

Transition Progress and Productivity Growth- the Case of Telecommunications in EBRD Countries of Operation

Marijana Petrović
marijanap@sf.bg.ac.rs

Dalibor Petrović

Snežana Pejčić Tarle

Nataša Bojković

Abstract

Telecommunications and information technologies have been rapidly developing over the last three decades. Besides the intensive technological development, changes in policy and regulation have also been seen as the driving forces of a better sector performance. This invoked a specific challenge for scholars, policy-makers and practitioners - to investigate whether the liberalization, deregulation and open telecommunications markets have led to growth in sectors efficiency and productivity. The task is particularly challenging when analyzing countries that are in the process of transition from command to market economies. In this study we examine the change in Total Factor Productivity (TFP) of telecommunications sector and its relation to transition indicator scores for 22 EBRD (European Bank for Reconstruction and Development) countries from 1998 to 2007. For productivity estimation we relied on DEA (Data Envelopment Analysis) Malmquist index. The results showed that countries that have achieved greater progress towards a market economy had also experienced a higher TFP growth.

Keywords - EBRD, DEA, Malmquist index, productivity, telecommunications, transition.

JEL classification: D00

Introduction

The relationship between regulatory reform and growth in telecommunications has been investigated in many studies, but scholars remain equivocal about the fact that one leads to the other. Empirical evidence of positive influence of regulatory issues on sector development is, among other studies, found by **Gasmi and Recuero Virto (2009)**, **Lam and Shiu (2008)**, **Lien and Peng (2001)**. However, there have been some opposite conclusions. **Fink, Mattoo and Rathindran (2003)** found that some improvements in telecommunications performance were not directly attributable to the policy variables considered. **Bernstein and Sappington (1998)** examined price cap regulation and demonstrated that sometimes regulation might even hinder growth. **Rodríguez and Rodrik (2000)** characterized the methods used to ascertain the link between trade policy and growth as having serious shortcomings.

Analysis of reform contribution to the development is particularly challenging in the ever-changing telecommunications environment of transition countries.

For a long time telecommunications in transition countries was considered as a non-profit-oriented production process aiming to support the socio-economic superstructures with a state owned telecommunications industry characterized by very poor performance and low technology deployment (**Markova, 2009**). In addition to this, inadequate institutional background to regulatory reform hindered growth. This resulted in an unfavourable starting point that exerted a strong influence on the future development of these countries (**Falcetti, Lysenko and Sanfey, 2006**). All transition countries are still burdened by poor fixed line telecommunications infrastructure, due to insufficient investment during the period of old PTT systems, but show significant deployment in the mobile segment (**Vagliasindi, Güney and Taubman, 2006**).

European Bank for Reconstruction and Development (EBRD) is one of the international organizations that monitors, analyses and supports transition process of 29 economies in central Europe, Western Balkan and central Asia. EBRD countries of operation are: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, FYR Macedonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Mongolia, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia, Tajikistan, Turkmenistan Turkey, Ukraine and Uzbekistan. The sub-regions that can be identified are Commonwealth and Independent States plus Mongolia (CIS+M), South-East European countries (SEE) and European Union (EU) members.

One of the sectors of particular interest to EBRD is telecommunications and broader-information and communication technologies (ICT). The reason lies in fact that ICT deployment is seen as one of the main drivers of development in information society. For SEE countries there is an additional propriety – harmonization in development particularly through the compliance with EU legislative framework.

Besides support on ICT services development, EBRD also focuses on devising appropriate regulatory and legal frameworks that assist the liberalization process. In other words besides financing different projects regarding the development of ICT networks and services (about 122 until 2012), EBRD also offers different assessment studies and reports that can help decision-makers to monitor and track their countries' progress towards open telecommunications markets. In 2008 the Bank set a study on comparative assessment of telecommunications sector in its countries of operation, with the aim to examine whether the legal and regulatory framework for communications is sufficiently extensive to secure fundamental sector transition and reform objectives. In the report published in 2008, EBRD highlighted the differences among its countries of operation. Broadband penetration differs across sub-regions and countries, ranging from below 5% in CIS+M to Estonia which exceeds EU average (see Table 1).

Table 1

DIFFERENCES IN PENETRATION LEVELS OF TELECOMMUNICATIONS IN SUB-REGIONS OF EBRD COUNTRIES
(EBRD, 2008:152)

Sub-region of EBRD countries	Average Fixed Penetration	Mobile Penetration	Broadband Penetration
EBRD countries of operation within EU	26%	105%	11%
South Eastern Europe	28%	94%	4%
CIS and Mongolia	25%	97%	3%

Experiences in establishing modern regulatory regimes for network utilities also vary. The latest regulatory assessment report showed that policy trends differ across the region regarding compliance with EU legislative framework (Table 2).

