k x_i^k \geq 0, \quad i = 1, \dots, K \\ & z^k \geq 0, \quad k = 1, \dots, N \\ & \sum_{k=1}^{N} z^k = 1 \end{aligned} \qquad (5)$$

where N is the number of firms, K and M is the number of inputs x and outputs y respectively, z is a N×1 vector of constants, and θ is an efficiency score, which is by construction grater then zero and does not exceed unity. It is necessary to solve N such problems for obtaining efficiency scores for every firm in the sample. Intuition behind this model is very simple: the firm *i* tries to cut its inputs in a radial fashion while remaining in the input set. The last term of (5) allows for measuring economies of scale that is crucial in the case of railways. Nash and Shires (1999) argue that namely joint costs and economies of scale are one of the characteristics that make measurement of railway performance particularly complex.

Chapter 4

METHODOLOGY

4.1. Specification of the DEA Model

As was mentioned above, in this study I estimate Farrell input oriented technical efficiency imposing VRS assumption. My model includes four inputs and two outputs. The list of inputs consists of total number of locomotives, sum of passenger and freight wagons, railway staff, and total length of track, while two outputs are number of passenger-kilometers (Pkm) and freight ton-kilometers (Tkm). This output specification is regarded as "revenue output measure" (Oum and Yu, 1994, p.122), since it reflects the actual amount of services consumed by passengers and freight customers. Another available measure of output, which reflects the measure of capacity supplied, is passenger and freight train-kilometers (Train-km). This specification allows for an efficient railway company running empty trains since actual number of passengers and freight carried is not taken into account. Train kilometers were included in my analysis as an alternative output measure: in one of my samples I compute efficiency scores under both specifications and then compare the results. I should also mention that applying DEA assumes homogenous quality of inputs and outputs used in the production process. In the case of railways, implying this assumption leaves no place for counting for speed of traffic on the first stage of our analysis. High-speed trains allow for increasing capacity of any given railway junction that will bring a higher level of output and, hence, higher efficiency.

Ideally, high-speed traffic should be included to the second stage of analysis as an environmental variable; however, this kind of data is unavailable at the moment.

4.2. Regression Analysis

After estimation of the efficiency we may proceed with the second stage of analysis – determining the impact of different environmental variables on the technical efficiency scores. At this stage researchers often use Tobit regression models, arguing that simple OLS may provide one with biased results because efficiency scores are truncated variables. Truncation above at unity implies that:

$$\begin{cases} y = y^{*}, y^{*} \leq 1 \\ \text{not observed, otherwise} \end{cases} \tag{6}$$

Indeed, efficiency is truncated, since firms above the frontier simply do not exist due to feasibility assumption of the DEA estimator. Truncation is often confused with the Tobit censoring, which implies that observations beyond some threshold (point of censoring) are mapped into a single value. Censoring above at unity can be written as

$$\begin{cases} y = y^{*}, y < 1 \\ \text{y} = 1, \text{otherwise} \end{cases} \tag{7}$$

It is hard to say why in most previous studies (Cantos, 2001; Oum and Yu, 1994) authors used Tobit models while arguing that their data is truncated.

Simar and Wilson (2003) have shown explicitly that truncated regression models perform much better than Tobit models in dealing with two-stage problems. However, both methods will provide a researcher with biased results since DEA efficiency scores, estimated at the first stage, are correlated with unknown structure of the correlation. According to Simar and Wilson (2003), the best way to cope with this problem is to use truncated regression model with double bootstrap bias correction mechanism: on the basis of Monte-Carlo experiments this technique has shown the best results in terms of coverage of confidence intervals.

Another methodological problem is the choice of proper technical tool for dealing with the panel data. A very short period under consideration (the pioneer reforms started no more than 20 years ago) and small sample of countries, where reforms take place and data on these reforms is publicly available, leave no place for performing any thorough cross-sectional or time series analysis, hence, aggregating data to a panel seems to be the best choice in this situation. Oum and Yu (1994) assumed that there were no country specific effects in their model and used just pooled Tobit in their estimations. This assumption may be questioned because many explanatory variables exhibit little or no change during the whole period. For example, degree of managerial autonomy was fixed during all 12 years since data on this variable was available only for a single year. Cantos (2001) used a set of time dummies "not to confuse the effect of reforms with possible effects common to all countries, e.g. due to the economic cycle". Capturing time effects may be important when we are looking at the performance of railways during three decades; however, in the case of including only time dummies, country specific factors are ignored again.

After performing a careful analysis of the previous studies and the data I possess, I decided to apply a truncated regression model, in which I included country specific dummies. In the past some scholars argued that fixed effects (FE) MLE models suffered from "incidental parameters problem" (see Wooldbridge, 2002). However, there was little evidence on the behavior the MLE/FE estimators until Greene (2004), who used Monte Carlo experiments to test this hypothesis. Greene (2004) found that FE Tobit and truncated models, unlike binary choice models, exhibit almost zero bias in the slope coefficients. A small bias, however, still exists in the estimators of the disturbance variance. This bias will affect estimated marginal effects if the number of time periods is small, but even for five time periods "MLE/FE estimator performs quite well". At this stage I report the results without bias correction proposed by Simar and Wilson (2003), however, performing a bootstrap for this purpose is one of the supposed future developments of this research.

