*Theoretical and Applied Economics*
*Volume XXVI (2019), No. 1(618), Spring, pp. 89-114*

# Are institutions a crucial determinant of cross country economic efficiency? A two-stage double bootstrap data envelopment analysis

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**Abstract.** *This paper analyses the role of institutions in enhancing the economic efficiencies across countries in a two stage Double Bootstrap DEA framework based on nonparametric frontier analysis as proposed by Simar and Wilson (2007). In the first stage, cross country workers' efficiency is estimated using a bootstrapped DEA approach over the period of 1990-2000 for 78 countries. In the second stage, the impact of institutions on these efficiency estimates is analyzed in a truncated bootstrapped regression. Twenty-nine institutional indicators from the same period have been utilized to extract three orthogonal factors based on principal component analysis. These factors namely institutional and policy rents, political rents and risk reducing technologies, along with their aggregated index are used as institutional variables. Findings suggest that inefficiencies in the economy are less where institutions are stronger. This study also shows that institutions that curb corruption, bureaucratic inefficiencies, lax regulations and unfriendly business policies, tend to have a larger effect on workers efficiency than other two indices that curb political rents and those that reduce transactional risks. Furthermore, when they are aggregated, the combined impact is more than the individual impact.*

**Keywords:** institutions; DEA; efficiency; bootstrap.

**JEL Classification:** C23, D24, Q22, O 43, Z13.

Economic growth does not depend only on the number of inputs in the production process but also on the better allocation of resources and introduction of productivity-enhancing innovations. (Olson, 1982; Baumol, 1990; North, 1990; Restuccia, 2004 and Landon-Lane and Robertson, 2005) attribute lower productivity and efficiency to the barriers for technological adoption as well as inefficient use of existing technology due to weak institutions. Siddiqui and Ahmed (2013) empirically explained how institutions influence economic growth in a theoretical framework proposed by North (1981)[(1)]. The present study takes this work a step further to explore if the growth is caused mainly by increase in efficiency of production and how this efficiency is affected by the quality of institutions. To accomplish this task, the present study follows a two-stage procedure.[(2)] In the first stage, efficiency indices of 78 countries are constructed covering a period of 1990-2000 based on a non-parametric method developed by Fare et al. (1985, 1994) using the data envelopment analysis (DEA). In the second stage, these efficiency indices as dependent variable are regressed against other determinants of efficiencies including institutions[(3)].

Most of the contemporary empirical literature relies on the traditional growth accounting approach to estimate efficiency and productivity (Solow, 1957; Denison, 1972; Griliches and Joregenson, 1967, etc.). This approach implicitly assumes that all countries are efficient and the relative efficiency is interpreted as distance from the frontier line. However later studies like (Kumar and Russell, 2002; Los and Timmer, 2005; Henderson and Russell, 2005) decompose productivity growth into technological change, changes in efficiency, and capital deepening.

Growth accounting approach also assumes that factor markets are perfectly competitive which is not true in practice. Another issue arises that it imposes a functional form restriction, i.e. TFP computed as a residual value (Solow residual) from the Cobb-Douglas production function. This seems to be unrealistic (see Hulten, 2000) hence, it will bias the estimates of the relative contributions of factors and productivity. Even relaxing the Cobb-Douglas assumption and dealing with different functional forms may face functional mis-specification problems (Basu and Weil, 1998; Caselli and Coleman, 2006). Furthermore, there is evidence that the share of capital's income is not equal across countries and also varies time wise especially in poor countries (Gollin, 2002; Caselli and Feyrer, 2007; Aiyar and Dalgaard, 2005). Hence, treating all countries as a single homogeneous group, for which the same variables have the same effect on economic growth, seems increasingly questionable and would lead to overestimation of the role of total factor productivity (TFP) (Caselli, 2005; Jerzmanowski, 2007; Brock and Durlauf, 2001).

An alternative parametric frontier methodology to measure efficiencies is the Stochastic Frontier model developed by Sealey and Lindley (1977)[(4)]. The stochastic frontier approach (SFA) allows disentangling the inefficiency component and a purely random component. Studies such as (Fare et al., 1994; Moroney and Lovell, 1997; Méon and Weill, 2006; Kuhey and Weill, 2007; Koop et al. 1999, 2000; Limam and Miller, 2004; Mastromarco, 2002; Kneller and Stevens, 2003; and Henry et al., 2003) applied this approach to aggregate production functions to estimate efficiency. However, its disadvantage is that it is a parametric approach and needs to impose a functional form. But the mis-specification of the functional form often results in bias in efficiency scores. For Instance Giannakas et al. (2003) estimated this bias up to 10-30% of output.

The nonparametric approach eliminates most of the above mentioned problems. DEA is considered a standard non-parametric methodology that is applied to firms, industries(5) and aggregate production functions (Fare et al., 1994; Chang and Luh, 1999; Kumar and Russell, 2002; Henderson and Russell, 2005; Arestis et al., 2006; Growiec, 2008; Maudos et al., 2000; Taskin and Zaim, 1997; Mathur, 2007; Milner and Weyman-Jones, 2003; Jerzmanowski, 2007; Dimelis and Dimopoulou, 2002; Deliktas and Balcilar, 2002). Efficiency frontier is formed from the most efficient countries on the frontier, and relative efficiency of the countries is calculated from their distance from this frontier. The smaller the distance (from the frontier), the higher the efficiency level as compared to others. In such a case, efficiency is defined as the ratio of the weighted sum of outputs to the weighted sum of inputs.

The main advantage of the method is that no subjective weights are used to combine the different measures of performance involved into a single composite measure. DEA resolves that problem by arguing that countries may have their own particular value system and therefore may legitimately define their own peculiar set of weights. Hence each country is 'free' to choose weights for the criteria that maximize its own composite performance measure and derive the frontier values directly from the data. However, this property can be viewed also as a disadvantage of the method since this can lead to some countries being assessed only on a small subset of their performance. In addition, DEA neither requires specification of any particular functional form of the aggregate production function nor it assumes a perfectly competitive factor market. It is also free from distribution assumptions made in SFA and it does not assume a constant factor share in income. However, it does require an assumption concerning the returns to scale of the technology(6).

Nevertheless, the biggest drawback in this approach is that it is sensitive to noise and a measurement error as it attributes all the variation from the frontier to inefficiency. Hence, the estimation of inefficiency may show an upward bias. Simar and Wilson (1998, 2000) pointed out owing to measurement error, a frontier constructed by DEA methods should be treated as an estimate of the frontier based on a single sample drawn from some unknown population. Second, the estimator is biased, since the technological frontier is only defined relative to the best practice observations in the sample not the "true" frontier. What it uncovers is not absolute efficiency, but efficiency relative to the best practice country in the sample. An associated complication with inference is that since the true efficiency scores are not observed directly but are empirically estimated, they are serially correlated in an unknown way. Thus, the usual estimation procedures that assume independently distributed error terms are not valid (Simar and Wilson (1998, 2000)).