Table 2

RATINGS FOR COMPLIANCE WITH EU LEGISLATION IN TELECOMMUNICATIONS IN EBRD COUNTRIES OF
OPERATION (**EBRD, 2008:152**)

FULL COMPLIANCE	HIGH COMPLIANCE	MEDIUM COMPLIANCE	LOW COMPLIANCE
Croatia	Albania	Armenia	Azerbaijan
Czech Republic	Bosnia &	Kosovo	Belarus
Estonia	Herzegovina	Kyrgyz Republic	Serbia
FYR Macedonia	Bulgaria	Moldova	Kazakhstan
Hungary	Georgia	Mongolia	Tajikistan
Latvia		Montenegro	Turkmenistan
Lithuania		Russia	Uzbekistan
Poland		Ukraine	
Romania			
Slovak Republic			
Slovenia			

The “Comparative Assessment of the Telecommunications Sector in the Transition Economies” (**EBRD, 2008**) although provides meaningful and detailed information for policy creators and other decision-makers offers only time-cut analysis results, and thereby constrains tracking progress/regress over time. This is particularly important when investigating the transition progress and its impact on sector performance. Since one of the main aims of the EBRD in the field of telecommunications is to provide guidance for ongoing and future legal reform efforts in those countries, time series data on sector performance are needed. This is why the EBRD provides each of its countries operation with transition indicator scores that give insight about country-specific progress in transition. Besides overall transition indicator scores EBRD provides sector specific ones and one of them is transition indicator for infrastructure reform in telecommunications. This indicator reflects a country’s progress regarding commercialisation and regulation, and reveals how open a telecommunications market is i.e. it measure progress in moving from monopolistic to a competitive economy. The added value of these transition indicators (compared to data from the EBRDs’ 2008 comparative report) is that they provide information for a longer period – from 1989 to now days (see Appendix A). This allows researchers and policy makers to analyze the transition dynamics and its relation to other performance indicators.

This is a common approach exploited in many studies such as: **Radulescu and Barlow (2002); De Macedo and Martins (2008); Resende (2008); Petrović et al. (2011).**

For instance **Petrović et. al (2011)** exploited EBRD transition indicators within three-dimensional-benchmarking model named ISER. They used them to evaluate the regulatory aspect of countries' performance (dimension R) along with other two aspects (information society –IS and sector efficiency-E). The results were obtained for the years 2002 and 2007 i.e. the study relied on time cut efficiency estimations. However, dynamic analysis requires evaluation in the longer period of time and appropriate methodology that will acknowledge both relative efficiency change and the technological change.

Transition indicator scores compiled by the EBRD reflect country-specific progress in transition and increase throughout time. The question this paper attempts to answer is, whether telecommunications sector productivity follows this growth. For productivity estimation we relied on Data Envelopment Analysis (DEA) Malmquist Index. The research sample of our study contains 22 EBRD countries of operation. The study covers the period 1998-2007.

The paper is organized as follows.

The following section describes the non-parametric Data Envelopment Analysis (DEA) approach used to construct the Malmquist Index in order to measure the total factor productivity (TFP) growth in telecommunications in EBRD countries of operation. The section three gives TFP results and discussion with the emphasis on the relation between TFP and the transition indicator scores. The paper ends with the limitations of the study and future research directions.

Methodology and data

DEA-like Malmquist index studies of TFP in telecommunications

After the intensive regulatory reforms in 1980s there has been a growing interest in measuring the productivity and efficiency of the telecommunications sector (**Lam and Shiu, 2010**). There are different approaches to productivity measurement. **Hisali and Yawe (2011**, referring to **Mawson et al., 2003**) differ four main approaches: the growth accounting approach, the index number approach, a distance function approach and the econometric approach. One of the popular distance function

approaches is Malmquist TFP index which uses Data Envelopment Analysis (DEA) as supporting analytical tool. To support the idea of the distance function preceding estimation of the corresponding frontier is required. These estimations are carried out using DEA (**Hisali and Yawe, 2011**).

Besides measuring technical efficiency, Malmquist index approach helps assessing the evolution of TFP and efficiency through time in order to investigate whether an efficiency change has occurred. The growth of TFP is defined as the change in output due to technical change and technical efficiency change over time. The advantage of using DEA based Malmquist index for TFP calculation is in the possibility for rather simple and understandable decomposition of Malmquist index. This decomposition allows researchers to study the sources of TFP growth, i.e. to examine is it the consequence of efficiency or technological change (frontier shift). That is why in the time of extensive technological and regulatory changes, DEA based Malmquist index has become very popular for efficiency and productivity evaluation in telecommunications -both at company and cross-country level of analysis.

One of the earlier studies was conducted by **Madden and Savage (1999, 2001)** who calculated total factor productivity growth using the Malmquist productivity change index. Besides telecommunications productivity, they also examined technological catch-up and innovation in 74 countries for the period 1991-1995. For this they relied on the decomposition of Malmquist index values. They argued that there is a possibility for developing countries to enhance telecommunications productivity through technological catch-up. They also found evidence that support the hypothesis that market size is conducive to innovation. **Uri (2000, 2001a, 2001b)** have used Malmquist index and DEA to evaluate TFP, efficiency and technological change of local exchange carriers (LECs) in USA. They analyzed their results in relation to regulatory reform. **Calabrese, Campisi and Mancuso (2003)** focused on DEA-like linear programming method to compute the Malmquist index and evaluate the evolution of productivity in the telecommunications industries for 13 OECD countries over the period 1979-1998. They compared labour productivity with TFP results and no evidence of catch-up was found i.e. less developed countries did not exhibit the most rapid rate of growth in order to reduce the technological gap with the respect to the leading telecommunications industries. **Chen and Agha Iqbal (2004)** studied productivity of 500 Computer and Office Equipment companies from 1991 to 1997. They proposed new approach for obtaining and discussing results on DEA-based Malmquist productivity index that identifies the strategy shifts of analyzed companies. **Bollou and Ngwenyama (2008)** used Malmquist Index cross-country TFP evaluation in African countries over the period 1995-

2002 (period of liberalization and intensification of investments in ICT infrastructure). Their results showed that in spite of increasing investment in ICT infrastructure, TFP growth is declining in these countries. **Ariff, Cabanda and Sathye (2009)** exploited DEA-Malmquist Index to examine whether or not ownership changes accompanying privatization of state-owned enterprises (telecommunication firms) lead to TFP growth. They found strong evidence in support of the hypothesis that privatization leads to consistent gains in production and efficiency.

