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INSTITUTIONAL EFFICIENCY OF SELECTED EU & OECD COUNTRIES USING DEA-LIKE APPROACH

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Abstract

The paper estimates institutional efficiency of a sample of EU and OECD countries. We employ an output-oriented Data Envelopment Analysis (DEA-like) approach where six Worldwide Governance Indicators published by the World Bank in 2009 constitute a vector of outputs. Assuming that all countries should aim at the same level of institutional quality, inputs were considered unimportant. The results, as to in which areas and how much individual countries need to improve, were not surprising. Concerning the overall efficiency scores and rankings, the most institutionally efficient countries are situated in northern Europe. The Czech Republic ranked 24th in the overall sample and 3rd among New EU Member States. The biggest necessary improvements are in the area of government effectiveness and control of corruption. The robustness check using Principal Component Analysis revealed significant qualitative correlation with the DEA-like results, with the correlation coefficient of 0.9653. We propose that both sets of results could be used equally well as explanatory variables in growth and other regressions.

Keywords: efficiency, institutions, Worldwide Governance Indicators, PCA.

JEL Classification: C61, E02

1. Introduction

There is little doubt that institutions matter in terms of economic performance and play an important role in economic development. If institutions are trustworthy, new businesses are created easily, larger scale and technologically demanding production takes place, trade flourishes, productivity increases, competitiveness improves and markets function efficiently in general. Institutions also contribute to the domestic and international division of labour. In other words, transaction costs in the entire economy are considerably reduced.

Positive effects of institutions on promoting economic growth and development, investment, prosperity and well-being of the society were first empirically confirmed

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by Kormendi, Meguire (1985) and Scully (1988). Later studies include Borrmann *et al*. (2006) or Chousa *et al*. (2004). A comprehensive survey of studies dealing with the effect of institutions on growth up to 2000 can be found in Aron (2000). Institutions were also found to exert a positive effect on the pattern of foreign direct investment (Gwartney *et al*., 2004), which suggests that bad institutions discourage foreign investment more than the domestic one. The link between institutions, poverty and unequal distribution of income has been empirically explored in Chong, Calderon (2000, 2000b), or Bourguignon, Verdier (2000). When explaining determinants of trade flows, Levchenko (2007) found that institutions also represent a source of comparative advantage causing factor prices to diverge in the countries which do not gain from trade. On the micro level, it was proved that corruption stifles entry of new firms, introduction of new products and technologies, increases uncertainty and worsens delivery of public services (Romer, 1994).

Appropriate measures of institutional quality have been a matter of a wide discussion. It has in some cases been proxied by measures of political stability (Barro, 1991), such as coups and revolutions and political assassinations Gastil (1983, 1986), measures of political freedoms and civil liberties (Kormendi, Meguire, 1985; Scully, 1988) or shadow economy and barter trade volumes (Chousa *et al*., 2004). Other studies employed institutional indicators by the International Country Risk Guide (ICRG) and Business Environmental Risk Intelligence (BERI) (Knack, Keefer, 1995; Chong, Calderon, 2000a; Mauro, 1995), Economic Freedom of the World indicators (Adkins *et al*., 2002; Gwartney *et al*., 2003, 2004), Freedom House's Democratization Index (Chousa *et al*., 2004), data from The Global Competitiveness Report (WEF, 1980-2010), the World Bank - Doing Business (World Bank, 2004-2011) or the Worldwide Governance Indicators previously called Government Matters (Borrmann *et al*., 2006).

In many cases more variables were aggregated to obtain an overall index which would encompass a larger area of institutional quality, for instance using Principal Component Analysis (PCA) (Adkins *et al*., 2002; Wheeler, Mody, 1992), composing an unweighted average (Chong, Calderon, 2000, 2000a, 2000b; Mauro, 1995; Knack, Keefer, 1995) or using the notion of efficiency (Chousa *et al*., 2004).

Our paper will contribute to this stream of research by analyzing the data from Kaufmann *et al*. (2010), ***i.e.*** the Worldwide Governance Indicators. Using a DEA-like output-oriented approach we will (1) obtain relative efficiency of selected OECD and EU countries in terms of quality of institutions which can serve as an institutional input to further analyses. We will then (2) answer in which of the six areas of institutional quality, the countries are relatively lacking and by how much. Our methodology was motivated by Chousa *et al*. (2004) who, even though not with DEA, also constructed a composite institutional variable using relative efficiency under the assumption that the institutional framework of leading developed countries is efficient. We will then (3) carry out a robustness check of the DEA results taking advantage of the Principal Component Analysis (PCA) and measure rank correlations of the results obtained from the respective methods.

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The paper is structured as follows. In Section 2 we will introduce the methodology of the Data Envelopment Analysis and its adjustment necessary for our purposes. Section 3 sheds light on the dataset. In Section 4 we will provide empirical results and discussion and Section 5 will conclude and provide motivation for further research.

2. Methodology

2.1 Data Envelopment Analysis

For the analysis of institutional quality we will use the Data Envelopment Analysis-like (DEA) method. It is a non-parametric deterministic[1] frontier approach, the goal of which is to project an observation in the input-output space in its best possible light. First, the most efficient observations from the dataset form the efficiency frontier. Consequently, the distance of remaining observations from this frontier is determined and their relative level of inefficiency revealed.

For the purposes of this analysis we will employ a DEA output-oriented method, *i.e.* we will maximize a vector of six outputs given a 1×1 vector of inputs which will be set equal to 1 for all observations, assuming constant returns to scale.

For DEA cannot deal with potential outliers, which, if present, might cause serious ill to the results,[2] we will also check statistical homogeneity of the sample (for further discussion see Section 3).