In our case the truncated fixed effects regression will look like

$$INEFF_{it} = \begin{cases} \beta_0 * POLICY_{it} + \beta_1 * GDP_{it} + \beta_2 * URBAN_{it} + \beta_3 * SHARE_{it} + \\ \quad + \beta_4 * ELECTRO_{it} + \boldsymbol{\alpha}\mathbf{D} + u_{it}, \text{ if } INEFF_{it} \geq 0; \\ \text{Not observed, otherwise} \end{cases} \quad (8)$$

where

$INEFF_{it}$ - measure of railway's *i* inefficiency in period *t* computed as

INEFF= $-Log(\hat{TE}_{it})$, $INEFF_{it} \in (0,+\infty)$; $\hat{TE}_{it}$ is technical efficiency score estimated at the first stage

$POLICY_{it}$ – expert assessment of railway reform progress in the country *i* in period *t*.

GDP_{it} – per capita GDP in the country *i* in period *t*.

$URBAN_{it}$ – degree of urbanization in the country *i* in period *t*.

$SHARE_{it}$ – fall in the market share since 1990 in the country *i* in period *t*.

$ELECTRO_{it}$ – percentage of lines electrified in the country *i* in period *t*.

$\boldsymbol{\alpha}$ – N×1 vector of individual fixed effects; N – number of countries

D – N times N*T dummy variables; T – number of time periods

u_{it} – disturbance term which is supposed to have Truncated Normal Distribution

Under the main hypothesis reforms in railway sector should have a positive impact on the efficiency of railways. Obviously, policy variable cannot be regarded as the only determinant of the technical efficiency of railways. Therefore I include four more country specific explanatory variables, which may influence efficiency, namely per capita GDP, degree of urbanization, fall in the market share since 1990, and percentage of lines electrified. These variables are expected to have the following impact on the dependent variable:

a) Per capita GDP was introduced into the model as a proxy for demand. Countries with higher income tend to have higher demand for both passenger and freight railway traffic (Bennathan et al, 1992) that, in turn, is expected to increase railway's efficiency.

b) Degree of urbanization is supposed to proxy a load factor for passenger traffic. The more people live in the city the higher number of "people per train" is expected to be due to the extremely intensive suburban traffic. Heavy loaded trains should decrease efficiency if output is measured in train-kilometers and, conversely, increase efficiency if passenger-kilometers and ton-kilometers are chosen as output specification.

c) Percentage of lines electrified should influence efficiency of railways in the same direction as per capita GDP. Electrified route allows for increasing traffic density, since an electric locomotive is faster than a diesel or steam one.

d) Fall in the market share of freight traffic since 1990 shows how heavily a country relies on railway shipments in comparison with road shipments. This measure of performance of railways is relative (to trucks), since absolute effects are captured by GDP variable. Fall in the market share is supposed to decrease efficiency.

Chapter 5

DATA

Unfortunately, the lack of complete and reliable rail data remains the main problem of any research in the field. In the previous studies most authors used Union Internationale des Chemins de Fer (UIC) data on railway companies, since complete country-level dataset, which includes *all* European countries can be hardly found. There are two reasons for this. First, due to the nature of transition process some transition countries did not provide appropriate international institutions with accurate data. Second, after beginning of restructuring, many developed countries count for dozens of railway companies operating within the state, thus, collecting and aggregating information on all the railway operators is not an easy task. As a consequence, most of the available data sources are incomplete and inconsistent. As far as I used many data sources in this paper, I often faced with contradictions even in the datasets provided by the same institution. In this case I analyzed all the available information and included the most appropriate and reliable observation. As a result, I compiled a new dataset, which contains information on railroads of 31 European country for years 1993 through 2001, and I hope that these statistics will be useful in the future research in the field.

All the data used in this research may be divided into three categories: input and output data, policy data, and country-specific controls.

Input and output data includes railway staff, length of track, number of locomotives (including MU passenger fleet), freight wagons and passenger cars, number of passenger-kilometers and freight ton-kilometers, and, finally, number of passenger and freight train-kilometers. Most of the input and output information for this research was supplied by two institutions: Eurostat and UIC. The publication "European Union Energy and Transport in Figures" (2003) provides a rather full and reliable statistics, which, unfortunately, completely captures only 15 EU countries for the period from 1995 through 2001. Information on other countries was primarily taken from RAIL Information System and Analysis (RAILITSA) dataset available on UIC website. RAILITSA supplies information on all European countries, but for some of them the information is incomplete. Most of the gaps in RAILITSA data were filled by information from Railway Time Series Data (UIC, 2003). In this publication, which was kindly supplied to the author by the UIC statistical department, railway data is aggregated not by countries but by railway companies, that makes data analysis somewhat difficult. The list of companies represented in this publication is incomplete, hence, the data on railroads of selected countries does not always sum up to the correct country–level data. In the case of such discrepancies data was taken from other sources, such as UIC's annual reports, World Bank Railway Database, Statistical Trends in Transport (ECMT, 1995), IMPROVERAIL project, and national statistics and railway websites. Lastly, residual gaps, which made less than 0.5 percent of the total number of observations, were filled by means of simple linear approximation.

Table 2. Input and Output Data – Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
Route Length	8046.48	9390.95	274.00	41718.00
Staff	59469.53	86533.21	3031.00	456131.00
Total Wagons	44879.92	63502.20	1957.00	333457.00
Total Locomotives	2108.57	2721.35	71.00	13569.00
Ton-kilometers, 000	18600.00	34700.00	152.00	246000.00
Passenger-kilometers, 000	12700.00	19100.00	65.00	76000.00
Freight Train-kilometers	33120.09	46661.94	471.00	230598.00
Passenger Train-kilometers	88248.80	131877.20	1644.00	741011.00