An interesting study was done by **Seo et al. (2010)** who relied both on Malmquist index and Stochastic Frontier Analyses to examine productivity growth of telecommunications firms (25 Incumbent Local Exchange Carriers over the period 1996–2005) in relation to merging effects. The results they obtained by both methods indicated that the firms that do not merge under-perform in terms of average productivity growth. **Lam and Shiu (2010)** relied on DEA based Malmquist index in order to measure the TFP growth in telecommunications sectors of 105 countries between 1980 and 2006. They analyzed the results depending on the existence of competition and privatization in telecommunications. In their previous study **Lam and Shiu (2008)** evaluated productivity performance of China's telecommunications sector at the provincial level using the non-parametric DEA approach.

A recent study was conducted by **Hisali and Yawe (2011)** who used Malmquist Total Factor Productivity index based on input-oriented Data Envelopment Analysis to estimate total factor productivity growth in Uganda's telecommunications industry over the 2001–2006 period. As they stated "...The results show that the telecommunications sector posted impressive total factor productivity growth rates over the study sample" (**Hisali and Yawe 2011:18**).

DEA-based output oriented Malmquist productivity index

Malmquist (1953) first proposed comparing the input of firm at two different points of time in terms of the maximum factor by which the input in one period could be decreased such that the firm could still produce the same output level of the other time period. The idea lead to the Malmquist input index, which was extended by **Caves, Christensen and Diewert (1982)** who defined Malmquist productivity index.

Fare, Grosskopf and Lovell (1985) proposed DEA-based output oriented Malmquist productivity index. An alternative approach is to use input orientation where the frontier is the minimum set of

inputs required for a given level of output. However, if one assumes constant returns to scale, input oriented Malmquist measure is reciprocal of the output oriented measure of TFP changes.

The Malmquist output orientation index requires four DEA models to be estimated, which respectively specify efficiency in the current time period $\theta_0^t(x_0^t, y_0^t)$; efficiency in the next time period $\theta_0^{t+1}(x_0^{t+1}, y_0^{t+1})$; efficiency of the decision making units (DMU- represented by transition countries in this study) operating in this time period relative to DMUs operating in the next time period $\theta_0^{t+1}(x_0^t, y_0^t)$; and the efficiency of DMU operating in the next time period relative to the frontier in this time period $\theta_0^t(x_0^{t+1}, y_0^{t+1})$. The Malmquist productivity index is then calculated as in (1). M_0 measures the productivity change between the t and $t+1$ period. The above Malmquist productivity index can be written in an equivalent way as in (2), which allows the decomposition of productivity change into changes in efficiency and shifting of the frontier (Färe, Grosskopf and Lovell, 1985; Färe et al., 1989).

$$M_0 = \left[\frac{\theta_0^t(x_0^{t+1}, y_0^{t+1})}{\theta_0^t(x_0^t, y_0^t)} \frac{\theta_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{\theta_0^{t+1}(x_0^t, y_0^t)} \right]^{1/2}$$

(1)

$$M_0 = \frac{\theta_0^{t+1}(x_0^{t+1}, y_0^{t+1})}{\theta_0^t(x_0^t, y_0^t)} \left[\frac{\theta_0^t(x_0^{t+1}, y_0^{t+1})}{\theta_0^{t+1}(x_0^{t+1}, y_0^{t+1})} \frac{\theta_0^t(x_0^t, y_0^t)}{\theta_0^{t+1}(x_0^t, y_0^t)} \right]^{1/2}$$

(2)

The first term outside the bracket, measures the change of efficiency between periods t and $t+1$ (catching up to the frontier), whereas the bracketed term provides a measure of technological change (innovation, some authors refer to it as technical change, see Uri, 2001b). The change in productivity, i.e. M_0 , and its decomposition into technological change and efficiency change can have values of unity, greater than unity and less than unity, which are interpreted as no change, progress and regress, respectively.

We used Excel implementations of output oriented DEA models for calculations, introduced in Zhu (2003). Depending on the envelopment surface models can be applied with the assumption of CRS (constant returns to scale) or with VRS (variable returns to scale). In this study we decided on CRS specification, since some efficiency scores may return as "infeasible" when Malmquist is calculated

under non-CRS conditions. This is because under VRS, if technical progress occurs, observations in period t may not be feasible in period $t+1$ (Uri, 2001b).

We discussed the results in relation to the level of the telecommunications markets openness measured by EBRD's transition indicator for telecommunications. The measurement scale for the indicator ranges from 1 to 4+, where 1 represents little or no change from a rigid centrally planned economy and 4+ represents the standards of an industrialized market economy. More detailed description is given in Table 3. Additional rating symbols such as "+" and "-" are converted to numbers by adding 0.33 and subtracting 0.33 from the full value (Table with transition indicators values from 1984 to 2010 for 29 EBRD countries of operation can be found in the appendix A of this paper).