2.1.1 Formulation

Within the DEA framework, assume that a DMU produces s different outputs, $\mathbf{y} = (y_1, \ldots, y_s)$ using m different inputs $\mathbf{x} = (x_1, \ldots, x_m)$ and that there is a set of n DMUs, $\mathbf{N} = (1, \ldots, n)$. Consequently, the i-th DMU, $i \in \mathrm{N}$, is expressed in terms of its input and output vectors, such that $\mathrm{DMU}_i = (\mathbf{x}_i, \mathbf{y}_i)$

where $\mathbf{x}_i = (x_{1i}, \ldots, x_{mi})$, $\mathbf{y}_i = (y_{1i}, \ldots, y_{si})$.

The relative efficiency of DMU can be obtained by solving the fractional program as proposed by Charnes *et al*. (1978, p. 430):

$$\max_{\mathbf{u}_i, \mathbf{v}_i} \frac{\mathbf{u}_i' \mathbf{y}_i}{\mathbf{v}_i' \mathbf{x}_i} \tag{1}$$

s.t.

1 The entire deviation is assumed to be caused by inefficiency, as opposed to stochastic approaches which acknowledge existence of random noise.

2 If there is an outlier among inefficient observations, it will under- or over-estimate results only for this particular observation, however, if the outlier appears among the most efficient observations forming the locus of the most efficient observations, it will shift the frontier and thus reveal wrong results for all other observations in the dataset.

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$$\frac{\mathbf{u}_i^{'}\mathbf{y}_j}{\mathbf{v}_i^{'}\mathbf{x}_j} \leq 1 \ \forall j \in N$$

$$\mathbf{u}_i, \mathbf{v}_i \geq 0$$

where $\mathbf{u}_i$, $\mathbf{v}_i$ are vectors of weights attached to vectors of outputs $\mathbf{y}_i$ and inputs $\mathbf{x}_i$ respectively.

Put it differently, we aim to find a set of input and output weights ($\mathbf{u}_i$, $\mathbf{v}_i$) which maximize efficiency of the under the constraint that if these maximizing weights are applied to each of the other DMUs in the dataset, they lie on, or under the locus of fully efficient observations. It results that the linear program must be run times, once for each DMU.

In our case, the fractional problem will immediately reduce to a multiplier form (Charnes *et al*., 1978) since our input vector consists of just one element equal to 1 for all DMUs. Finding optimal input weights thus looses justification. The denominator of (1) will then be:

$$\mathbf{v}_i^{'}\mathbf{x}_i = 1 \tag{2}$$

Since maximization and minimization are dual problems, we will take advantage of Shephard's (1970) output distance function, where subscript stand for „output", which is reciprocal to Farrell's (1957) measure of output oriented technical efficiency, such that:

$$D_0(x_i, \mathbf{y_i}) = \min\left\{\boldsymbol{\lambda}_i : \left(\frac{\mathbf{y_i}}{\boldsymbol{\lambda}_i}\right) \in P(x)\right\} \tag{3}$$

for $y_i \in P\ (x)$, where $P(x) = \{\mathbf{y_i}: (x_i, \mathbf{y_i}) \in T\}$, which represents output set of the production technology and $D_0(x_i, \mathbf{y_i}) \leq 1$. Further $\mathbf{y_i} : \in I(x)$, where $I(x) = \{x_i : x_i \in L(y), \boldsymbol{\lambda}_i x_i \notin L(y),\ \boldsymbol{\lambda} < 1\}$ is the input isoquant with $L(y) = \{x_i : (\mathbf{y_i}, x_i) \in T\}$ representing the input set of the technology and $D_0(x_i, \mathbf{y_i}) = 1$. The input I(x) isoquant thus represents the locus of fully efficient observations in the input space. Given standard assumptions on the production set $T = \{(\mathbf{y}_i, x_i)$: x_i can produce $\mathbf{y}_i\}$, the output distance function $D_0\ (x_i, \mathbf{y_i})$ is non-increasing in *x* and is non-decreasing, homogeneous of degree +1 and convex in ***y***. Subscript *i* again denotes the DMU_i under scrutiny.

We thus minimize $\boldsymbol{\lambda}_i$, *i.e*. a vector of weights attached to DMU_i to cast it in the best possible light. In other words, if we divide the vector of outputs of DMU_i by the optimal $\boldsymbol{\lambda}$ vector, i.e. increase it by the particular proportion, the DMU concerned would be projected as feasible and efficient. That is, we have determined its distance to the frontier.

Similar to the fractional and multiplier forms, running *n* problems is needed. The vector $\boldsymbol{\lambda}$ is thus specific for each DMU. However, the advantage of the distance function stems from the fact that it involves fewer constraints than factional or multiplier representations.

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We will consider only constant returns to scale assumption, since all the countries should be able to achieve the best possible scores regarding the institutional quality variables. The size of the country is assumed not to play a role.

2.2 Robustness check

As a robustness check of the efficiency results obtained from DEA, we will carry out a Principal Component Analysis (PCA) which will allow us to aggregates all the institutional variables into one indicator. It is based on common components of the data. Variances in the data are projected as a new coordinate system. The greatest variance lies on the first coordinate, the second biggest variance constitutes the second coordinate, which is, however, uncorrelated with the first one, *etc.* Only the greatest variances are taken into account and a lower dimensional data is constructed (for more explanation see *e.g.* Jolliffe, 2002.) Considering only the biggest variance, we will construct our matrix into a vector.

Since PCA only rescales the matrix as opposed to DEA, correlation of the two sets of results is irrelevant. We are instead interested in the Spearman's Rank Correlation Coefficient (Spearman, 1904):

$$\rho = 1 - \frac{6 \times \sum d^2}{n\left(n^2 - 1\right)} \tag{4}$$

$$\rho \in \langle -1, 1 \rangle$$

where d stands for the difference in the ranks and n is the number of pairs compared. The highest rank is assigned to the most efficient observation (under DEA) and the highest indicator value (under PCA). When there are more observations with the same score, however, (*e.g.* fully efficient countries under DEA), their resulting rank is an average of the ranks which otherwise would be the case. There are unlikely to be two identical results under PCA since they are obtained as matrix multiplication. This might therefore result in a slight downward bias in the rank correlation coefficient for the two methods, which has to be kept in mind when interpreting the results.