Additional issue can arise if these efficiency estimates are used in the 2 stage procedure, like in our case. Since the two-stage procedure also depends upon other explanatory variables that are not taken into account in the first-stage efficiency estimation, these variables might be correlated with inputs and outputs of efficiency estimates. This implies that the error term must be correlated with the second-stage explanatory variables. In order to overcome these deficiencies, Simar and Wilson (1998, 2000, and 2007) introduced a bootstrapping method that provides the means of incorporating a stochastic element into DEA to obtain unbiased beta coefficients and valid confidence intervals. In this way, it allows one to benefit from the advantages of DEA, while performing statistical hypothesis testing on the DEA efficiency scores. The bootstrap is a computer-based method that re samples the original data in order to assign statistical properties. We follow the double bootstrap procedure of Simar and Wilson (2007) in which DEA scores are bootstrapped in the first stage to obtain bias corrected efficiency scores, and then in second step, regressing them on potential covariates with the use of a bootstrapped truncated regression. The bootstrap method is asymptotically efficient since the approximation error due to the bootstrap re sampling tends to zero.

Studies such as (Enflo and Hjertstrand, 2008; Badunenko et al., 2008) used this bootstrapping approach to obtain bias-corrected efficiency scores. Jeon and Sickles (2004) used this approach to test Malmquist-Luenberger productivity indices calculated through directional distance function method. There were attempts made to analyze the factors that influence macroeconomic efficiency in a 2 stage approach. However, large number of studies attributed this role to institutions. For example, (Hall and Jones, 1999; Olson et al., 1998; Bjørnskov and Foss, 2010; Chanda and Dalgaard, 2008) explained institution's influence in TFP growth through growth accounting approach. (Méon and Weill, 2005, 2006; Adkins et al., 2002; Klein and Luu, 2003; Doucouliagos and Ulubasoglu, 2005; Dang, 2009) used SFA to measure the impact of institutions on technical efficiency level, whereas Lambsdorff (2003) used the similar approach to measure institutional impact on productivity. Institution productivity relationship was also being tested using DEA based nonparametric Malmquist productivity index approach (Baris Yoruk, 2007; Krüger, 2003; and M del Mar and Javier, 2007), while (M del Mar and Javier, 2011; Lall et al., 2002; Cherchye and Moesen, 2003) tested institutional impact on efficiency estimates calculated through DEA. Nearly all of the above mentioned studies found a strong and positive influence of institutions including those that inhibit corruption, on countries macroeconomic productivity and in terms of efficiency level.

There could be other determinants of efficiency. Yves and Laurent (2010), using SFA, identified financial development as a major factor while Milner and Thomas (2003) applying DEA approach, found trade openness playing this role. Using Traditional growth accounting approach, (Easterly and Levine, 2003; Alcála and Ciccone, 2004) focused on the impact of other determinants like trade openness and geography on TFP growth.

However, efficiency estimates in all of these studies could be biased due to limitation in their approaches as discussed above. Furthermore, the institutional proxies used in these studies might not be fully representative nor do they identify the channels through which these institutions could influence efficiencies.

## 2. Efficiency estimates methodology

Concept of efficiency analysis and measurement was developed by Farrell (1957), inspired by the earlier work of Debreu (1951) and Koopmans (1951). He defined efficiency as the ratio of the observed values to the optimal values of output and input relative to a given technology. Efficiency frontier is made up of these optimal values and acts as a benchmark. Country's relative efficiency ($E^{it}$) is calculated as a ratio of radial distance between their inputs-outputs $(y^{it}, x^{it})$ and potential optimum inputs-outputs that lies on the frontier$(y^{*t}, x^{*t})$. This efficiency could have an output orientation or input orientation. An output oriented efficiency $(E_o)$ would then be the increase in output produced with given inputs and technology as compared to the output produced with similar inputs but with a reference technology $\left(E^{ot} = \frac{(y^{*t}, x^{*t})}{(y^{it}, x^{it})}\right)$. An alternative input oriented efficiency $(E_i)$ change would be the reduction in inputs to produce the same output under given technology as compared to the possible reduced inputs without reducing outputs under a reference technology $\left(E^{it} = \frac{(y^{it}, x^{it})}{(y^{*t}, x^{*t})}\right)$. Those countries that lie on efficiency frontier would have E = 1, comparatively less efficient countries would have scores less than one (in case of input orientation) or more than one (in case of output orientation).

Radial distance functions used to measure efficiency are calculated in this study through DEA linear programming (LP) methodology. This nonparametric deterministic approach pioneered by Farell (1957), used input and output quantities data points of countries in our sample to solve a series of LP problems one for each country. To estimate input distance functions, Variable Return to Scale (VRS) models (Banker et al., 1984) assume convexity whereas Constant Return to Scale (CRS) (Charnes et al., 1978) assumes proportionality between inputs and outputs i.e. a proportionate increase in inputs results in the same proportionate increase in outputs. In that case, CRS measures the overall efficiency for each unit, aggregating pure technical efficiency and scale efficiency into one value whereas VRS measures pure technical efficiency alone (Gollani and Roll, 1989). The scale efficiency score is obtained by dividing the aggregate CRS score by the pure technical efficient VRS score (Fare et al., 1994). A unit is considered scale efficient when its size of operation is optimal, whereas for reduced or increased sizes its efficiency will drop. In the real world, however, this optimal behavior is often precluded by a variety of circumstances such as types of market power, constraints on finances, externalities, imperfect competition, regulatory and financial environment, and protectionist policies.

Since DEA approach has serious shortcomings, we apply the double bootstrap procedure of Simar and Wilson (2007). This method is the only practical avenue to estimate confidence intervals, as well as to correct for the above mentioned bias. Details of the estimation algorithm can be found in Simar and Wilson (2007). More specifically, this consists of the following steps:

- First, standard DEA efficiency point estimates are calculated.
- Then we carry out a truncated normal regression with the maximum likelihood method, regressing estimated efficiency scores that are larger than one on the environmental variables.
- We then perform a bootstrap, drawing 10000 samples from the truncated empirical normal distribution of the estimated efficiency scores.
- Bias-corrected efficiency scores are then calculated with the bootstrap results.
- Bias-corrected efficiency estimates are then used in the second (double) parametric bootstrap based on the truncated maximum likelihood to re-estimate the marginal effects of the environmental variables in the second stage. We obtain 1,600 replications for

each parameter estimate of the marginal effect of environmental variables. Standard errors are thus created for the parameters of the regression.