Table 3

DESCRIPTION OF EBRDs' TRANSITION INDICATORS FOR INFRASTRUCTURE REFORM IN TELECOMMUNICATIONS

VALUE	DESCRIPTION
1	Little progress in commercialization and regulation. Minimal private sector involvement and strong political interference in management decisions. Low tariffs, with extensive cross-subsidization. Liberalization not envisaged, even for mobile telephony and value-added services.
2	Modest progress in commercialization. Corporatization of dominant operator and some separation from public sector governance, but tariffs are still politically set.
3	Substantial progress in commercialization and regulation. Telecommunications and postal services fully separated; cross-subsidies reduced. Considerable liberalization in the mobile segment and in value-added services.
4	Complete commercialization, including privatization of the dominant operator; comprehensive regulatory and institutional reforms. Extensive liberalization of entry.
4+	Effective regulation through an independent entity. Coherent regulatory and institutional framework to deal with tariffs, interconnection rules, licensing, concession fees and spectrum allocation. Consumer ombudsman function.

Source: http://www.ebrd.com/pages/research/analysis/surveys/ti_methodology.shtml

Research sample

The research sample of our study is panel data for 22 transition countries covered by EBRD transition reports for the 1998-2007 period. The countries in the study are Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Estonia, FYR Macedonia, Hungary, Kyrgyz Republic, Lithuania, Moldova, Mongolia, Poland, Romania, Serbia, Slovak Republic, Slovenia, Turkey, Ukraine and Uzbekistan. Because of the lack of data and given the fact that DEA is sensitive to measurement errors the seven EBRD countries of operation needed to be excluded from the study (Georgia, Kazakhstan, Latvia, Montenegro, Russian Federation, Tajikistan and Turkmenistan).

Similar to many previous studies (e.g. **Lam and Shiu, 2010, 2008; Giokas and Pentzaropoulos 2008 Lien and Peng, 2001; Madden and Savage, 1999, 2001; Sueyoshi, 1994**), the total telecommunications services revenue (in US dollar) is used as a measure of output, while number of main lines, annual telecommunications investment and the number of full-time telecommunications staff are selected to be input measures. Descriptive statistics on input and output data used for Malmquist index calculations are given in Appendix B of this paper. All data were taken from the Yearbook of Statistics-Telecommunications Services Chronological time Series 1998-2007 by International Telecommunications Union. The missing data were obtained from other sources (e.g. OECD, World Bank and National Statistical Offices). If they couldn't be obtained from other sources, the missing data were estimated by the method of simple extrapolation (i.e. assuming constant changes in the figures between the years).

Results and discussion

Productivity change, efficiency change and technological change

Table 4 presents the Malmquist index i.e. TFP scores for 22 EBRD countries from 1998 to 2007. The results indicate that changes in productivity vary over time thus reflecting the instability of markets in EBRD countries of operation.

There are five of 22 analysed countries that showed TFP growth in each of the observed years (Bulgaria, Estonia, Former Yugoslav Republic of the Macedonia, Hungary and Lithuania), while Croatia experienced "one-time" regress (2000-01 period).

From the time perspective, on average, the highest productivity growth EBRD countries showed in the 2002-03 period (23.36%). This can be explained by the fact that the 2004 was the year of EU enlargement and ending the period of fostered changes in regulation followed by increased investments.

Table 4

Malmquist Index for telecommunications in EBRD countries 1998-2007

	1998- 99	1999- 00	2000- 01	2001- 02	2002- 03	2003- 04	2004- 05	2005- 06	2006- 07
ALB	0.822	0.758	1.580	1.181	1.169	0.958	1.443	1.135	1.019
ARM	1.183	0.947	1.678	0.773	1.004	1.193	1.383	0.899	0.993
AZE	0.599	1.182	0.913	1.818	0.980	0.730	1.018	0.626	1.437
BLR	1.163	0.936	0.904	1.208	1.035	1.031	0.954	0.894	1.001
BIH	1.119	1.137	0.637	1.000	1.653	1.087	0.937	1.097	1.562
BGR	1.265	1.274	0.907	1.028	1.430	1.243	1.148	1.151	1.247
HRV	1.031	0.892	0.981	1.485	1.213	1.006	1.206	1.146	1.158
EST	1.253	1.057	1.091	1.287	1.292	1.370	1.011	1.035	1.027
FYRM	1.248	1.047	1.056	1.561	1.254	1.129	1.000	1.182	0.964
HUN	1.067	1.401	1.071	1.009	1.395	1.101	1.133	1.068	1.071
KGZ	1.212	1.188	0.668	1.290	1.184	1.313	1.128	1.036	1.000
LTU	1.141	1.106	1.242	1.768	1.568	1.240	1.038	1.191	1.201
MDA	1.016	0.825	2.028	0.608	1.577	1.106	1.128	1.190	0.767
MNG	1.456	0.845	1.056	0.828	0.870	0.962	0.940	0.759	1.088
POL	0.972	1.193	1.031	0.841	0.950	1.489	1.058	1.000	1.308
ROM	1.166	0.855	1.480	1.850	0.865	1.337	1.246	1.261	1.221
SRB	0.899	0.953	1.262	1.227	1.262	0.693	1.591	1.250	1.124
SVK	0.914	1.240	0.890	1.287	1.481	1.250	1.196	1.078	1.308
SVN	1.002	0.858	1.470	1.120	1.781	1.391	0.745	1.089	0.823
TUR	1.183	1.297	1.117	1.603	1.230	0.464	0.899	1.134	1.097
UKR	0.836	1.033	1.085	1.141	1.092	1.123	0.915	1.110	1.126
UZB	1.377	0.786	1.011	0.864	0.854	0.776	1.941	1.138	1.000