3. Data

The data on institutional variables was obtained from the Database of Worldwide Governance Indicators (Kaufmann *et al*., 2010).[3] Even though this data is perception-based, we believe that our dataset is considerably robust since each of the six indicators is based on a several hundred variables obtained from 31 different data sources (Kaufmann *et al*., 2010). Being provided with standard errors of each indicator, we excluded insignificant variables and thus reduced much of error or possible bias in the

3 Available online under http://info.worldbank.org/governance/wgi/sc country.asp

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data. Significance of variables was tested using the standard Student's T-test with 90, 95 and 99 percent confidence intervals.

The final dataset for our analysis consists of a cross-section of 35 countries observed in 2009, all of which are EU-27 and OECD members, or both. However, we initially considered 48 countries, which covered all 34 OECD countries + Russia as an EU candidate, EU-27 countries which are not OECD members, EU candidates, *i.e.* Croatia, Monte Negro, Macedonia (former Yugoslavia), and EU potential candidates, *i.e.* Albania, Bosnia and Herzegovina, Serbia and Kosovo. The rationale to include all these countries was consistent with Chousa *et al.* (2004) who argued that institutional quality becomes particularly important when advanced forms of global, regional or economic integration are at stake. Unfortunately, after initial check of the data we excluded 18 countries due to data inconsistency. Specifically, a country was excluded if more than 2 out of 6 variables were insignificant, or if besides two significant variables, others were significant at only 95 or 90%. Besides, we also excluded Russia and Israel, the values of which were significant but extremely low with respect to the rest of the sample. These two countries were utmost likely to be outliers, to which the DEA methodology is very sensitive. The input data for Italy and Greece also suggest that we should be cautious when interpreting their results. Specifically, 2 variables were insignificant in case of Greece, the remaining variables were significant even at 1% level. Italy reported only one insignificant variable, however, three others were significant at 95% confidence interval only. The final list of countries is included in the appendix in Tables A2 and A3.

3.1 Output and Input Variables

Six variables of institutional quality that aim to define "traditions and institutions by which authority in a country is exercised" (Kaufmann *et al*., 2010, p. 4) enter the analysis as a **vector of outputs**. They address different spheres of the overall government performance. The indicators can be divided into three areas, which include (Kaufmann *et al*., 2010):

I. Process by which governments are selected, monitored and replaced
   (1) Voice and Accountability
   (2) Political Stability and Absence of Violence/Terrorism

II. Capacity of the government to effectively formulate and implement sound policies
   (3) Government Effectiveness
   (4) Regulatory Quality

III. Respect of citizens and the state for the institutions that govern economic and social interactions among them
   (5) Rule of Law
   (6) Control of Corruption

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Specifically, **voice and accountability** capture the perception of the extent to which citizens can participate in electing government, can exercise freedom of expression, freedom of association and free media. **Political stability and absence of violence/ terrorism** captures the perception of the probability that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism. **Government effectiveness** measures the perception of the quality of public services, civil service and the degree of its political independence, the quality of policy formulation and implementation and the credibility of the government's commitment to such policies. **Regulatory quality** then represents perception of the extent to which governments can formulate and implement sound policies and regulations that permit and promote private sector development. **Rule of law** belongs to the last group of indicators and captures the confidence the agents have in rules, particularly the quality of contract enforcement, property rights, police and courts and their perception of the likelihood of crime and violence. The last indicator, **control of corruption**, captures the perception of the extent to which public power is exercised for private gains, including all forms of corruption (Kaufmann *et al*., 2010, p. 4). All the six estimated variables in the database span from approximately -2.5 to +2.5, however, countries included in this analysis consistently reveal only data above zero in all areas. Descriptive statistics of the data is reported in Table 1.

Table 1
Descriptive Statistics

Variable	Mean	Median	Minimum	Maximum	St. dev.
voice and accountability	1.225	1.210	0.690	1.570	0.259
political stability	0.896	0.915	0.410	1.440	0.263
government effectiveness	1.339	1.320	0.520	2.190	0.455
regulatory quality	1.318	1.350	0.800	1.820	0.307
rule of law	1.360	1.430	0.390	1.940	0.455
control of corruption	1.385	1.410	0.250	2.420	0.673

Kaufmann *et al.* (2010) themselves acknowledge that the six variables should not be thought of as totally independent from one another. They are indeed positively correlated also for the countries selected here. The correlation matrix is provided in Table A1. Correlation is technically not a problem in non-parametric estimation, even though it has been argued that it artificially increases dimensionality. In our case, it is nevertheless even desirable to keep all the six variables. Explanation of results would otherwise lose implications since we want to determine in which areas of institutional quality, as defined by the Worldwide Government Indicators, the countries are behind, and how much they can improve relative to the institutionally most efficient countries. We will reduce dimensionality only in the robustness check and compare the resulting rankings.

The vector of inputs consists of only one element which is set equal to one for all observations. The purpose of the analysis was not to measure efficiency as such, but rather

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to find out where the countries can still improve in terms of institutional quality. We, nevertheless, acknowledge that there might be some "inputs" that are likely to "produce" our institutional quality variables. These might include, for instance, previous political experience or history of the particular country. These variables are nevertheless impossible to measure in such a way to be included into the analysis as inputs. Furthermore, since all these countries are in some kind of integration process, they all should be equal partners aiming at the same quality of institutions regardless of their historical experience - the same reasons why we consider only the constant returns to scale DEA model.

Institutional efficiency was estimated using Coelli's DEA Software DEAP Version 2.1. For PCA and general analyses the statistical software Gretl (Cottrell & Lucchetti, 2007) was used.