- Confidence intervals are then constructed for the regression parameters as well as for the efficiency scores.

Practically, to obtain the DEA efficiency scores, we utilized FEAR 2 software (Wilson, 2008) which is freely available online, and then truncated regression models were performed in STATA(7).

## 3. Input/output specification and data description in efficiency analysis

In productivity analysis, output per worker is used as output, whereas Physical capital per worker and human capital per worker are taken as inputs. We took these values from the data set developed by Baier et al. (2006). They used a perpetual inventory method of calculating the stock of physical and human capital, human capital stock made up of enrolment rates, years of schooling and experience. This data set covers 145 countries and spans for about hundred years for few countries.

| Regions | Countries included |
|---|---|
| Africa | 9 |
| East Asia and Australia | 11 |
| Eastern Europe | 12 |
| Latin America | 18 |
| Middle East and North Africa | 8 |
| North America | 2 |
| South Asia | 4 |
| Western Europe | 14 |

This data set is divided into a 10 year interval. The time span is long enough to neutralize the impact of business cycle fluctuations in the data. Table 1 reports the summary statistics of input and output variable used in this analysis.

We included 78 countries from this data set in our analysis and used the last two observations for each country covering the period of 1990 and 2000. In Growth accounting literature Summers and Heston (1988) database is widely used to estimate the production function. However, the information on human capital is not included in that database and is taken separately from other databases like Barro and Lee (1993).

**Table 1.** *Summary statistics of input and output variables*

| | Input Variables | | | | Output variable | |
|---|---|---|---|---|---|---|
| | Human Capital per Worker | | Physical Capital per Worker | | Income per Worker | |
| | 2000 | 1990 | 2000 | 1990 | 2000 | 1990 |
| Mean | 5.505933 | 4.959734 | 29955.59 | 26161.26 | 15931.57 | 13531.3 |
| Median | 5.624855 | 5.227323 | 21327.7 | 17807.79 | 10637.72 | 9507.424 |
| Maximum | 7.620805 | 7.299808 | 83329.67 | 77606 | 47047.83 | 38854.14 |
| Minimum | 2.411952 | 2.219233 | 656.1504 | 128.0718 | 743.4831 | 1001.961 |
| Std. Dev. | 1.332949 | 1.254658 | 25019.51 | 22726.33 | 13278.2 | 10648.75 |
| Skewness | -0.433125 | -0.288717 | 0.737446 | 0.786006 | 0.772058 | 0.808043 |
| Kurtosis | 2.377278 | 2.129405 | 2.21345 | 2.226252 | 2.212441 | 2.31949 |
| Observations | 82 | 82 | 82 | 82 | 82 | 82 |

**Table 2.** *Output oriented efficiency indices*

| S. No. | Country | 2000 | | | 1990 | | |
|---|---|---|---|---|---|---|---|
| | | Pure Efficiency (P) VRS | Efficiency (E) CRS | Scale Efficiency (E / P ) | Pure Efficiency (P) VRS | Efficiency (E) CRS | Scale Efficiency (E / P ) |
| 1 | ALGERIA | 1.788 | 1.826 | 1.021 | 1.498 | 1.621 | 1.082 |
| 2 | ARGENTINA | 1.135 | 1.148 | 1.011 | 1.792 | 1.819 | 1.015 |
| 3 | AUSTRALIA | 1.282 | 1.306 | 1.018 | 1.083 | 1.094 | 1.010 |
| 4 | AUSTRIA | 1.147 | 1.170 | 1.020 | 1.242 | 1.260 | 1.014 |
| 5 | BANGLADESH | 1.111 | 2.085 | 1.877 | 1.000 | 1.000 | 1.000 |
| 6 | BELGIUM | 1.000 | 1.020 | 1.020 | 1.000 | 1.006 | 1.006 |
| 7 | BOLIVIA | 2.117 | 2.259 | 1.067 | 2.101 | 2.189 | 1.042 |
| 8 | BOTSWANA | 1.039 | 1.107 | 1.066 | 1.527 | 1.618 | 1.059 |
| 9 | BRAZIL | 1.450 | 1.503 | 1.037 | 1.449 | 1.489 | 1.028 |
| 10 | BULGARIA | 3.037 | 3.085 | 1.016 | 2.083 | 2.103 | 1.010 |
| 11 | CANADA | 1.253 | 1.303 | 1.040 | 1.122 | 1.124 | 1.002 |
| 12 | CHILE | 1.424 | 1.428 | 1.003 | 1.244 | 1.307 | 1.051 |
| 13 | CHINA | 2.222 | 2.384 | 1.073 | 3.440 | 3.777 | 1.098 |
| 14 | COLOMBIA | 1.443 | 1.505 | 1.043 | 1.540 | 1.541 | 1.001 |
| 15 | COSTA RICA | 1.172 | 1.211 | 1.034 | 1.547 | 1.557 | 1.007 |
| 16 | CZECH REP. | 1.410 | 1.425 | 1.010 | 1.705 | 1.946 | 1.142 |
| 17 | DENMARK | 1.260 | 1.295 | 1.028 | 1.350 | 1.373 | 1.017 |
| 18 | DOMINICAN REP. | 1.370 | 1.422 | 1.038 | 1.687 | 1.716 | 1.017 |
| 19 | ECUADOR | 2.333 | 2.397 | 1.028 | 1.578 | 1.657 | 1.050 |
| 20 | EGYPT | 1.000 | 1.000 | 1.000 | 1.196 | 1.247 | 1.042 |
| 21 | EL SALVADOR | 1.220 | 1.346 | 1.103 | 1.941 | 1.948 | 1.004 |
| 22 | ESTONIA | 2.067 | 2.104 | 1.018 | 1.770 | 1.966 | 1.111 |
| 23 | FINLAND | 1.361 | 1.420 | 1.043 | 1.226 | 1.227 | 1.001 |
| 24 | FRANCE | 1.208 | 1.247 | 1.032 | 1.000 | 1.000 | 1.000 |
| 25 | GERMANY | 1.280 | 1.318 | 1.029 | 1.158 | 1.163 | 1.005 |
| 26 | GREECE | 1.167 | 1.180 | 1.011 | 1.374 | 1.392 | 1.013 |
| 27 | GUATEMALA | 1.000 | 1.140 | 1.140 | 1.000 | 1.141 | 1.141 |
| 28 | HONDURAS | 2.119 | 2.314 | 1.092 | 1.699 | 1.731 | 1.018 |
| 29 | HUNGARY | 1.547 | 1.550 | 1.002 | 1.464 | 1.674 | 1.144 |
| 30 | INDIA | 2.019 | 2.249 | 1.114 | 2.635 | 2.722 | 1.033 |
| 31 | INDONESIA | 2.482 | 2.650 | 1.068 | 1.951 | 1.961 | 1.005 |
| 32 | IRELAND | 1.000 | 1.000 | 1.000 | 1.203 | 1.245 | 1.035 |
| 33 | ISRAEL | 1.111 | 1.111 | 1.000 | 1.112 | 1.158 | 1.041 |
| 34 | ITALY | 1.223 | 1.250 | 1.022 | 1.045 | 1.059 | 1.013 |
| 35 | JAMAICA | 2.895 | 2.927 | 1.011 | 1.836 | 2.099 | 1.143 |
| 36 | JAPAN | 1.329 | 1.354 | 1.019 | 1.274 | 1.275 | 1.001 |
| 37 | JORDAN | 1.823 | 1.927 | 1.057 | 1.122 | 1.176 | 1.048 |
| 38 | KENYA | 3.094 | 4.130 | 1.335 | 3.632 | 3.818 | 1.051 |
| 39 | KOREA, SOUTH | 1.459 | 1.470 | 1.007 | 1.226 | 1.290 | 1.052 |
| 40 | LATVIA | 1.967 | 1.975 | 1.004 | 1.671 | 1.778 | 1.064 |
| 41 | LITHUANIA | 2.154 | 2.189 | 1.016 | 1.825 | 2.055 | 1.126 |
| 42 | MALAWI | 2.278 | 4.833 | 2.122 | 2.182 | 3.786 | 1.735 |
| 43 | MALAYSIA | 1.795 | 1.880 | 1.047 | 1.209 | 1.404 | 1.161 |
| 44 | MEXICO | 1.575 | 1.594 | 1.013 | 1.067 | 1.197 | 1.122 |
| 45 | MOROCCO | 1.000 | 1.197 | 1.197 | 1.000 | 1.000 | 1.000 |
| 46 | NAMIBIA | 1.140 | 1.203 | 1.055 | 1.000 | 1.387 | 1.387 |
| 47 | NETHERLANDS | 1.214 | 1.280 | 1.055 | 1.218 | 1.220 | 1.002 |
| 48 | NEW ZEALAND | 1.477 | 1.515 | 1.026 | 1.321 | 1.325 | 1.003 |
| 49 | NICARAGUA | 1.831 | 2.087 | 1.140 | 2.170 | 2.235 | 1.030 |
| 50 | NIGERIA | 2.777 | 4.167 | 1.500 | 2.038 | 2.651 | 1.301 |
| 51 | NORWAY | 1.106 | 1.127 | 1.019 | 1.190 | 1.205 | 1.012 |