THE NEXT TWO TABLES (5 AND 6) SHOW THE RESULTS OF MALMQUIST INDEX DECOMPOSITION AND GIVE INSIGHT ABOUT EFFICIENCY CHANGE (TABLE 5) AND FRONTIER SHIFT (TABLE 6). THIS ALLOWS US TO COMMENT ON SOURCES OF TFP GROWTH/REGRESS.

Table 5

Efficiency change for telecommunications in EBRD countries 1998-2007

	1998- 99	1999- 00	2000- 01	2001- 02	2002- 03	2003- 04	2004- 05	2005- 06	2006- 07
ALB	1.000	0.725	1.380	1.000	1.000	0.792	1.262	1.000	1.000
ARM	1.106	0.871	1.623	0.654	0.810	1.313	1.451	0.903	1.020
AZE	0.672	0.997	0.891	1.197	0.816	1.885	1.068	0.595	1.397
BLR	1.136	0.790	0.695	0.976	0.822	1.465	1.001	0.898	1.028
BIH	1.000	0.823	0.622	0.816	1.269	0.868	0.865	0.993	1.569
BGR	1.213	1.062	0.787	0.863	1.100	0.981	1.063	1.013	1.199
HRV	1.000	0.710	1.004	1.244	0.862	0.824	1.162	1.066	1.030
EST	1.179	0.817	1.060	1.154	0.925	1.081	1.000	1.000	1.000
FYRM	1.208	0.829	1.071	1.317	0.870	0.980	1.049	1.154	0.906
HUN	1.000	1.000	1.000	1.000	1.000	0.967	1.034	1.000	1.000
KGZ	1.427	1.082	0.609	1.137	0.956	1.529	1.184	1.041	1.027
LTU	1.082	0.813	1.312	1.579	1.048	1.073	0.995	1.120	1.037
MDA	1.022	0.711	1.896	0.502	1.279	1.128	1.184	1.196	0.758
MNG	1.824	1.000	1.000	0.783	0.703	0.998	0.987	0.769	1.073
POL	0.940	0.880	1.071	0.727	0.789	1.224	1.001	0.918	1.256
ROM	1.119	0.675	1.398	1.523	0.704	1.089	1.120	1.109	1.165
SRB	0.807	0.762	1.295	0.988	0.925	0.626	1.459	1.226	1.105
SVK	0.889	0.978	0.858	1.180	1.194	1.023	1.080	0.948	1.205
SVN	0.984	0.627	1.231	1.120	1.177	1.000	0.899	1.003	0.749
TUR	1.000	1.000	1.000	1.000	1.000	0.839	0.910	1.124	1.031
UKR	0.829	0.865	1.031	0.964	0.885	1.059	0.904	1.150	1.080
UZB	1.357	0.693	0.950	0.730	0.679	0.883	2.036	1.144	1.027

Table 6**Frontier shift for telecommunications in EBRD countries 1998-2007**

	1998- 99	1999- 00	2000- 01	2001- 02	2002- 03	2003- 04	2004- 05	2005- 06	2006- 07
ALB	0.822	1.046	1.145	1.181	1.169	1.210	1.143	1.135	1.019
ARM	1.070	1.086	1.034	1.183	1.240	0.909	0.953	0.995	0.974
AZE	0.890	1.186	1.025	1.519	1.201	0.387	0.953	1.052	1.029
BLR	1.024	1.185	1.302	1.237	1.259	0.704	0.953	0.995	0.974
BIH	1.119	1.381	1.025	1.226	1.303	1.253	1.084	1.104	0.996
BGR	1.042	1.200	1.153	1.191	1.300	1.267	1.081	1.137	1.040
HRV	1.031	1.256	0.977	1.193	1.408	1.221	1.037	1.075	1.124
EST	1.063	1.294	1.029	1.115	1.397	1.267	1.011	1.035	1.027
FYRM	1.033	1.263	0.986	1.185	1.441	1.152	0.953	1.024	1.064
HUN	1.067	1.401	1.071	1.009	1.395	1.138	1.096	1.068	1.071
KGZ	0.849	1.098	1.097	1.135	1.239	0.858	0.953	0.995	0.974
LTU	1.054	1.360	0.947	1.120	1.496	1.156	1.043	1.063	1.158
MDA	0.995	1.159	1.070	1.212	1.233	0.980	0.953	0.995	1.011
MNG	0.798	0.845	1.056	1.058	1.238	0.965	0.953	0.987	1.015
POL	1.033	1.355	0.963	1.156	1.203	1.216	1.057	1.089	1.041
ROM	1.042	1.267	1.058	1.215	1.228	1.228	1.113	1.137	1.048
SRB	1.114	1.250	0.975	1.242	1.364	1.106	1.090	1.019	1.017
SVK	1.028	1.268	1.038	1.091	1.240	1.222	1.108	1.138	1.086
SVN	1.019	1.369	1.195	1.000	1.514	1.391	0.828	1.086	1.100
TUR	1.183	1.297	1.117	1.603	1.230	0.553	0.988	1.009	1.064
UKR	1.008	1.195	1.052	1.184	1.234	1.060	1.012	0.965	1.042
UZB	1.015	1.134	1.064	1.184	1.258	0.879	0.953	0.995	0.974