The policy data includes: (a) information on enactments of laws concerned with vertical separation, increase in railways independence from governmental decisions, and privatization of railways; and (b) assessment of railway reform progress. The data on policies applied by different governments, was collected from the variety of sources. *De jure* implementation of reforms, i.e. years in which appropriate national legislative acts were introduced, is highlighted in the country overview sections of ECMT publications (1998, 2000, 2001) and Carbajo (2003) and supplemented with information from IMPROVERAIL (2002) and United Nations Inland Transport Committee reports. Policy evaluation scores, or *de facto* realization of reforms, were taken from Rail Restructuring in Europe (ECMT, 1998) and from EBRD Transition Reports (1998 - 2001). Since ECMT (1998) publication contains policy rankings only on 25 out of 31 countries, I filled all the missing gaps using information from the national legislation and other related literature. Despite the fact that I used the same ranking criteria as ECMT did, any policy evaluation is based on the subjective judgment, thus, I take all the responsibility for all grades for Norway, Luxembourg, Macedonia, Switzerland, Turkey, and Ukraine and selected grades for some other countries. All the policy data is listed in the tables A1-A3 of the Appendix A.

The data on per capita GDP and degree of urbanization was taken from the World Development Indicators (WDI) (World Bank, 2003). Per capita GDP was converted to constant 1995 US dollars. All the information necessary for estimation of the market share of freight railway traffic was found in WDI and European Union Energy and Transport in Figures (Eurostat, 2003). Market share of railways was estimated as a ratio of freight ton-kilometers delivered by railways to the sum of ton-kilometers shipped by railroads and trucks. Pipelines and maritime transport were not taken into account since they cannot be regarded as direct competitors of the railways. Moreover, most of the pipeline traffic in the Eastern Europe is transitory, hence, counting for it may curve the results. Information on the market share contains some gaps, since neither of the above-mentioned sources delivers full road freight traffic statistics for all countries and for all years. The observed data gaps were apparently caused by problems with data collection and cannot be regarded as systematically related to the phenomenon being modeled. Thus, according to Greene (2000), missing observations may be ignored without significant impact on the results of estimations. Finally, the data on percentage of route electrified was taken from the Railway Time Series Data (UIC, 2003).

Table 3. Country-Specific Data – Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
GDP per capita, USD	16109.48	14559.07	623.23	56381.98
Degree of Urbanization,%	0.684	0.123	0.416	0.974
Market share, %	.3433	0.247	.018	.905
Lines electrified,%	.4159314	0.261	0	.997

Chapter 6

RESULTS

6.1. Transition Countries

Firstly, I estimated DEA efficiency scores for 18 transition countries for years 1998 through 2001, descriptive statistics of which can be found in the Table 4. (Full results were put to the Table A4 of the Appendix A). Six out of eighteen countries were efficient during almost all the period, namely Estonia, Latvia, Hungary, Ukraine, Macedonia, and Bosnia.

Table 4. DEA Efficiency Estimates for 18 countries, 4 years – Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	# of Efficient DMUs
Eff	72	0.813	0.182	25

Good performance of the first three countries is not surprising since they are one of the top progressing countries in Eastern Europe in putting their railways in accordance with EU standards. High efficiency score for Ukraine may be explained by high industrialization, large size of the country, and heavy reliance on domestic railways. Detailed discussion of the issues concerned with the Ukrainian railway is provided in the Section 7 of this work. Poor results of other EU candidates raise too many questions for further analysis: it is evident that estimated technical efficiency does not count for a number of factors. One of the ways of solving this problem is to regress obtained efficiency scores on some environmental variables, which are supposed to affect the efficiency of each observation. Estimated coefficients then allow correcting efficiency scores for the impact of environmental factors. The list of environmental variables includes railway reform progress, which is proxied by EBRD Railway Reform Indicator, per capita GDP, degree of urbanization, fall in the market share, and percentage of lines electrified. Table 5 presents the results. Unfortunately, due to the lack of data on passenger and freight train kilometers for some transition countries, it was possible to compute efficiency only for revenue output specification. As was reported in the Methodology section, I use fixed effects truncated regression as the main tool in my analysis. Despite standard F Test cannot reject the hypothesis of joint significance of country dummies, I decided to compare my results with simple pooled truncated estimation. I also tried fixed effects, random effects, and pooled Tobit models for performing some kind of "robustness check": The final results may be regarded as trustworthy, if different econometric techniques, which violate different assumptions, give at least qualitatively similar results.

Table 5. Estimation output for 18 countries, 4 years

Model	Reforms	Pecent of Lines Electr.	GDP pc	Fall in the Market Share	Degree of Urbanization	Constant
Truncated, FE	0.1***	-0.6	0.078	-0.262	0.099	-----
Tobit, FE	-0.02	0.304	0.044	0.057	19.534	-----
Truncated, Pooled	0.238*	-0.161	0.014	0.127	0.266	-1.15*
Tobit, Pooled	0.061	0.099	-0.004	-0.494	0.485	-0.59*
Tobit, RE	0.042**	0.107***	0.008**	-0.06	0.742*	-0.843*

Notes: Dependent variable is inefficiency score defined as $Ineff_{it} = -Log(TE_{it}(x,y))$
The signs of the coefficients were then reversed for the easiness of interpretation
Significance at: * - 1%, ** - 5%, *** - 10%

On the whole, the variable representing reforms seems to be the only one that justifies our expectations: reforms in the railway sector have a positive impact on the efficiency of railroads. According to these results, a unit increase in the grade for reforms (i.e. getting B instead of C grade) leads to a ten percent raise in the efficiency score. Two out of four added models also support findings of Truncated FE estimation. The other four variables were found to have no effect on the efficiency of railways because of their low statistical sense. I also tried a simple OLS model, in which I regressed Malmquist productivity indexes on the same explanatory variables taken in first differences. The results of this estimation also support my hypothesis on positive and significant impact of reforms on technical efficiency of railways, while other explanatory variables turned to be insignificant as in the previous estimations. I attempted to include country size and "being a EU candidate" dummy in the truncated FE model. Theoretically, these variables may explain railway efficiency, but they also demonstrate no statistical significance. Despite our theory is poorly supported by the data, it is still hard to believe that policy is "all that matters". One of the possible explanations of these results is that my theory does not work when transition countries are benchmarked against other transition countries.