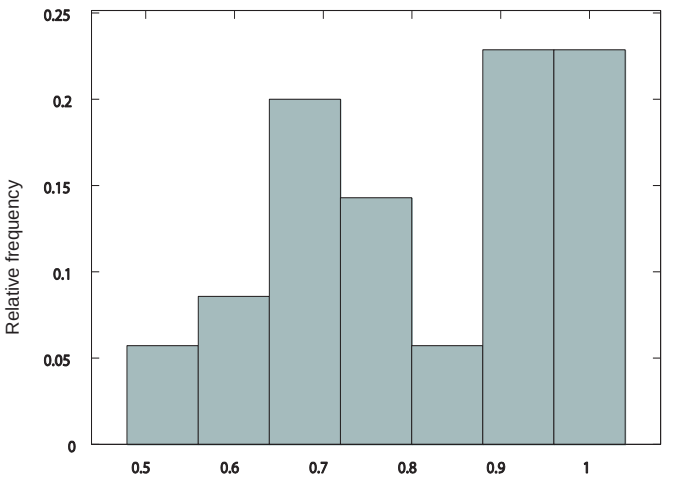
4. Empirical Results

Results of the efficiency analysis are presented in column (3) in Table A2. Countries were ordered in a descending manner.

The interpretation of the efficiency score is such that when a country, *e.g.* the Czech Republic, reaches the efficiency score of 0.714, it could increase its institutional efficiency by 40% relative to the most efficient observations. In other words, there is a scope for efficiency improvement reaching 28.6 percentage points. Higher scores imply a better ranking provided in column (4) of Table A2.

Average DEA-like efficiency of our sample is 0.811 meaning that on average there is an improvement potential of 23.3%. Median efficiency value reaches 0.804 and standard deviation is 0.154. These results are further supported by the distribution of DEA efficiency scores in Figure 1.

Figure 1
Frequency Plot - DEA Efficiency



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The most efficient countries includes the Nordic countries, *i.e*. Denmark, Finland, Norway, Sweden; and Luxembourg, New Zealand and Switzerland, which are immediately followed by the Netherlands. It suggests some clustering of institutionally efficient countries in northern Europe, which is to a large extent consistent with Esping-Andersen's 1990 typology of social-democratic states. The front position of Switzerland may be explained by a considerable level of independence from the influence of various multinational institutions. The next most successful EU countries occupy then 12th - 16th rank with scores above 0.88. France takes the 18th rank with score slightly above 0.80 and is thus the last country in the list to score above the average. EU countries of 2004 and 2007 accession, Portugal, Spain, Italy and Greece reach below average scores, with Estonia being most successful. The Czech Republic takes the 3rd position among 10 New EU Member States and is 24th in the overall sample. The low efficiency scores of the Mediterranean countries is consistent with their recent poor economic development. It is also important to keep in mind that Spain, Italy and Greece, together with the United Kingdom, Cyprus and South Korea, did not reveal significant data for all 6 areas of interest which, by itself, signals some inconsistency in their policies.

In Table A3, we provide original values of the institutional quality variables together with their targets, *i.e*. what each country should be able to achieve relative to the rest of the sample. The target value was obtained as a linear combination of its peers (*i.e.* efficient observations that are placed on the frontier).

Table 2 through Table 7 show the countries which require the biggest and lowest improvements to be placed on the frontier, for each of the six variables considered. The output-oriented distance to the frontier is expressed both in absolute and relative terms.[4] Neither fully efficient observations, nor observations that did not reveal reliable data for the particular indicator were considered.

Table 2

Highest and Lowest Necessary Improvements in *(1) voice and accountability*

Highest			Lowest		
country	**% of original**	**abs.value**	**country**	**% of original**	**abs. value**
KOREA, SOUTH	1.22	0.85	**NETHERLANDS**	0.01	0.01
LATVIA	0.97	0.77	**ICELAND**	0.06	0.08
GREECE	0.78	0.69	**CANADA**	0.07	0.11
LITHUANIA	0.77	0.68	**AUSTRIA**	0.12	0.16
SLOVAKIA	0.76	0.67	**AUSTRALIA**	0.12	0.17

4 Column "% of original" indicates, if multiplied by 100, the percentage improvement with respect to the country's original value. Column "-" denotes absolute difference between the targeted and original value.

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Table 3

Highest and Lowest Necessary Improvements in *(2) political stability*

Highest				Lowest			
% of original		absolute difference		% of original		absolute difference	
country	value	country	value	country	value	country	value
UNITED STATES	2.32	UNITED STATES	0.95	ICELAND	0.06	ICELAND	0.07
LATVIA	1.36	ITALY	0.66	IRELAND	0.10	IRELAND	0.10
ITALY	1.25	FRANCE	0.61	NETHERLANDS	0.14	NETHERLANDS	0.13
FRANCE	1.11	LATVIA	0.60	CANADA	0.18	CANADA	0.18
HUNGARY	0.80	LITHUANIA	0.51	AUSTRIA	0.20	AUSTRALIA	0.21

Table 4

Highest and Lowest Necessary Improvements in *(3) government effectiveness*

Highest				Lowest			
% of original		absolute difference		% of original		absolute difference	
country	value	country	value	country	value	country	value
LATVIA	2.42	LATVIA	1.55	BELGIUM	0.20	BELGIUM	0.30
ITALY	2.33	HUNGARY	1.33	CANADA	0.20	CANADA	0.36
GREECE	1.90	LITHUANIA	1.30	NETHERLANDS	0.22	ICELAND	0.36
HUNGARY	1.83	ITALY	1.21	ICELAND	0.22	NETHERLANDS	0.37
LITHUANIA	1.80	CZECH REPUBLIC	1.16	AUSTRALIA	0.26	FRANCE	0.39

Table 5

Highest and Lowest Necessary Improvements in *(4) regulatory quality*

Highest				Lowest			
% of original		absolute difference		% of original		absolute difference	
country	value	country	value	country	value	country	value
KOREA, SOUTH	1.05	KOREA. SOUTH	0.90	NETHERLANDS	0.01	NETHERLANDS	0.01
LATVIA	0.86	LATVIA	0.84	AUSTRALIA	0.05	AUSTRALIA	0.08
SLOVENIA	0.83	ICELAND	0.76	CANADA	0.07	CANADA	0.12
ICELAND	0.79	LITHUANIA	0.75	IRELAND	0.10	BELGIUM	0.16
GREECE	0.78	SLOVENIA	0.74	GERMANY	0.13	IRELAND	0.17