Unlike the Malmquist Index scores the highest efficiency change EBRD countries showed for the period of 2004-05 (10.10%). Here we want to point out that DEA efficiency scores reflect how a country converts its inputs to outputs relative to other countries and sometimes a country seen as poor can be found to be efficient. This can be explained by the facts that a country is poor as a result of being undercapitalized and not because it makes inefficient use of negligible capital inputs (for further

discussion see **Kumar and Russell, 2002**). In our sample besides Lithuania who gained the highest efficiency change (mean value for the observed period is 10.05%) Kyrgyz Republic also showed prominent efficiency change (7.88%). When analysing CIS+M countries (so called “early transition countries”) Kyrgyz Republic is an interesting case. In its comparative assessment EBRD reports medium regulatory compliance for Kyrgyz Republic which is better than majority of other CIS+M countries and better than Serbia (a SEE country)-see Table 2.

When compared to the results on Malmquist index calculations, efficiency scores show lower correlations than scores on frontier shift (0.64 compared to 0.79 for Pierson Coefficient of Correlation). However, the difference is rather small thus the decomposition of Malmquist index is not straightforward concerning the sources of TFP growth. The reason may be found in ever-changing nature in transition markets especially when it comes to relative assessment in a dynamic field such are telecommunications. This means that although the technological change/development is evident (especially in the field of mobile and wireless communications) regional disparities have stronger influence and therefore may be seen as key productivity factor.

In further discussion we analyse TFP results in relation to the transition indicators scores.

Transition progress and productivity growth

Table 7 summarizes the mean TFP and transition scores for 22 EBRD countries from 1998 to 2007. Mean values for the Malmquist output orientation index and its decomposing elements (efficiency change and frontier shift i.e. technological change) are presented along with the changes towards open telecommunications markets (expressed by changes in transition indicator scores).

The results indicate that the TFP growth is more result of the technological change than the change in efficiency. This is in line with the results obtained by **Lam and Shiu (2010)** that studied and proved that the innovations or technological change is the major source of TFP growth. Technological change (especially deployment of mobile communications and fibre-optic cable networks) along with market reforms can help developing and transition economies to improve the efficiency and productivity of their telecommunications. This means that developing countries and transition economies can achieve a better productivity performance than developed countries in recent years. The effect is called “latecomers’ advantage” or “leapfrogging strategy” (see **Lam and Shiu, 2010; Petrović et al., 2011**)

Table 7**Malmquist Index and Transition scores for telecommunications in EBRD countries 1998-2007**

	Malmquist index*	Efficiency change*	Frontier shift*	Transition indicator change**
LTU	1.260	1.101	1.145	3.33-3.67
ROM	1.221	1.066	1.145	3.00-3.33
BGR	1.179	1.022	1.153	3.00-3.67
SVK	1.168	1.032	1.132	2.33-3.67
EST	1.151	1.018	1.130	4.00-4.00
FYRM	1.148	1.031	1.113	2.00-3.33
HUN	1.139	1.000	1.139	4.00-4.00
HRV	1.113	0.976	1.140	2.00-3.67
SRB	1.112	0.989	1.124	2.00-2.33
SVN	1.099	0.957	1.148	2.33-3.00
BIH	1.099	0.948	1.159	1.00-2.33
KGZ	1.095	1.079	1.015	2.00-3.00
ALB	1.090	1.000	1.090	1.00-3.33
ARM	1.089	1.042	1.045	2.33-2.67
POL	1.078	0.964	1.118	3.33-4.00
MDA	1.071	1.008	1.063	2.33-3.00
TUR	1.064	0.986	1.079	-3.33***
UKR	1.046	0.968	1.080	2.33-2.67
UZB	1.037	0.992	1.045	2.00-2.00
BLR	1.009	0.958	1.054	1.00-2.00
AZE	0.971	0.997	0.974	1.00-1.67
MNG	0.961	0.977	0.983	2.33-2.67

* -mean values; ** -from 1998 to 2007; *** - 2008 data.

Lithuania is the country with the highest productivity growth (mean value 26.00%) while Azerbaijan and Mongolia experienced productivity regress. These two countries also showed fairly modest progress in transition. In ten years Azerbaijan shifted from the lowest score 1.00 to 1.67 meaning that

little progress in commercialization and regulation was achieved. In EBRD terminology this implies: minimal private sector involvement and strong political interference in management decisions; low tariffs with extensive cross-subsidisation; absence of liberalisation, even for mobile telephony and value-added services.

The results also revealed that productivity decreases and increases within the observed time, while the level of reforms (measured by EBRDs' transition indicator) tends to rise throughout. However, on average, European Union (EU) members showed highest TFP growth (16.9%), followed by growth of 11.24% in south East European Countries (SEE), while Commonwealth and Independent States (CIS) showed modest growth of only 3.48%. This is in line with the differences in transition indicator scores. Namely, in this period EU countries achieved the most in regulatory reform (their transition indicator scores are at maximum or close to the maximum). In contrast CIS countries showed little or no shift from a centrally planned economy.