6.2. European Countries

To deal with this problem I repeated all the estimations for the extended sample of countries: I added 17 Western European states but excluded Caucasus Republics and Bosnia, since data necessary for estimation of efficiency scores for these countries was available only from the year 1998. Table 6 presents descriptive statistics of efficiency scores for extended sample, while full results for both output specifications are available in the Tables A5 and A6 of the Appendix. A

Table 6. DEA efficiency estimates for 31 countries, 9 years – Descriptive Statistics

Output spec.	# of Obs.	Mean	Std. Dev.	# of Efficient DMUs
Pkm&Tkm	279	0.799	0.223	123
Train-km	279	0.809	0.200	114

This time the results seem to be more corresponding to our expectations. In Pkm and Tkm output specification model Estonia, Latvia, Macedonia, Ukraine, and 10 developed countries were found to be efficient. All other transition countries included to this sample exhibited extremely poor efficiency scores averaging as low as to 0.5. The fact that all previous best practice railways from «transition» sample but for Hungary are still efficient even when compared to developed railroads stresses a high gap in performance between these states and other transition countries. One more interesting detail observed is the consequences of unification of Eastern and Western Germany in 1993. After railways merged it took less then two years to rebuild them and raise efficiency from 0.58 to unity.

If output is specified in train-km the picture changes somewhat. Railroads of Denmark, France, Germany, Ireland, Luxembourg, Macedonia, Netherlands, Spain, Sweden, and Switzerland remained efficient during almost all the period, while railways of Ukraine, Latvia, and Italy left the best practice group. Three railways, namely Slovenian, Norwegian, and Austrian, enlarged group of efficient companies under this output specification. Railways inefficient when output is measured in Pkm and Tkm but efficient in alternative specification are the main candidates for been marked as "regulated", since running a lot of low loaded trains does not coincide with cost minimizing behavior.

After computing the efficiency scores I repeated the same estimations as for previous sample. Unfortunately, I was unable to find a proper proxy for reforms in the railroad industry, which could capture all countries and all years of this model. The only available outcome in this situation is to use another country-level policy variable, which, by construction, is low relevant to the reforms in the railway sector but could be highly correlated with railroad-policy variable if such existed. At the current stage of this research I included to the regression the indicator of Regulatory Quality provided by the World Bank. According to the World Bank's official cite

> *Regulatory Quality* focuses more on the policies themselves, including measures of the incidence of market-unfriendly policies such as price controls or inadequate bank supervision, as well as perceptions of the burdens imposed by excessive regulation in areas such as foreign trade and business development.

The Regulatory Quality index is available only for years 1996 through 2001; hence, years 1993, 1994, and 1995 were not included into regression. The correlation of this variable with the EBRD Railway Reform Restructuring

Index is 0.6. Reforms, proxied by the Regulatory Quality indicator, were found to have no impact on the railway's performance in this sample. The results are presented in the Table 7.

As it can be easily seen, after including to the analysis some developed countries, per capita GDP and fall in the market share demonstrate highly significant expected effect on the railway's efficiency scores under any estimation technique been applied. According to the truncated FE model, a coefficient for per capita GDP is .025 for the revenue output specification and 0.054 for the alternative specification. It can be interpreted as a one thousand increase in per capita GDP stipulates for a rise in consumer demand for passenger and freight traffic that is sufficient for a five percent increase in railway's efficiency when output is measured in train-km.

Table 7. Estimation output for 31 countries, 6 years

Model	Output spec.	Policy	GDP pc	Fall in the Market Share	Pecent of Lines Electr.	Degree of Urbanization	Constant
Truncated,FE	Train-km	-0.033	0.054**	-0.811*	-1.9	-0.356	---
	Pkm&Tkm	0.015	0.025**	-0.959*	-2.7*	1.665*	---
Tobit, FE	Train-km	-0.02	0.014	-1.019*	-0.409	-1.919***	---
	Pkm&Tkm	0.044	0.007	-0.899*	-2.236*	-0.227	---
Truncated,Pooled	Train-km	0.134*	0.006	-0.71*	0.119	0.033	-0.502*
	Pkm&Tkm	-0.121***	0.018*	-1.098*	-0.563*	0.135	-0.364**
Tobit, Pooled	Train-km	0.069	0.019*	-0.582**	0.082	-0.116	-0.401*
	Pkm&Tkm	-0.226*	0.022*	-2.018*	-0.6*	1.325*	-0.818*
Tobit, RE	Train-km	0.029***	0.002*	-0.152*	-0.078	-0.196**	-0.12425
	Pkm&Tkm	0.003	0.016*	-1.322*	-0.431*	0.236**	-0.45*

Notes: Dependent variable is inefficiency score defined as $Ineff_{it} = -Log(TE_{it}(x,y))$
The signs of the coefficients were then reversed for the easiness of interpretation
Significance at: * - 1%, ** - 5%, *** - 10%

In the case of revenue output specification identical increase in GDP leads to a lower increase in efficiency (only 2.5 percent), that can easily explained: the richer a county becomes, the higher attention is paid to the quality of services. An increase in the number of trains, which is one of the main quality indicators in the passenger traffic, inflates efficiency scores if output is measured in train-km.