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Table 6

Highest and Lowest Necessary Improvements in *(5) rule of law*

Highest				Lowest			
% of original		absolute difference		% of original		absolute difference	
country	value	country	value	country	value	country	value
ITALY	3.82	ITALY	1.49	NETHERLANDS	0.05	NETHERLANDS	0.09
SLOVAKIA	1.94	SLOVAKIA	1.26	CANADA	0.07	CANADA	0.13
GREECE	1.94	GREECE	1.24	ICELAND	0.08	ICELAND	0.14
POLAND	1.71	POLAND	1.16	AUSTRALIA	0.08	AUSTRALIA	0.14
LITHUANIA	1.58	LITHUANIA	1.14	AUSTRIA	0.10	IRELAND	0.18

Table 7

Highest and Lowest Necessary Improvements in *(6) control of corruption*

Highest				Lowest			
% of original		absolute difference		% of original		absolute difference	
country	value	country	value	country	value	country	value
LITHUANIA	7.95	LATVIA	2.12	ICELAND	0.06	ICELAND	0.11
LATVIA	7.07	LITHUANIA	1.99	NETHERLANDS	0.09	NETHERLANDS	0.18
SLOVAKIA	5.73	SLOVAKIA	1.84	CANADA	0.13	CANADA	0.26
HUNGARY	3.97	HUNGARY	1.83	AUSTRALIA	0.19	AUSTRALIA	0.39
CZECH REPUBLIC	3.92	CZECH REPUBLIC	1.81	AUSTRIA	0.27	AUSTRIA	0.47

Countries that ended up in the worst performing group are to a large extent not a surprise for any of the indicators. Even the worst situation of the United States in indicator *(2) political stability* is not surprising keeping in mind the potential threat of terrorism, the USA. are facing. The countries which classified as needing the least improvement are considerably stable across indicators.

The Czech Republic ended up on the 24th place from the total, however, among the new EU accession countries it ranks the 3rd, following Estonia and Malta. It reached overall efficiency score of 0.714. As far as improvements in individual variables are concerned, it needs the 5th biggest improvement in *(6) control of corruption*, both in absolute and relative terms. In *(3) government effectiveness,* the 5th biggest improvement is also required, however, only in absolute terms. In summary, *(1) voice and accountability* needs to be increased by 45%, *(2) political stability* by 40%, *(3) government effectiveness* by 119%, *(4) regulatory quality* by 40%, *(5) rule of law* by 100% and *(6) control of corruption* by about 392% relative to its values of the Worldwide Governance Indicators published by the World Bank in 2009.

Targets of the Czech Republic were further compared to the results of Slovakia, which took the 30th position reaching efficiency score of 0.645. Panel (a) of Figure 2 depicts absolute differences between the original values and targets for the Czech

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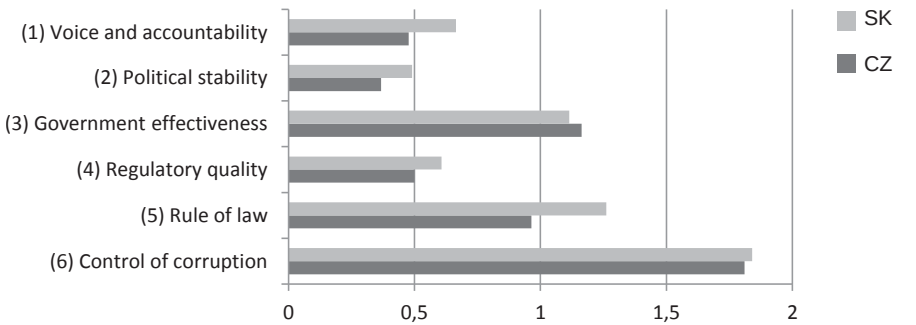
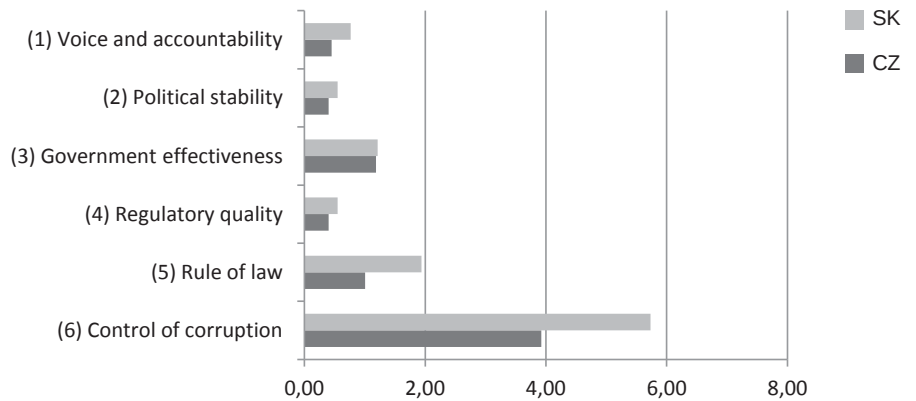
Republic and Slovakia, panel (b) compares the necessary improvements for both countries in relative terms. Even though these two countries had a similar starting position in 1993, when they split, the results reveal that Slovakia needs to improve more in all the observed areas, both in absolute and relative terms. The only exception is *(3) government effectiveness* where Slovakia is slightly better, both in absolute and relative terms.

Figure 2
Czech Republic vs. Slovakia

(a) absolute terms



(b) relative terms



4.1 Robustness check

Our DEA-like approach provides us with invaluable information as to where each country should improve in terms of institutional quality, however, as also Kaufmann *et al*. (2010) pointed out and Table A1 revealed, the institutional quality variables are correlated. Even though correlation is technically not a problem in DEA, it is not ideal if the primary focus of the analysis are efficiency scores. We therefore tested

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correlation of efficiency results obtained from DEA and the Principal Component Analysis, which creates a system of coordinates uncorrelated to one another. Results of the PCA are provided in Table 8.