Romania and Bulgaria, countries that joined EU in 2007 (latest year of our observation) can be considered as successful ones in terms of both TFP and transition, even better than some countries that are EU members from 2004. Formal Yugoslav Republic of Macedonia (FYRM) was also found among the most successful ones. The reasons may be found in fact that these countries achieved 'synergic benefits' from technological innovations (deployment of wireless technologies) and regulatory reform (transition towards open telecommunications markets). For instance, transition score for FYRM increased from 2.00 to 3.33 meaning substantial progress in commercialisation and regulation; full separation of telecommunications and postal services; reduction of cross-subsidies and considerable liberalisation in the mobile segment and in value-added services.

The opposite example is Poland, an EU member from 2004, who achieved modest TFP growth although reached full compliance with standards of an industrialized market economy, as defined by EBRD. The reason may be found in some "finer" indicators concerning regulatory assessment, like independence of National Regulatory Authority (NRA). Independent regulatory authority is the foremost for the country's legal framework in the field of telecommunications. It means that NRA is independent from the operators and from the political pressure. It may be the case that although this is formally set (through legislative framework) in practice NRA does not necessarily behave in an independent and fair way. This is very hard to monitor and evaluate objectively. In its report EBRD states that the regulator has to demonstrate that it makes decisions that are fair, transparent, and non-

discriminatory after taking into account the market conditions and by consulting widely. The other reason for rather low performance of Poland may be found in fact that by EBRD's 2008 Report Poland was below EU average regarding mobile and broadband penetration (**EBRD, 2008**)- which are two main drivers of telecommunications development.

Conclusion

In this study we analyzed the TFP growth in EBRD countries of operation using DEA-based Malmquist index. Lithuania was found to be the most successful one, while 'early transition countries' (primarily CIS) showed modest TFP scores. The results on decomposition of the Malmquist index were not straightforward about the sources of TFP growth - we found that it is to some extent related to the technological change and transition progress. However, the results must be taken with caution since the used capital inputs (number of main lines) reflect capacities for fixed line and Internet services but due to lack of data for the analyzed period, fail to capture the state of mobile resources. The data on labour input (full-time telecommunications staff) can also be misleading since the official data often combine employees from postal and telecommunications sector and it is difficult to separate them (especially for the period of old PTT systems). This should be corrected in some future studies as the availability of the appropriate data improves. Nevertheless, the DEA based Malmquist index along with indicators on policy improvements can help to evaluate the synergic effects of technological innovations and market openness on productivity and efficiency of telecommunications in EBRD countries of operation.

Acknowledgment

This paper is part of the "Critical infrastructure management for sustainable development in postal, communication and railway sector of Republic of Serbia" project, funded by the Ministry of Education and Science of the Republic of Serbia, Project number: TR36022.

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Appendix A- Transition index scores for infrastructure reform of telecommunications in EBRD countries of operation.

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Albania	ALB	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.33	3.33	3.33	3.33
Armenia	ARM	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.67	2.67	3.00	3.00	3.00
Azerbaijan	AZE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67	1.67	1.67	1.67	1.67
Belarus	BLR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bosnia and Herz.	BIH	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
Bulgaria	BGR	1.00	1.00	1.00	1.00	2.33	2.33	2.33	2.33	2.67	3.00	3.00	3.00	3.00	3.00	3.00	3.33	3.33	3.67	3.67	3.67	3.67	3.67
Croatia	HRV	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	3.00	3.00	3.33	3.33	3.33	3.33	3.33	3.67	3.67	4.00	4.00	4.00
Estonia	EST	1.00	1.00	1.00	2.33	3.00	3.00	3.00	3.00	3.33	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
FYR Macedonia	FYR M	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.33	2.33	2.67	3.00	3.00	3.00	3.33	3.33	3.67	3.67
Georgia	GEO	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.33	2.33	2.33	2.33	2.33	2.33	2.67	2.67	2.67	2.67	2.67
Hungary	HUN	1.00	1.00	2.00	2.33	2.67	3.33	3.33	3.33	3.33	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Kazakhstan	KAZ	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.33	2.33	2.33	2.33	2.33	2.67	2.67	3.00	3.00	3.00	3.00	3.00
Kyrgyz Republic	KGZ	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.33	2.33	2.33	2.67	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Latvia	LAT	1.00	1.00	1.00	1.00	1.00	2.67	2.67	2.67	2.67	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.33	3.33	3.33	3.33
Lithuania	LTU	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.33	3.33	3.33	3.33	3.33	3.33	3.33	3.33	3.67	3.67	3.67	3.67	3.67	3.67
Moldova	MDA	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.67	3.00	3.00	3.00	3.00	3.00	3.00
Mongolia	MNG	1.00	1.00	1.00	1.67	1.67	1.67	2.00	2.33	2.33	2.33	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	3.00	3.00	3.00
Montenegro	MNE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.67	1.67	2.33	2.33	2.33	2.67	3.00	3.00	3.33	3.33	3.33	3.33
Poland	POL	1.00	2.33	2.33	2.33	2.33	2.33	2.67	3.00	3.00	3.33	3.33	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Romania	ROM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.67	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.33	3.33	3.33	3.33	3.33
Russia	RUS	1.00	1.00	1.00	1.00	1.00	2.33	2.33	2.67	2.67	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.33	3.33	3.33
Serbia	SRB	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.33	2.33	2.67	2.67	3.00
Slovak Republic	SVK	1.00	1.00	1.00	1.00	1.00	1.00	2.33	2.33	2.33	2.33	2.33	2.33	3.00	3.33	3.33	3.33	3.67	3.67	3.67	3.67	3.67	3.67
Slovenia	SVN	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.33	2.33	2.33	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.33	3.33	3.33
Tajikistan	TJK	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33
Turkey	TUR	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na	3.33	3.33	3.33
Turkmenistan	TKM	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.67	1.67	1.67
Ukraine	UKR	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.33	2.67	2.67	2.67	2.67	2.67
Uzbekistan	UZB	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Appendix B- Descriptive statistics on input and output data used for Malmquist Index calculations