Coefficient for market share implies that a one percentage point fall in the market share leads to approximately equal decrease in the efficiency score. Degree of urbanization follows our expectations only in terms for revenue output specification: if one percent of the population moves from countryside to city a railway is expected to become 1.7 percent more efficient. This works only for models where output is measured in ton-kilometers and passenger kilometers since heavy loaded trains decrease inefficiency by raising passenger output. I supposed that for the train-kilometers specification high suburban traffic would make railways less efficient, but the data confirmed this hypothesis only in terms of sign but not in terms of significance. In contrast to the theory developed in the Methodology section, percentage of lines electrified was found to have no impact on the performance of railways for the alternative output specification. For the revenue output specification the corresponding coefficient is negative and significant, that may be regarded as an unexpected result. It implies that highly electrified railroads are less efficient then low electrified, that contradicts my theory and findings of Oum and Yu (1994).

While interpreting the coefficients I considered only the behavior of 31 railroads included to my sample. If not these railways but *any* world railway makes some interest for us, i.e. we consider the whole population of railways, and the coefficients can be treated in the way described above only qualitatively. Numeric values can be obtained from marginal effects (MEs), which are represented in the Table 8.

Table 8. Truncated FE Model: Marginal Effects

Output Specification		GDP pc	Fall in the market Share	Degree of Urbanization	Policy
Train-km	Marginal effects	-0.052273**	0.7908599*	0.3477105	0.0318475
	Coefficient	-0.0535895**	0.8107786*	0.3564679	0.0326497
Pkm&Tkm	Marginal effects	-0.0248149**	0.9593736*	-1.663821*	-0.0152478
	Coefficient	-0.0248151**	0.9593816*	-1.663835*	-0.015248

Notes: Dependent variable is inefficiency score defined as $Ineff_{it} = -Log(TE_{it}(x,y))$
MEs were computed at the mean of independent variables
The signs of the coefficients were NOT reversed since MEs should be higher than the coefficients
Significance at: * - 1%, ** - 5%, *** - 10%

Another available policy data for this sample at the moment is four ECMT reform indicators for degree of vertical separation, degree of governmental influence, legal constitution status, and freedom of railways to set tariffs. This data was published only for year 1998 and I decided not to use it for the whole panel assuming its permanence as Oum and Yu (1994) did. Instead I run a cross-sectional regression, where I try to explain inefficiency of railways in 1998 by theses four reform indicators. In fact, this is a replication of Cantos' et al (2001) model, where he used the same variables in explaining efficiency of railroads. The main discrepancies are in data: while Cantos used data on 17 railway companies, my data is aggregated over countries. I extended list if countries by including 14 transition countries and Turkey but excluding United Kingdom[1]. Firstly, I used Tobit model to check the consistence of my findings with those of Cantos (2001). The results presented in the Table 9

Table 9. Tobit model estimation results: a single cross-section

Policy Variable	Tobit Model		Truncated Model	
	Train-km	Pkm&Tkm	Train-km	Pkm&Tkm
Legal Constitution	0.143035**	0.22752**	0.094921	0.035918
Vertical Separation	0.12839*	0.149702**	0.156238**	0.093479
Gov. Regulation	0.326087*	0.144221	0.062049	0.137919
Freedom to Set Tariffs	-0.0000356	-0.089378	0.038778	-0.070478
Constant	-1.523466*	-1.115023**	-0.84118	-0.127384

Notes: Significance at: * - 1%, ** - 5%, *** - 10%

Partially, my findings are similar to those of Cantos' (2001): degree of legal constitution and vertical separation has a strong positive impact inefficiency railway. However, degree of governmental regulation turns to be significant only when output is measured in train-kilometers. This can be hardly explained, since regulation was expected to have a strong impact on the number of passenger kilometers and, hence, on the second output specification. This model has two major drawbacks: it is sensitive to adding

[1] United Kingdom was excluded from all the samples considered in this work because I have data only on several railway companies operating in this country. Total number of railways in the United Kingdom exceeds two dozens, hence, I was unable come up with a country-level data.

other regressors, such as GDP, fall in the market share and so on, and it is does not works if truncated regression is used instead of Tobit. This fact stresses the sensibility of the policy analysis to controlling for different environmental factors and choosing the estimation technique.

Chapter 7

A CASE STUDY: THE UKRAINIAN RAILWAY

While analyzing the results of this research, I have found that two railways, namely Macedonian and Ukrainian, may be regarded as outliers in terms of discovered positive relationship between reform progress and efficiency of railroads. Despite very modest progress in restructuring their railroads (at least according to the grades provided by international institutions) both countries exhibit high efficiency scores when being benchmarked against either transition or developed states. Below I provide a detailed analysis of performance of Ukrzaliznitsya (the Ukrainian National Railway Operator), leaving the case of Macedonia for further research.

After collapse of the Soviet Union freight railway traffic started to fall dramatically, and in the year 1999 it made less than thirty five percent of its pre-transition level. Depreciated rolling stock and huge costs of maintaining a giant rail network are supposed to push Ukraine into the group of the most inefficient countries; however, my results report the opposite. Ukrzaliznitsya is found to be fully efficient in both samples when passenger-kilometers and freight ton-kilometers are chosen as output specification. In terms of train-kilometer output specification efficiency exactly follows the path of Ukrainian GDP in the recent years: it starts to decline from the fully efficient point in 1993, and in the year 1999 it falls as low as to 0.55. In the two subsequent years efficiency goes up and in the year 2001 it reaches that year's mean of 0.82 (see Table 10).