| S. No. | Country | 2000 | | | 1990 | | |
|---|---|---|---|---|---|---|---|
| | | Pure Efficiency (P) VRS | Efficiency (E) CRS | Scale Efficiency (E / P ) | Pure Efficiency (P) VRS | Efficiency (E) CRS | Scale Efficiency (E / P ) |
| 52 | PAKISTAN | 1.268 | 1.989 | 1.569 | 1.000 | 1.497 | 1.497 |
| 53 | PANAMA | 1.816 | 1.838 | 1.012 | 1.754 | 1.855 | 1.058 |
| 54 | PARAGUAY | 1.465 | 1.569 | 1.071 | 2.245 | 2.263 | 1.008 |
| 55 | PERU | 1.599 | 1.622 | 1.014 | 2.161 | 2.336 | 1.081 |
| 56 | PHILIPPINES | 1.697 | 1.701 | 1.003 | 2.274 | 2.692 | 1.184 |
| 57 | POLAND | 1.567 | 1.604 | 1.024 | 1.855 | 2.016 | 1.087 |
| 58 | PORTUGAL | 1.364 | 1.366 | 1.001 | 1.358 | 1.372 | 1.010 |
| 59 | ROMANIA | 1.423 | 1.423 | 1.000 | 2.478 | 2.876 | 1.161 |
| 60 | RUSSIA | 2.851 | 2.926 | 1.026 | 1.623 | 1.701 | 1.048 |
| 61 | SINGAPORE | 1.000 | 1.030 | 1.030 | 1.209 | 1.274 | 1.053 |
| 62 | SLOVAKIA | 1.456 | 1.459 | 1.002 | 1.834 | 2.161 | 1.179 |
| 63 | SOUTH AFRICA | 1.059 | 1.080 | 1.020 | 1.678 | 1.853 | 1.105 |
| 64 | SPAIN | 1.366 | 1.366 | 1.000 | 1.100 | 1.153 | 1.048 |
| 65 | SRI LANKA | 2.094 | 2.133 | 1.019 | 1.868 | 2.237 | 1.198 |
| 66 | SWEDEN | 1.350 | 1.364 | 1.010 | 1.143 | 1.168 | 1.022 |
| 67 | SWITZERLAND | 1.059 | 1.062 | 1.003 | 1.108 | 1.185 | 1.069 |
| 68 | TAIWAN | 1.209 | 1.217 | 1.006 | 1.026 | 1.026 | 1.000 |
| 69 | TANZANIA | 1.000 | 3.273 | 3.273 | 1.000 | 2.871 | 2.871 |
| 70 | THAILAND | 2.225 | 2.317 | 1.042 | 1.771 | 1.790 | 1.011 |
| 71 | TUNISIA | 1.000 | 1.036 | 1.036 | 1.095 | 1.116 | 1.019 |
| 72 | TURKEY | 1.485 | 1.547 | 1.042 | 1.380 | 1.399 | 1.014 |
| 73 | UKRAINE | 3.725 | 3.818 | 1.025 | 1.840 | 2.155 | 1.171 |
| 74 | UNITED KINGDOM | 1.215 | 1.235 | 1.016 | 1.111 | 1.141 | 1.027 |
| 75 | UNITED STATES | 1.000 | 1.049 | 1.049 | 1.000 | 1.000 | 1.000 |
| 76 | VENEZUELA | 2.233 | 2.296 | 1.028 | 1.331 | 1.513 | 1.137 |
| 77 | ZAMBIA | 3.395 | 4.865 | 1.433 | 3.686 | 3.893 | 1.056 |
| 78 | ZIMBABWE | 2.164 | 2.317 | 1.070 | 2.767 | 3.092 | 1.118 |
| | Mean | 1.626 | 1.809 | 1.110 | 1.583 | 1.736 | 1.099 |