	Main (fixed) telephone lines (000s)				Total staff in telecommunications sector				Telecommunications investment (current US\$)*10x6				Telecommunications revenue (current US\$)*10x6			
	min	max	mean	st dev	min	max	mean	st dev	min	max	mean	st dev	min	max	mean	st dev
ALB	115.700	300.000	209.350	64.657	2868.000	4510.000	3531.343	660.991	0.734	67.522	20.032	26.193	58.461	648.015	221.474	213.170
ARM	531.500	624.700	566.623	31.968	5286.000	8420.000	6311.099	1256.377	18.142	51.443	29.553	10.222	52.592	194.738	91.482	49.758
AZE	680.200	1253.300	931.260	188.427	8142.000	17912.000	11480.221	3116.870	8.353	238.202	29.408	83.929	57.414	823.256	140.253	269.871
BLR	2489.900	3671.800	3008.938	360.267	26283.000	26782.000	26510.936	182.294	44.914	370.289	108.955	124.962	155.826	765.127	295.309	231.522
BIH	333.200	1064.500	762.647	256.462	1754.000	7004.000	4497.838	2408.844	31.250	255.696	94.063	78.253	157.386	855.944	396.573	268.393
BGR	2300.400	2887.000	2688.308	217.880	20472.000	27482.000	25093.248	1983.735	54.245	736.364	250.728	233.793	306.163	2346.154	943.549	719.472
HRV	1558.000	1887.600	1780.459	112.318	8850.000	11600.000	10605.110	784.870	105.648	352.055	190.970	99.792	659.832	2705.224	1296.405	784.979
EST	442.000	522.800	480.398	30.313	2319.000	3671.000	3010.349	419.911	47.159	129.571	64.856	26.687	215.199	1013.736	478.178	282.799
FYRM	439.200	560.000	505.230	39.119	1732.782	3776.089	2591.336	886.379	33.182	228.723	49.665	59.208	135.142	538.005	271.670	128.193
HUN	3250.600	3798.300	3550.862	184.447	14156.000	21526.000	18487.185	2937.255	412.572	750.462	527.819	105.774	2056.824	5781.784	3846.858	1244.252
KGZ	368.400	482.000	407.568	39.247	6685.000	8518.000	7423.396	513.518	5.031	31.994	15.948	9.288	25.891	144.882	57.648	45.764
LTU	792.400	1187.700	944.203	172.167	3670.383	9196.000	5038.238	1733.143	92.000	217.063	125.189	43.110	192.500	1180.159	488.042	357.922
MDA	555.300	1079.900	764.725	183.604	7243.000	10063.000	7961.521	964.905	14.068	158.649	46.645	44.944	39.639	444.811	123.458	141.875
MNG	103.400	195.100	136.524	31.249	3935.000	40009.340	5667.534	11210.452	1.063	30.607	6.184	10.106	29.561	152.539	63.162	39.118
POL	8812.300	12553.500	11130.376	1120.523	50533.000	175385.000	82540.946	42886.331	1170.115	3040.005	1701.754	571.154	5256.034	15867.750	8642.402	3330.261
ROM	3599.000	4388.000	4104.077	275.633	36934.000	48411.000	42821.309	2961.801	293.228	1229.508	571.990	355.701	676.576	5737.705	1855.806	1795.039
SRB	2280.726	2993.400	2540.269	213.129	1416.534	15047.004	10572.780	3905.335	79.010	426.094	164.296	129.627	285.897	2008.377	599.113	530.814
SVK	1150.800	1698.000	1377.449	207.627	9651.000	16864.000	12558.423	2678.688	177.824	641.297	338.270	152.450	637.220	2533.414	1184.765	649.509
SVN	723.200	857.100	800.179	38.255	2172.000	4742.000	3714.429	881.380	149.623	365.759	267.306	78.197	351.523	1315.155	707.840	362.772
TUR	16807.000	19125.200	18483.426	709.546	45000.000	75576.000	64666.702	9225.685	198.013	1906.923	636.818	552.179	5065.385	16253.077	8948.530	3490.215
UKR	9698.200	12905.900	11147.005	1054.505	120385.456	131000.000	124917.721	3555.624	268.015	2572.416	704.035	816.918	1161.581	8194.069	2603.314	2442.909
UZB	1536.700	1895.400	1710.185	109.873	17350.452	28090.000	23094.425	3364.493	33.750	157.238	76.471	43.942	162.000	563.912	261.426	125.582