Table 10. Performance of the Ukrainian Railway

	1990	1993	1994	1995	1996	1997	1998	1999	2000	2001
Freight output, mil t*km	473 953	246 356	200 423	195 762	163 384	160 433	158 693	156 336	172 840	177 465
Passenger output, mil p*km	76 038	75 896	70 882	63 752	59 079	54 540	49 938	47 600	51 767	49 661
Efficiency, train-km output specification.[1]	---	1.00	0.90	0.88	0.71	0.72	0.62	0.55	0.62	0.82
Efficiency, pkm&tkm output specification.[2]	---	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Efficiency, pkm&tkm output specification.[3]	---	---	---	---	---	---	1.00	1.00	1.00	1.00

Sources: UIC and authors calculations
Notes: [1] Sample of 31 European countries
[2] The same
[3] Sample of 18 transition countries

Reforms in the railroad industry proceed at very slow pace that cannot explain high efficiency scores obtained under revenue output specification. In the year 2001 EBRD graded railroad reforms in the country by a "C" grade, while World Bank's mark for regulatory quality was only 2.1 out of 6 points, which is comparable with the grades of such countries as Vietnam, Sudan, and Cameroon.

So, why Ukraine is so unexpectedly efficient? After performing a careful analysis of the nature of the traffic of Ukrzaliznitsya, I came up with two specific reasons, which were not included into my model, but may be applicable in terms of Ukrainian railway. First aspect refers to the issues of density of the goods carried by a railway operator. Products of very high density, such as iron ore, coal, and steel make a large share of freight traffic that substantially increases the number of freight ton-kilometers. Recession of nineties did not decrease the ratio of raw materials to consumer goods transported by Ukrzaliznitsya, since steel and coal producers could not switch to other kinds of transportation services due to the nature of products they produced. This fact is supported by an increase in the market share of railways that is not typical for other transition countries.

In terms of passenger traffic we should refer to regulation issues. According to IER (2000), "The industry (Ukrainian railway) is organized as a single, highly integrated company managed by the railways administration, which is a part of the government". Indeed, Ukrainian railway is part of the government, but government manages with it without imposing any regulations on output, i.e. on frequency of service. Nash and Shires (1999) argue, "A railway manager wishing to minimize costs might run one very long train per day, but this would not be very attractive to customers". Without taking into account quality issues, which are not captured by analysis provided in this work, Ukrzaliznitsya runs a very small number of overcrowded trains (at least relatively to the country size and its population). This fact does not satisfy consumers, queuing near a booking office, but it clearly makes a railroad company better off. Thus, by cutting the number of trains, Ukrzaliznitsya remains fully efficient in terms of revenue output specification but gives up some efficiency when output specified in train-kilometers.

The main problems of Ukrainian railway come from the financial side of the business, which is cannot be deeply analyzed at the moment due to inaccessibility to the proper data. Firstly, the Ministry of Economics heavily regulates Ukrzaliznitsya in terms of passenger and freight tariffs. Secondly, Ukrainian railway has to subsidize extremely loss-making passenger traffic at the expense of freight profit, which leaves no money for capital investment. Passenger traffic is a real burden of Ukrainian railway since government not only prohibits Ukrzaliznitsya charging higher prices, but also it does not reimburse costs of servicing privileged categories of passengers, such as students and pensioners (IER, 2000). Finally, Ukrzaliznitsya, as many other state enterprises, suffers from agency problem: most railway managers are corrupted, and they hardly care about increasing efficiency of the domestic railroad.

Nevertheless, in the recent years Ukrzaliznitsya exhibits some progress in terms of increasing outputs, revenues, and even profits. The year 2000 was a turning point for Ukrainian railway since that year was it firstly declared a positive profit. If during the next decade the Ukrainian government realizes its plans concerned with restructuring of the industry, Ukrzaliznitsya is expected to improve its performance. According to government's business plan, in 2006 - 2007 Ukrzaliznitsya will be transformed to the state joint stock company. The year 2008 is supposed to bring full separation of infrastructure from services and introduction of private participation. From 2009 to 2011 railway services will be privatized and the reforms will end up with the competition on the railway market.

Chapter 8

CONCLUSIONS

Recent reforms in the railway industry provided by dozens of developed and developing countries attracted attention of many scholars. Governments, railroad management, and shareholders became interested in the assessment of intermediate results of the reforms, as well as in comparison of their railway's performance with the experience of other countries. A number of studies done in the field performed a comparative benchmarking of railways and discovered a significant positive impact of reforms on the productivity of railways. My paper is the first work in the field, which provides analytical analysis of railroad reforms in both developed and transition countries. Following our expectations, railways of transition countries were found to be far less efficient then railroads of Western European states. The results of empirical tests partially support the hypothesis of the positive impact of reforms on the railways' performance. A policy variable was significant in the sample of 18 transition countries but it turned to be insignificant after adding to the analysis some developed countries, which may be partially explained by the unavailability of a good proxy for reforms in the developed countries. Another finding of this work is a high influence of per capita GDP and market share of freight railway traffic on the railway's efficiency indicators. The fact of highly significant statistical relationship between inefficiency of railways and exogenous factors, as well as inappropriateness of using Tobit models and existence of country-specific factors, questions the results of many previous studies in the area. The applicability of the results of this research to the real life situation on the railway market has two major drawbacks. Firstly, evaluating performance by means of technical efficiency without taking into account any financial aspects of railway's activity may not be valid in the case of this industry. Secondly, it is hard to find an ideal proxy for railway reforms. Representing reforms in the field in terms of grades provided by different institutions and scholars may be criticized because of subjective assessment. The results of this paper may be summarized as "Policy matters, but it is not the only thing that matters". Ukraine is good example of a country with slow reform progress but fully efficient railway. After analyzing the case of Ukrzaliznitsya in detail I found that the main determinants of high efficiency of Ukrainian railway are high density of the products carried (coal, steel, iron ore) and low frequency of passenger traffic.