**Table 3.** *Bias corrected efficiency indices and their confidence intervals*

| | | 2000 | | | | | | 1990 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Country | Pure Efficiency (P) VRS | 95% confidence Interval | | Efficiency (E) CRS | 95% confidence Interval | | Pure Efficiency (P) VRS | 95% confidence Interval | | Efficiency (E) CRS | 95% confidence Interval | |
| | | | Low | High | | Low | High | | Low | High | | Low | High |
| 1 | ALGERIA | 1.866 | 1.803 | 1.959 | 1.879 | 1.831 | 1.975 | 1.579 | 1.518 | 1.655 | 1.695 | 1.628 | 1.792 |
| 2 | ARGENTINA | 1.180 | 1.143 | 1.238 | 1.178 | 1.151 | 1.229 | 1.896 | 1.805 | 2.001 | 1.884 | 1.825 | 1.977 |
| 3 | AUSTRALIA | 1.385 | 1.299 | 1.492 | 1.396 | 1.311 | 1.532 | 1.185 | 1.093 | 1.289 | 1.189 | 1.106 | 1.298 |
| 4 | AUSTRIA | 1.226 | 1.158 | 1.327 | 1.239 | 1.174 | 1.360 | 1.320 | 1.256 | 1.422 | 1.332 | 1.269 | 1.443 |
| 5 | BANGLADESH | 1.253 | 1.128 | 1.419 | 2.410 | 2.104 | 2.843 | 1.315 | 1.016 | 1.706 | 1.186 | 1.021 | 1.376 |
| 6 | BELGIUM | 1.070 | 1.012 | 1.157 | 1.082 | 1.024 | 1.187 | 1.063 | 1.009 | 1.150 | 1.059 | 1.011 | 1.145 |
| 7 | BOLIVIA | 2.299 | 2.142 | 2.520 | 2.374 | 2.270 | 2.571 | 2.240 | 2.117 | 2.441 | 2.305 | 2.200 | 2.490 |
| 8 | BOTSWANA | 1.082 | 1.049 | 1.127 | 1.134 | 1.110 | 1.180 | 1.644 | 1.549 | 1.748 | 1.660 | 1.622 | 1.736 |
| 9 | BRAZIL | 1.504 | 1.461 | 1.567 | 1.539 | 1.507 | 1.602 | 1.520 | 1.466 | 1.595 | 1.532 | 1.494 | 1.597 |
| 10 | BULGARIA | 3.158 | 3.056 | 3.315 | 3.159 | 3.093 | 3.288 | 2.241 | 2.106 | 2.377 | 2.198 | 2.112 | 2.324 |
| 11 | CANADA | 1.346 | 1.264 | 1.461 | 1.388 | 1.309 | 1.515 | 1.210 | 1.137 | 1.320 | 1.182 | 1.130 | 1.275 |
| 12 | CHILE | 1.485 | 1.439 | 1.550 | 1.465 | 1.432 | 1.529 | 1.294 | 1.252 | 1.355 | 1.343 | 1.312 | 1.399 |
| 13 | CHINA | 2.321 | 2.244 | 2.427 | 2.453 | 2.391 | 2.572 | 3.790 | 3.466 | 4.346 | 4.210 | 3.807 | 4.756 |
| 14 | COLOMBIA | 1.498 | 1.455 | 1.558 | 1.541 | 1.509 | 1.605 | 1.639 | 1.562 | 1.748 | 1.585 | 1.546 | 1.664 |
| 15 | COSTA RICA | 1.217 | 1.181 | 1.271 | 1.241 | 1.214 | 1.293 | 1.632 | 1.565 | 1.710 | 1.603 | 1.562 | 1.672 |
| 16 | CZECH REP. | 1.467 | 1.420 | 1.538 | 1.461 | 1.428 | 1.526 | 1.756 | 1.710 | 1.837 | 2.001 | 1.951 | 2.099 |
| 17 | DENMARK | 1.343 | 1.275 | 1.454 | 1.372 | 1.299 | 1.493 | 1.470 | 1.367 | 1.582 | 1.467 | 1.387 | 1.564 |
| 18 | DOMIN. REP. | 1.424 | 1.382 | 1.483 | 1.457 | 1.425 | 1.518 | 1.770 | 1.704 | 1.854 | 1.761 | 1.722 | 1.836 |
| 19 | ECUADOR | 2.444 | 2.356 | 2.576 | 2.463 | 2.404 | 2.577 | 1.638 | 1.587 | 1.713 | 1.701 | 1.662 | 1.774 |
| 20 | EGYPT | 1.300 | 1.019 | 1.560 | 1.179 | 1.013 | 1.395 | 1.408 | 1.208 | 1.652 | 1.433 | 1.269 | 1.645 |
| 21 | EL SALVADOR | 1.288 | 1.236 | 1.350 | 1.392 | 1.351 | 1.472 | 2.117 | 1.969 | 2.300 | 2.039 | 1.956 | 2.191 |
| 22 | ESTONIA | 2.146 | 2.079 | 2.253 | 2.159 | 2.110 | 2.255 | 1.832 | 1.777 | 1.925 | 2.018 | 1.972 | 2.103 |
| 23 | FINLAND | 1.473 | 1.376 | 1.600 | 1.524 | 1.428 | 1.666 | 1.325 | 1.242 | 1.445 | 1.295 | 1.235 | 1.401 |
| 24 | FRANCE | 1.299 | 1.224 | 1.402 | 1.333 | 1.252 | 1.462 | 1.124 | 1.019 | 1.220 | 1.102 | 1.020 | 1.203 |
| 25 | GERMANY | 1.391 | 1.304 | 1.499 | 1.425 | 1.327 | 1.560 | 1.233 | 1.169 | 1.339 | 1.225 | 1.170 | 1.326 |
| 26 | GREECE | 1.220 | 1.174 | 1.292 | 1.225 | 1.184 | 1.305 | 1.471 | 1.384 | 1.560 | 1.451 | 1.397 | 1.531 |
| 27 | GUATEMALA | 1.086 | 1.018 | 1.139 | 1.168 | 1.143 | 1.218 | 1.164 | 1.018 | 1.284 | 1.171 | 1.143 | 1.225 |
| 28 | HONDURAS | 2.243 | 2.146 | 2.349 | 2.368 | 2.320 | 2.461 | 1.817 | 1.721 | 1.951 | 1.787 | 1.736 | 1.886 |
| 29 | HUNGARY | 1.619 | 1.564 | 1.698 | 1.597 | 1.554 | 1.682 | 1.509 | 1.469 | 1.578 | 1.720 | 1.679 | 1.802 |
| 30 | INDIA | 2.161 | 2.049 | 2.311 | 2.353 | 2.259 | 2.535 | 2.937 | 2.663 | 3.309 | 2.960 | 2.737 | 3.310 |