Table 8
Principal Component Analysis

	PC1	PC2	PC3	PC4	PC5	PC6
Eigenvalue	4.9176	0.6275	0.2600	0.0915	0.0699	0.0335
Proportion	0.8196	0.1046	0.0433	0.0152	0.0116	0.0056
Cummulative	0.8196	0.9242	0.9675	0.9828	0.9944	1.0000
Component loadings						
Voice and accountability (1)	0.431	-0.100	0.210	-0.837	0.244	-0.009
Political stability (2)	0.320	-0.853	-0.377	0.157	-0.053	0.034
Government effectiveness (3)	0.436	0.095	0.215	0.441	0.577	-0.477
Regulatory quality (4)	0.376	0.480	-0.787	-0.053	0.030	0.070
Rule of law (5)	0.436	0.112	0.209	0.041	-0.776	-0.387
Control of corruption (6)	0.437	0.106	0.323	0.276	-0.030	0.785

The first principal component explains over 81 % of the data. We used only the first component to obtain a vector of institutional values. When looking at principal loadings for all the six variables for the first component, one notices that they are to some extent similar.

We multiplied the original variables by their loadings for the first component, the results of which are depicted in the 5th column of Table A2. Descriptive statistics of the resulting values are provided in Table 9, together with the like for the DEA results. The graph of distribution of final PCA values is provided in Figure 3. Unfortunately the two sets of results are quantitatively not comparable since the latter is a transformation of the original data, while the former are efficiency scores spanning in the [0;1] interval.

Table 9
Descriptive Statistics of the Results

	Efficiency DEA	PCA PC1
	(1)	(2)
Mean	0.811	3.217
Median	0.804	3.197
Minimum	0.519	1.622
Maximum	1.000	4.517
St. Dev.	0.154	0.898

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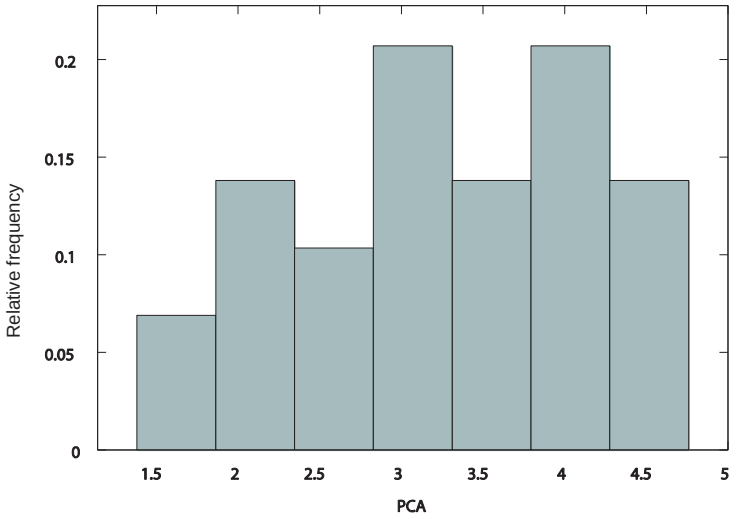
Figure 3
Frequency Plot - PCA Values



We therefore ranked the results of the PCA in the 6th column of Table A2, and calculated the Spearman's Rank Correlation Coefficient (Spearman, 1904) which proved to be 0.9653. We significantly rejected the null hypothesis of no rank correlation even at 1 % significance level. It has to be kept in mind in this context that the coefficient might still be slightly downward biased due to the fact that identical efficiency scores under DEA are ranked the same (for more discussion see Section 2) No two values were identical under PCA.

5. Conclusions

This paper builds on a widespread application of institutional variables in growth and other macroeconomic regressions. The general results show that better institutions determine higher income and investments, institutional improvements lead to higher rates of economic growth (even though in a considerable time lag). Building of institutions can thus be thought of as a form of technology transfer that allows increased productivity.

We looked at institutions from a different perspective. Using Worldwide Governance Indicators published by the World Bank in 2009, we employed an output-oriented Data Envelopment Analysis (DEA-like) approach, where the six institutional quality indicators constituted a vector of outputs. Inputs were set equal to 1 for all countries. We were interested in institutional quality of a statistically homogeneous sample of 35 countries (EU and OECD members) and assumed that all countries should aim at identical institutional quality regardless of their "inputs", the more so that these countries are in an advanced process of regional or economic integration.

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We analyzed the position of individual countries in the sample with respect to the six Worldwide Governance Indicators. It allowed us to determine in which areas of institutional quality each country is lacking and by how much, relative to the best performers in the sample. We also aggregated the indicators and constructed relative efficiency scores lying in the interval [0;1].

Average efficiency of the sample reached 0.811, median was 0.804. The most institutionally efficient countries are situated in northern Europe. As far as major and minor necessary improvements are concerned, the results were not surprising. The Czech Republic took up the 24th rank in the overall sample and the 3rd among New EU Member States. Major improvements here were found to be necessary in the area of government effectiveness and control of corruption where it scored among the 5 worst countries. However, in comparison with Slovakia, the Czech Republic scored better in most areas.

We then carried out a robustness check of the aggregated results using the Principal Component Analysis and computed Spearman's Rank Correlation Coefficient. DEA and PCA scores were significantly correlated with the coefficient of 0.9653. The significant qualitative correlation between the two sets of results suggests, that our efficiency scores could equally well be employed in growth and other regressions requiring institutional quality as an explanatory variable - however, as literature suggests, some lag with respect to other variables of the growth regression should be considered.

The advantage of the DEA-like non-parametric method stems from the fact it can be adjusted for any variables, including those that are expressed in natural units only (such as days required to obtain a construction permit). The motivation for further research thus is to use a different sets of institutional quality variables and compare the resulting scores and rankings with those obtained in this paper.