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APPENDIX A: TABLES

Table A1. Assessment of Railway Reforms

Country	Gov. Regulation	Vertical Separation	Legal Constitution	Freedom to Set Tariffs
Austria	2	4	2	3
Belgium	2	4	2	3
Bulgaria	3	4	4	4*
Croatia	3	4*	4	1
Czech Rep.	2	4	4	4
Denmark	2	1	3	4
Estonia	3	5	2	4
Finland	2	1	3	1
France	3	1	3	5
Germany	2	4	2	1
Greece	2	5	3	4*
Hungary	3	4	2	4
Ireland	2	5	3	5
Italy	3	3	2	3*
Latvia	3	4	2	4
Lithuania	3	5	2	4
Luxembourg	2*	3*	2.5*	3*
Macedonia	2*	4*	2.5*	4*
Moldova	3	5*	4	5
Netherlands	1.5	2	2	4
Norway	2*	3*	3*	3*
Poland	3	4	4	3
Portugal	2.5	1	4	5
Romania	3	4	3	5
Slovakia	3	4*	4	4
Slovenia	3	3	2	3
Spain	2	1*	3	2
Sweden	2	1	3	1
Switzerland	3*	3*	2.5*	3*
Turkey	3	4*	4	5
Ukraine	3*	4*	4*	5*

Source: ECMT, 1998

Notes: grades denoted with * were estimated by the author. Despite the fact that I used the same assessment criteria as ECMT did, any policy evaluation is based on the subjective judgment. Thus, I take all the responsibility for all grades for Norway, Luxembourg, Macedonia, Switzerland, Turkey, and Ukraine and selected grades for some other countries. While filling the gaps I used information from ECMT publications (1998, 2000, 2001), Carbajo (2003), IMPROVERAIL (2002), and United Nations Inland Transport Committee reports.

Table A2. Railway Reform Indicators

Country	1998	1999	2000	2001
Armenia	2	2	2	2
Azerbaijan	2	2	2.3	2.3
Bosnia	2	2	2	3
Bulgaria	3	3	3	3
Croatia	2.3	2.3	2.3	2.3
Czech Republic	2.3	2.3	2.3	2.3
Estonia	4	4	4	4.3
Georgia	3	3	3	3
Hungary	3.3	3.3	3.3	3.3
Latvia	3.3	3.3	3.3	3.3
Lithuania	2.3	2.3	2.3	2.3
Macedonia	2.3	2	2	2
Moldova	3	2	2	2
Poland	3.3	3.3	4	4
Romania	4	4	4	4
Slovak Republic	2	2	2.3	2.3
Slovenia	3.3	3.3	3.3	3.3
Ukraine	1.3	1.3	2	2

Source: EBRD, 1998 – 2001

Table A3. Regulatory Quality Indexes

Country	1996	1997	1998	1999	2000	2001
Austria	1.27	1.24	1.21	1.35	1.50	1.58
Belgium	1.10	1.08	1.07	0.91	0.75	1.07
Bulgaria	-0.12	0.17	0.47	0.34	0.21	0.42
Croatia	-0.12	0.11	0.34	0.32	0.30	0.25
Czech Rep	0.98	0.88	0.78	0.72	0.66	0.89
Denmark	1.38	1.39	1.40	1.39	1.38	1.56
Estonia	1.18	1.12	1.06	1.18	1.30	1.33
Finland	1.26	1.38	1.51	1.64	1.77	1.85
France	0.98	0.97	0.97	0.87	0.77	1.01
Germany	1.29	1.24	1.19	1.27	1.36	1.48
Greece	0.65	0.74	0.83	0.87	0.91	1.02
Hungary	0.47	0.81	1.15	1.12	1.09	1.15
Ireland	1.33	1.43	1.54	1.60	1.67	1.65
Italy	0.70	0.75	0.81	0.79	0.76	0.96
Latvia	0.41	0.57	0.72	0.62	0.52	0.69
Lithuania	0.27	0.24	0.21	0.36	0.51	0.74
Luxembourg	1.26	1.26	1.27	1.56	1.86	1.84
Macedonia	-0.19	-0.18	-0.16	-0.02	0.13	0.01
Moldova	0.01	-0.19	-0.39	-0.74	-1.09	-0.63
Netherlands	1.50	1.51	1.51	1.69	1.87	1.87
Norway	1.29	1.27	1.25	1.09	0.93	1.23
Poland	0.34	0.59	0.83	0.71	0.60	0.64
Portugal	1.22	1.21	1.19	1.11	1.03	1.25
Romania	-0.43	-0.07	0.30	0.01	-0.27	-0.11
Slovakia	0.18	0.23	0.29	0.32	0.36	0.56
Slovenia	0.38	0.56	0.74	0.69	0.64	0.73
Spain	0.96	1.06	1.16	1.26	1.36	1.39
Sweden	1.22	1.18	1.14	1.25	1.36	1.53
Switzerland	1.18	1.18	1.18	1.35	1.52	1.57
Turkey	0.39	0.62	0.86	0.55	0.24	0.16
Ukraine	-0.57	-0.73	-0.89	-1.04	-1.19	-0.91