| | | 2000 | | | | | | 1990 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Country | Pure Efficiency (P) VRS | 95% confidence Interval | | Efficiency (E) CRS | 95% confidence Interval | | Pure Efficiency (P) VRS | 95% confidence Interval | | Efficiency (E) CRS | 95% confidence Interval | |
| | | | Low | High | | Low | High | | Low | High | | Low | High |
| 31 | INDONESIA | 2.585 | 2.505 | 2.696 | 2.720 | 2.658 | 2.841 | 2.101 | 1.978 | 2.264 | 2.033 | 1.968 | 2.156 |
| 32 | IRELAND | 1.118 | 1.013 | 1.208 | 1.085 | 1.011 | 1.188 | 1.265 | 1.215 | 1.351 | 1.310 | 1.252 | 1.412 |
| 33 | ISRAEL | 1.203 | 1.122 | 1.293 | 1.176 | 1.115 | 1.279 | 1.173 | 1.124 | 1.242 | 1.232 | 1.166 | 1.311 |
| 34 | ITALY | 1.318 | 1.238 | 1.420 | 1.336 | 1.256 | 1.466 | 1.120 | 1.056 | 1.213 | 1.130 | 1.067 | 1.230 |
| 35 | JAMAICA | 3.061 | 2.924 | 3.256 | 3.006 | 2.935 | 3.144 | 1.896 | 1.844 | 1.985 | 2.170 | 2.105 | 2.296 |
| 36 | JAPAN | 1.416 | 1.338 | 1.534 | 1.430 | 1.357 | 1.571 | 1.376 | 1.292 | 1.504 | 1.342 | 1.282 | 1.451 |
| 37 | JORDAN | 1.960 | 1.854 | 2.090 | 1.982 | 1.932 | 2.080 | 1.185 | 1.140 | 1.240 | 1.213 | 1.180 | 1.266 |
| 38 | KENYA | 3.577 | 3.149 | 4.135 | 4.654 | 4.156 | 5.401 | 4.176 | 3.667 | 4.808 | 4.354 | 3.861 | 4.931 |
| 39 | KOREA, SOUTH | 1.537 | 1.470 | 1.637 | 1.534 | 1.474 | 1.650 | 1.284 | 1.232 | 1.354 | 1.330 | 1.294 | 1.389 |
| 40 | LATVIA | 2.070 | 1.988 | 2.180 | 2.020 | 1.980 | 2.100 | 1.744 | 1.678 | 1.837 | 1.831 | 1.784 | 1.910 |
| 41 | LITHUANIA | 2.246 | 2.167 | 2.361 | 2.239 | 2.194 | 2.328 | 1.885 | 1.831 | 1.976 | 2.108 | 2.061 | 2.200 |
| 42 | MALAWI | 2.589 | 2.312 | 2.949 | 5.696 | 4.892 | 6.743 | 2.634 | 2.221 | 3.078 | 4.370 | 3.857 | 4.994 |
| 43 | MALAYSIA | 1.982 | 1.816 | 2.145 | 1.956 | 1.884 | 2.096 | 1.301 | 1.226 | 1.398 | 1.481 | 1.412 | 1.570 |
| 44 | MEXICO | 1.647 | 1.587 | 1.733 | 1.646 | 1.599 | 1.739 | 1.126 | 1.080 | 1.194 | 1.279 | 1.208 | 1.362 |
| 45 | MOROCCO | 1.085 | 1.017 | 1.142 | 1.251 | 1.202 | 1.345 | 1.228 | 1.018 | 1.404 | 1.178 | 1.022 | 1.330 |
| 46 | NAMIBIA | 1.184 | 1.150 | 1.233 | 1.231 | 1.206 | 1.279 | 1.274 | 1.017 | 1.500 | 1.452 | 1.394 | 1.536 |
| 47 | NETHERLANDS | 1.323 | 1.228 | 1.439 | 1.382 | 1.289 | 1.515 | 1.318 | 1.236 | 1.434 | 1.286 | 1.229 | 1.382 |
| 48 | NEW ZEALAND | 1.555 | 1.485 | 1.670 | 1.584 | 1.520 | 1.703 | 1.416 | 1.337 | 1.541 | 1.398 | 1.334 | 1.514 |
| 49 | NICARAGUA | 2.021 | 1.864 | 2.236 | 2.227 | 2.097 | 2.464 | 2.270 | 2.186 | 2.394 | 2.298 | 2.241 | 2.412 |
| 50 | NIGERIA | 3.038 | 2.826 | 3.244 | 4.441 | 4.185 | 4.909 | 2.339 | 2.073 | 2.611 | 2.876 | 2.663 | 3.211 |
| 51 | NORWAY | 1.179 | 1.114 | 1.277 | 1.191 | 1.130 | 1.307 | 1.295 | 1.200 | 1.409 | 1.304 | 1.216 | 1.423 |
| 52 | PAKISTAN | 1.423 | 1.289 | 1.555 | 2.047 | 1.995 | 2.149 | 1.294 | 1.017 | 1.570 | 1.551 | 1.502 | 1.645 |
| 53 | PANAMA | 1.887 | 1.832 | 1.965 | 1.880 | 1.842 | 1.955 | 1.820 | 1.763 | 1.905 | 1.904 | 1.860 | 1.984 |
| 54 | PARAGUAY | 1.534 | 1.481 | 1.603 | 1.605 | 1.572 | 1.668 | 2.378 | 2.267 | 2.539 | 2.327 | 2.269 | 2.442 |
| 55 | PERU | 1.673 | 1.614 | 1.759 | 1.661 | 1.626 | 1.731 | 2.235 | 2.171 | 2.333 | 2.398 | 2.343 | 2.507 |
| 56 | PHILIPPINES | 1.843 | 1.719 | 1.993 | 1.760 | 1.708 | 1.861 | 2.355 | 2.285 | 2.478 | 2.808 | 2.703 | 3.002 |