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Appendix

Table A1

Correlation Matrix

voice and accountability	political stability	government effectiveness	regulatory quality	rule of law	control of corruption	
(1)	(2)	(3)	(4)	(5)	(6)	
1	0.7087	0.8596	0.7723	0.8741	0.9105	(1)
	1	0.6507	0.4547	0.6438	0.6048	(2)
		1	0.8144	0.9357	0.9474	(3)
			1	0.8288	0.7873	(4)
				1	0.9513	(5)
					1	(6)

Table A2

Efficiency Results

Country	ID	Efficiency	Rank_DEA	PCA_PC1	Rank_PCA
(1)	(2)	(3)	(4)	(5)	(6)
DENMARK	6	1.000	1	4.517	1
FINLAND	8	1.000	1	4.490	2
LUXEMBOURG	19	1.000	1	4.172	5
NEW ZEALAND	21	1.000	1	4.317	4
NORWAY	22	1.000	1	4.002	9
SWEDEN	28	1.000	1	4.332	3
SWITZERLAND	29	1.000	1	4.121	6
NETHERLANDS	20	0.992	8	4.034	7
AUSTRALIA	1	0.956	9	3.919	10
ICELAND	14	0.948	10	3.734	12
CANADA	4	0.932	11	4.007	8
AUSTRIA	2	0.907	12	3.748	11
IRELAND	15	0.906	13	3.581	13
GERMANY	10	0.889	14	3.523	14
BELGIUM	3	0.886	15	3.197	15
UNITED KINGDOM	30	0.885	16	.	.
CHILE	13	0.824	17	2.851	20
FRANCE	9	0.804	18	3.034	16
ESTONIA	7	0.791	19	2.653	21
UNITED STATES	31	0.789	20	2.910	17
MALTA	35	0.788	21	2.904	18
PORTUGAL	24	0.771	22	2.618	22
SPAIN	27	0.760	23	.	.
CZECH REPUBLIC	5	0.714	24	2.268	24
CYPRUS	32	0.709	25	.	.
JAPAN	17	0.687	26	2.861	19
ITALY	16	0.662	27	.	.
POLAND	23	0.662	27	1.870	27
HUNGARY	12	0.646	29	1.918	25
SLOVAKIA	25	0.645	30	1.898	26
SLOVENIA	26	0.638	31	2.493	23
LITHUANIA	34	0.565	32	1.692	28
GREECE	11	0.561	33	.	.
LATVIA	33	0.538	34	1.622	29
KOREA, SOUTH	18	0.519	35		

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Table A3
Countries - Original vs. Projected Values and Absolute and Relative Differences