Table A4. DEA Efficiency Estimates for Transition Countries

Country	1998	1999	2000	2001
Armenia	1.00	1.00	0.85	0.98
Azerbaijan	0.52	0.51	0.51	0.48
Bosnia	1.00	1.00	1.00	1.00
Bulgaria	0.88	0.77	0.71	0.73
Croatia	0.47	0.54	0.54	0.67
Czech Rep	0.57	0.63	0.64	0.67
Estonia	1.00	1.00	1.00	1.00
Georgia	0.56	0.56	0.57	0.58
Hungary	0.91	1.00	1.00	1.00
Latvia	1.00	1.00	1.00	1.00
Lithuania	0.86	0.86	0.86	0.76
Macedonia	1.00	1.00	1.00	1.00
Moldova	0.85	0.70	0.71	0.72
Poland	0.72	0.83	0.79	0.87
Romania	0.76	0.92	0.83	0.82
Slovakia	0.57	0.55	0.53	0.58
Slovenia	0.90	0.87	0.89	0.92
Ukraine	1.00	1.00	1.00	1.00

Table A5. DEA Efficiency Estimates for European Countries: Train-km Output Specification

Country	1993	1994	1995	1996	1997	1998	1999	2000	2001
Austria	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Belgium	0.84	0.76	0.76	0.79	0.75	0.75	0.73	0.70	0.71
Bulgaria	0.46	0.47	0.67	0.66	0.66	0.52	0.51	0.52	0.58
Croatia	0.39	0.62	0.53	0.53	0.55	0.54	0.59	0.62	0.78
Czech Rep	0.80	0.75	0.84	0.84	0.75	0.56	0.51	0.50	0.57
Denmark	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Estonia	0.57	0.50	0.54	0.57	0.74	0.80	0.97	1.00	1.00
Finland	0.79	0.75	0.72	0.73	0.84	0.82	0.82	0.80	0.80
France	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Germany	1.00*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Greece	0.47	0.51	0.48	0.52	0.44	0.70	0.71	0.73	0.64
Hungary	0.43	0.54	0.60	0.61	0.57	0.53	0.57	0.56	0.61
Ireland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	0.84	0.80	0.97	0.97	1.00	0.90	0.73	0.74	0.82
Latvia	0.63	0.59	0.56	0.68	0.78	0.67	0.65	0.74	0.85
Lithuania	0.70	0.56	0.62	0.66	0.69	0.61	0.62	0.68	0.66
Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Macedonia	1.00	1.00	1.00	1.00	0.95	1.00	1.00	1.00	1.00
Moldova	0.52	0.41	0.46	0.49	0.52	0.51	0.50	0.55	0.54
Netherlands	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Norway	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poland	0.71	0.76	0.88	0.91	0.91	0.79	0.71	0.68	0.63
Portugal	0.92	0.86	0.96	0.86	0.99	0.92	0.76	0.84	0.84
Romania	0.46	0.46	0.52	0.51	0.50	0.36	0.32	0.31	0.34
Slovakia	0.86	0.76	0.84	0.82	0.84	0.74	0.65	0.63	0.66
Slovenia	0.89	0.91	1.00	1.00	1.00	0.98	1.00	1.00	1.00
Spain	1.00	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Switzerland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Turkey	0.60	0.54	0.58	0.60	0.69	0.61	0.58	0.67	0.53
Ukraine	1.00	0.90	0.88	0.71	0.72	0.62	0.55	0.62	0.82

Notes: * - aggregated efficiency score for railways of Western and Eastern Germany in this year was computed after summing up their inputs and outputs

Table A6. DEA Efficiency Estimates for European Countries: Pkm and Tkm Output Specification

Country	1993	1994	1995	1996	1997	1998	1999	2000	2001
Austria	1.00	1.00	0.72	0.75	0.65	0.66	0.68	0.69	0.65
Belgium	0.55	0.59	0.63	0.65	0.63	0.62	0.63	0.60	0.63
Bulgaria	0.55	0.52	0.61	0.68	0.72	0.62	0.54	0.51	0.41
Croatia	0.33	0.32	0.41	0.42	0.39	0.39	0.44	0.44	0.52
Czech Rep	0.41	0.44	0.45	0.47	0.42	0.39	0.34	0.37	0.37
Denmark	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Estonia	0.97	0.94	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Finland	0.82	0.84	0.85	0.79	0.79	0.79	0.77	0.72	0.70
France	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Germany	0.58*	0.63	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Greece	0.58	0.53	0.53	0.57	0.47	0.68	0.74	0.83	0.63
Hungary	0.36	0.37	0.43	0.43	0.44	0.43	0.44	0.43	0.46
Ireland	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Italy	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Latvia	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lithuania	1.00	1.00	0.92	0.84	0.79	0.79	0.81	0.82	0.73
Luxembourg	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Macedonia	1.00	1.00	1.00	1.00	0.95	1.00	1.00	1.00	1.00
Moldova	0.92	0.74	0.74	0.81	0.79	0.80	0.63	0.69	0.66
Netherlands	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Norway	0.89	0.89	0.96	1.00	0.95	0.95	0.99	0.94	0.96
Poland	0.46	0.52	0.63	0.75	0.72	0.65	0.64	0.57	0.51
Portugal	1.00	1.00	1.00	0.97	0.89	0.79	0.67	0.71	0.73
Romania	0.51	0.50	0.55	0.55	0.48	0.45	0.41	0.37	0.36
Slovakia	0.47	0.50	0.57	0.54	0.51	0.50	0.44	0.44	0.43
Slovenia	0.52	0.62	0.77	0.62	0.59	0.62	0.64	0.64	0.63
Spain	0.97	0.92	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Sweden	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Switzerland	0.88	0.96	0.98	1.00	1.00	1.00	1.00	1.00	1.00
Turkey	0.71	0.66	0.76	0.74	0.76	0.74	0.74	0.71	0.62
Ukraine	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Notes: * - aggregated efficiency score for railways of Western and Eastern Germany in this year was computed after summing up their inputs and outputs