| | | 2000 | | | | | | 1990 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Country | Pure Efficiency (P) VRS | 95% confidence Interval | | Efficiency (E) CRS | 95% confidence Interval | | Pure Efficiency (P) VRS | 95% confidence Interval | | Efficiency (E) CRS | 95% confidence Interval | |
| | | | Low | High | | Low | High | | Low | High | | Low | High |
| 57 | POLAND | 1.635 | 1.576 | 1.721 | 1.641 | 1.608 | 1.705 | 1.929 | 1.862 | 2.031 | 2.072 | 2.023 | 2.159 |
| 58 | PORTUGAL | 1.441 | 1.377 | 1.530 | 1.422 | 1.370 | 1.524 | 1.441 | 1.375 | 1.517 | 1.427 | 1.376 | 1.503 |
| 59 | ROMANIA | 1.543 | 1.440 | 1.664 | 1.470 | 1.428 | 1.550 | 2.556 | 2.487 | 2.674 | 2.973 | 2.885 | 3.142 |
| 60 | RUSSIA | 2.966 | 2.867 | 3.138 | 3.019 | 2.934 | 3.188 | 1.724 | 1.631 | 1.829 | 1.763 | 1.707 | 1.853 |
| 61 | SINGAPORE | 1.143 | 1.019 | 1.246 | 1.085 | 1.032 | 1.193 | 1.321 | 1.226 | 1.431 | 1.365 | 1.285 | 1.487 |
| 62 | SLOVAKIA | 1.525 | 1.473 | 1.597 | 1.493 | 1.462 | 1.553 | 1.891 | 1.841 | 1.977 | 2.235 | 2.168 | 2.364 |
| 63 | SOUTH AFRICA | 1.097 | 1.069 | 1.139 | 1.106 | 1.083 | 1.150 | 1.787 | 1.703 | 1.889 | 1.932 | 1.860 | 2.038 |
| 64 | SPAIN | 1.525 | 1.380 | 1.649 | 1.480 | 1.379 | 1.621 | 1.154 | 1.110 | 1.229 | 1.216 | 1.161 | 1.306 |
| 65 | SRI LANKA | 2.250 | 2.120 | 2.431 | 2.210 | 2.141 | 2.344 | 1.946 | 1.877 | 2.070 | 2.361 | 2.248 | 2.557 |
| 66 | SWEDEN | 1.450 | 1.362 | 1.561 | 1.450 | 1.369 | 1.582 | 1.204 | 1.154 | 1.289 | 1.231 | 1.176 | 1.323 |
| 67 | SWITZERLAND | 1.163 | 1.071 | 1.268 | 1.119 | 1.064 | 1.231 | 1.212 | 1.124 | 1.316 | 1.304 | 1.198 | 1.425 |
| 68 | TAIWAN | 1.287 | 1.219 | 1.372 | 1.270 | 1.221 | 1.365 | 1.093 | 1.040 | 1.150 | 1.064 | 1.030 | 1.117 |
| 69 | TANZANIA | 1.322 | 1.016 | 1.693 | 3.784 | 3.299 | 4.533 | 1.318 | 1.020 | 1.711 | 3.336 | 2.921 | 3.872 |
| 70 | THAILAND | 2.318 | 2.246 | 2.427 | 2.374 | 2.323 | 2.473 | 1.869 | 1.787 | 1.990 | 1.838 | 1.795 | 1.924 |
| 71 | TUNISIA | 1.038 | 1.009 | 1.080 | 1.061 | 1.039 | 1.105 | 1.149 | 1.106 | 1.213 | 1.146 | 1.119 | 1.193 |
| 72 | TURKEY | 1.540 | 1.495 | 1.606 | 1.583 | 1.550 | 1.646 | 1.454 | 1.392 | 1.546 | 1.436 | 1.403 | 1.501 |
| 73 | UKRAINE | 3.891 | 3.748 | 4.100 | 3.906 | 3.827 | 4.060 | 1.900 | 1.847 | 1.991 | 2.212 | 2.160 | 2.314 |
| 74 | UNTD KINGDOM | 1.286 | 1.223 | 1.382 | 1.300 | 1.239 | 1.408 | 1.183 | 1.123 | 1.267 | 1.215 | 1.151 | 1.296 |
| 75 | UNITED STATES | 1.097 | 1.018 | 1.191 | 1.135 | 1.056 | 1.242 | 1.129 | 1.017 | 1.217 | 1.071 | 1.011 | 1.141 |
| 76 | VENEZUELA | 2.355 | 2.258 | 2.492 | 2.368 | 2.302 | 2.500 | 1.469 | 1.351 | 1.593 | 1.592 | 1.522 | 1.717 |
| 77 | ZAMBIA | 3.688 | 3.446 | 3.980 | 5.266 | 4.896 | 5.889 | 4.129 | 3.749 | 4.471 | 4.088 | 3.909 | 4.404 |
| 78 | ZIMBABWE | 2.436 | 2.197 | 2.744 | 2.474 | 2.328 | 2.741 | 3.007 | 2.784 | 3.430 | 3.419 | 3.112 | 3.858 |
| | Mean | 1.742 | | | 1.907 | | | 1.711 | | | 1.838 | | |

*These values obtained from 10,000 bootstrap replications.*

## 4. Efficiency results and discussion

Tables 2 and 3 report the efficiency scores of the sample countries at 1990 and 2000 intervals. Efficiency score starts from one; the lower the efficiency score, the higher the countries' efficiency. Belgium, United States and Tunisia are considered as the most efficient countries since they have lower scores under constant and variable return to scale assumption in both the tables. Countries that ranked high in pure efficiency were Belgium, Tunisia, United States, Guatemala, Morocco and Switzerland. Out of the top eleven countries, five belong to the western European region. These countries are considered to be frontier countries under variable return to scale as they scored unity in both periods. Whereas least efficient countries under VRS were Zambia, Kenya, China, Ukraine, and Zimbabwe. Average pure efficiency of all the countries in both periods is about 1.73. This implies that on average all countries could achieve the desired output even after cutting their inputs by 43%. North America seems to be the most efficient region with 83% efficiency followed by Western Europe with 79%, whereas least efficient regions seem to be South Asia and Africa with about 56% and 42% efficiency respectively. Overall efficiency witnessed a marginal increase of about 2% and 4% with CRS and VRS assumption respectively, from period 1990 to 2000. Moreover, efficient regions like North America and Western Europe, witnessed a decline in efficiency over the period, whereas Africa and South Asia witnessed an increase, demonstrating some signs of convergence. However, average efficiency of all countries in both periods measured under CRS assumption is lower than similar efficiency under VRS assumption. This decrease is due to countries operating at inefficient scale; the scale efficiency refers to size of production and working at economies of scale. As depicted in table 2, United States and Belgium were operating at most efficient scale closest to CRS frontier and capturing economies of scale more than others. There was a marginal increase of about 1% in scale inefficiencies during the period. This could be due to technological innovation causing major structural changes in the economies that might have moved them away from optimal scale of production.