Country	(1) voice and accountability				(2) political stability				(3) government effectiveness				(4) regulatory quality				(5) rule of law				(6) control of corruption			
	original	target	%	-	original	target	%	-	original	target	%	-	original	target	%	-	original	target	%	-	original	target	%	-
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)
AUSTRALIA	1.39	1.56	0.12	0.17	0.83	1.04	0.25	0.21	1.74	2.19	0.26	0.45	1.74	1.82	0.05	0.08	1.73	1.87	0.08	0.14	2.03	2.42	0.19	0.39
AUSTRIA	1.37	1.53	0.12	0.16	1.13	1.36	0.20	0.23	1.63	2.13	0.31	0.50	1.47	1.73	0.18	0.26	1.76	1.94	0.10	0.18	1.75	2.22	0.27	0.47
BELGIUM	1.39	1.57	0.13	0.18	0.79	1.18	0.49	0.39	1.48	1.78	0.20	0.30	1.27	1.43	0.13	0.16	1.37	1.88	0.37	0.51	1.43	1.99	0.39	0.56
CANADA	1.44	1.55	0.07	0.11	1.02	1.20	0.18	0.18	1.78	2.14	0.20	0.36	1.64	1.76	0.07	0.12	1.78	1.91	0.07	0.13	2.04	2.30	0.13	0.26
CZECH REPUBLIC	1.06	1.54	0.45	0.48	0.92	1.29	0.40	0.37	0.98	2.14	1.19	1.16	1.25	1.75	0.40	0.50	0.96	1.92	1.00	0.96	0.46	2.27	3.92	1.81
DENMARK	1.56	1.56	0.00	0.00	1.04	1.04	0.00	0.00	2.19	2.19	0.00	0.00	1.82	1.82	0.00	0.00	1.87	1.87	0.00	0.00	2.42	2.42	0.00	0.00
ESTONIA	1.11	1.56	0.41	0.45	0.59	1.04	0.76	0.45	1.18	2.19	0.86	1.01	1.44	1.82	0.26	0.38	1.13	1.87	0.65	0.74	1.00	2.42	1.42	1.42
FINLAND	1.53	1.53	0.00	0.00	1.36	1.36	0.00	0.00	2.13	2.13	0.00	0.00	1.73	1.73	0.00	0.00	1.94	1.94	0.00	0.00	2.22	2.22	0.00	0.00
FRANCE	1.26	1.57	0.24	0.31	0.55	1.16	1.11	0.61	1.44	1.83	0.27	0.39	1.19	1.48	0.24	0.29	1.43	1.88	0.31	0.45	1.41	2.04	0.45	0.63
GERMANY	1.39	1.56	0.13	0.17	0.85	1.10	0.29	0.25	1.48	2.01	0.36	0.53	1.47	1.65	0.13	0.18	1.63	1.87	0.15	0.24	1.70	2.24	0.31	0.54
GREECE	0.88	1.57	0.78	0.69	.	0.00	.	.	0.61	1.77	1.90	1.16	0.80	1.43	0.78	0.63	0.64	1.88	1.94	1.24	.	0.00	.	.
HUNGARY	1.01	1.56	0.55	0.55	0.60	1.08	0.80	0.48	0.73	2.06	1.83	1.33	1.10	1.70	0.55	0.60	0.82	1.87	1.28	1.05	0.46	2.29	3.97	1.83
CHILE	0.96	1.56	0.63	0.60	0.63	1.04	0.65	0.41	1.21	2.19	0.81	0.98	1.50	1.82	0.21	0.32	1.25	1.87	0.50	0.62	1.37	2.42	0.77	1.05
ICELAND	1.47	1.55	0.06	0.08	1.21	1.28	0.06	0.07	1.61	1.97	0.22	0.36	0.96	1.72	0.79	0.76	1.72	1.86	0.08	0.14	2.06	2.17	0.06	0.11
IRELAND	1.37	1.55	0.13	0.18	0.98	1.08	0.10	0.10	1.30	2.13	0.64	0.83	1.63	1.80	0.10	0.17	1.71	1.89	0.10	0.18	1.72	2.38	0.39	0.66
ITALY	1.04	1.57	0.51	0.53	0.53	1.19	1.25	0.66	0.52	1.73	2.33	1.21	0.90	1.39	0.54	0.49	0.39	1.88	3.82	1.49	.	0.00	.	.
JAPAN	1.03	1.54	0.49	0.51	0.95	1.38	0.46	0.43	1.26	2.02	0.60	0.76	1.07	1.70	0.59	0.63	1.31	1.91	0.46	0.60	1.35	2.15	0.59	0.80
KOREA, SOUTH	0.69	1.54	1.22	0.85	.	0.00	.	.	1.11	2.14	0.93	1.03	0.85	1.75	1.05	0.90	1.00	1.93	0.93	0.93	0.52	2.25	3.33	1.73
LUXEMBOURG	1.55	1.55	0.00	0.00	1.44	1.44	0.00	0.00	1.76	1.76	0.00	0.00	1.64	1.64	0.00	0.00	1.83	1.83	0.00	0.00	1.97	1.97	0.00	0.00
NETHERLANDS	1.55	1.56	0.01	0.01	0.95	1.08	0.14	0.13	1.69	2.06	0.22	0.37	1.68	1.69	0.01	0.01	1.78	1.87	0.05	0.09	2.10	2.28	0.09	0.18
NEW ZEALAND	1.49	1.49	0.00	0.00	0.99	0.99	0.00	0.00	1.88	1.88	0.00	0.00	1.77	1.77	0.00	0.00	1.91	1.91	0.00	0.00	2.38	2.38	0.00	0.00
NORWAY	1.57	1.57	0.00	0.00	1.19	1.19	0.00	0.00	1.73	1.73	0.00	0.00	1.39	1.39	0.00	0.00	1.88	1.88	0.00	0.00	1.94	1.94	0.00	0.00
POLAND	1.03	1.56	0.51	0.53	0.91	1.37	0.51	0.46	0.64	1.75	1.74	1.11	0.93	1.57	0.69	0.64	0.68	1.84	1.71	1.16	0.48	1.96	3.09	1.48
PORTUGAL	1.21	1.57	0.30	0.36	0.79	1.19	0.51	0.40	1.21	1.73	0.43	0.52	1.04	1.39	0.34	0.35	1.04	1.88	0.81	0.84	1.08	1.94	0.80	0.86
SLOVAKIA	0.87	1.54	0.76	0.67	0.89	1.38	0.55	0.49	0.92	2.03	1.21	1.11	1.10	1.71	0.55	0.61	0.65	1.91	1.94	1.26	0.32	2.16	5.73	1.84
SLOVENIA	0.99	1.55	0.57	0.56	0.87	1.37	0.57	0.50	1.16	1.82	0.57	0.66	0.89	1.63	0.83	0.74	1.11	1.81	0.63	0.70	1.06	2.00	0.89	0.94
SPAIN	1.19	1.57	0.32	0.38	.	0.00	.	.	0.94	1.89	1.01	0.95	1.17	1.54	0.32	0.37	1.13	1.88	0.66	0.75	1.01	2.11	1.09	1.10
SWEDEN	1.56	1.56	0.00	0.00	1.10	1.10	0.00	0.00	1.99	1.99	0.00	0.00	1.66	1.66	0.00	0.00	1.93	1.93	0.00	0.00	2.23	2.23	0.00	0.00
SWITZERLAND	1.56	1.56	0.00	0.00	1.21	1.21	0.00	0.00	1.92	1.92	0.00	0.00	1.55	1.55	0.00	0.00	1.75	1.75	0.00	0.00	2.01	2.01	0.00	0.00
UNITED KINGDOM	1.31	1.52	0.16	0.21	.	0.00	.	.	1.48	2.07	0.40	0.59	1.54	1.74	0.13	0.20	1.71	1.93	0.13	0.22	1.54	2.26	0.47	0.72
UNITED STATES	1.11	1.53	0.38	0.42	0.41	1.36	2.32	0.95	1.39	2.13	0.53	0.74	1.36	1.73	0.27	0.37	1.53	1.94	0.27	0.41	1.18	2.22	0.88	1.04
CYPRUS	1.06	1.56	0.47	0.50	.	0.00	.	.	1.32	2.19	0.66	0.87	1.29	1.82	0.41	0.53	1.16	1.87	0.61	0.71	1.00	2.42	1.42	1.42
LATVIA	0.79	1.56	0.97	0.77	0.44	1.04	1.36	0.60	0.64	2.19	2.42	1.55	0.98	1.82	0.86	0.84	0.83	1.87	1.25	1.04	0.30	2.42	7.07	2.12
LITHUANIA	0.88	1.56	0.77	0.68	0.66	1.17	0.77	0.51	0.72	2.02	1.80	1.30	0.97	1.72	0.77	0.75	0.72	1.86	1.58	1.14	0.25	2.24	7.95	1.99
MALTA	1.21	1.54	0.27	0.33	1.06	1.35	0.27	0.29	1.11	2.06	0.86	0.95	1.35	1.71	0.27	0.36	1.51	1.92	0.27	0.41	0.90	2.19	1.43	1.29