Tables 2 and 3 show that bias corrected inefficiency scores for every country are more than its corresponding uncorrected biased figure. This is in line with other empirical evidence that the 'true' frontier lies somewhat above the estimated frontier. However, the ranking of regions according to efficiency remains relatively stable even after the bias-correction.

One of the objectives of the paper is to see the impact of institutional quality on workers' efficiency. This requires the construction of a comprehensive index that can measure the quality of institutions across countries and encompass various facets to institutions. A brief methodology and description of Institutional index is elaborated below.

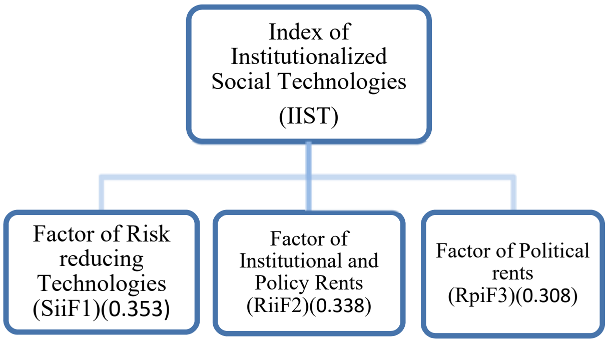
## 5. Methodology and rationale for the index

Following Siddiqui and Ahmed (2013), this study tried to collect twenty-nine indicators for 84 countries. Total observations of the data set are 2314 with 122 missing observations less than 5% in 7 indicators. These missing observations were replaced by using the expectation maximization (EM) method[8] and some other indicators measuring the same concept were also utilized as predictor variables for missing values. For each country one observation was made by taking the average of all available observations for the period from 1990 to 2000. We performed exploratory factor analysis[9] in which the data set was first standardized, then factors were extracted using Principal Components Analysis (PCA) following the criteria of Kaiser (1974) retaining the factors followed by Orthogonal rotation using Equamax Method. Factors retained explained about 75 per cent of the total variance of the dataset distributed almost evenly among three factors (Table 4). They were then combined into an index using the similar weights. Table 4 also shows each factor loadings along with a relative weight of each variable in each factor in proportion to its loadings. Three orthogonal factors were identified as the factor of Institutional and Policy Rents (RiiF1), the factor of Political Rents (RpiF2) and, the factor of Risk reducing Technologies (SiiF3) respectively. Indicators were also found suitable for factor analysis following Bartlett and KMO test. Factor scores were estimated using multiple regressions and later the scores were rescaled from 0 to 1 with higher values denoting stronger institutions.

Theoretical and economic intuitions of the indices and their principal components can be found in Siddiqui and Ahmed (2013). The Index of Institutional Social Technologies (IIST) is made up of three factors identified above with almost equal weights according to Factor analysis. This First factor of the IIST named *Risk-reducing Technologies (SiiF1)* refers to institutions that reduce the cost of protecting property rights and strengthen contract enforcement. These services include provision of public goods such as rule of law and justice. Indicators that are strongly related to this factor include the rule of law, Non-discriminatory Judiciary, Political Stability, torture, extrajudicial killings, and political imprisonment. However, the 'Property rights' index of Heritage foundation are also conceptually related to this factor.

The Second factor named as Factor of Institutional and Policy Rents (RiiF2), focuses on technologies that help to eliminate or minimize two kinds of rent – institutional and policy rents which include Bureaucracy efficiency and Effectiveness, control of corruption, freedom to start and operate business, market structure, informal economies, and price controls. Third factor named Factor of Political Rent (RpiF2) measures the extent of power granted by institutions to political authorities. This factor focuses on political competitiveness, as well as voice and accountability, political rights, civil liberties, executive recruitment and constraints.

Countries' scores of these indices are reported in Table 5. Apart from absolute values, their relative rankings are also shown. According to the results, New Zealand, Netherlands and Denmark bagged first three positions respectively, while Nigeria, Cameroon and Algeria were the worst performers. Western European region captured eight out of top eleven positions whereas six out of bottom eleven went to African region. These scores seem to be highly correlated with the level of human development and economic progress. This index along with the two sub-indices was later used as explanatory variable in second stage regression.




**Box Legend:** Index name is displayed followed by its abbreviation (first bracket) and its weights[2] in the parent index (second bracket).

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**Table 4.** *Factor analysis*

| Variance explained by Retained Factors | | | |
|---|---|---|---|
| Factors | Initial Eigenvalues | After Rotation | % of Variance |
| RiiF1 | 17.51183 | 7.74371 | 26.7025 |
| RpiF2 | 2.88673 | 7.41850 | 25.5810 |
| SiiF3 | 1.50571 | 6.74206 | 23.2485 |
| Cumulative % of variance by all retained Factors. | | | 75.5320 |

| Variables | | | Factor loadings after Rotation[1] (Weights and correlations between each variable and the factor.) | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mean | St. Dev. | Name | | | | | | |
| 6.304 | 1.275 | Bureaucracy costs | 0.3582 | 27% | 0.6971 | 53% | 0.2610 | 20% |
| 0.399 | 0.979 | Government Effectiveness-WGI | 0.6097 | 37% | 0.6559 | 40% | 0.3739 | 23% |
| 0.611 | 0.205 | Government Effectiveness-ICRG | 0.5334 | 34% | 0.6286 | 40% | 0.3981 | 26% |
| 0.578 | 0.186 | Control of Corruption-ICRG | 0.5839 | 41% | 0.3994 | 28% | 0.4384 | 31% |
| 0.300 | 1.071 | Control of Corruption-WGI | 0.6144 | 37% | 0.6465 | 39% | 0.3801 | 23% |
| 68.866 | 11.696 | Business Freedom-HI | 0.1692 | 15% | 0.7189 | 62% | 0.2765 | 24% |
| 5.480 | 1.379 | Starting a business-EFW | 0.3379 | 32% | 0.7521 | 70% | -0.0214 | -2% |
| 10.578 | 4.270 | regulation of entry-The number of procedures | -0.3507 | 35% | -0.6357 | 63% | -0.0198 | 2% |
| 0.606 | 0.654 | regulation of entry-cost+time as share of per capita GDP | -0.0624 | 7% | -0.5699 | 63% | -0.2698 | 30% |
| 0.468 | 0.698 | Type of Economic Organization | 0.5271 | 33% | 0.6325 | 39% | 0.4524 | 28% |
| 6.992 | 0.692 | Administrative requirements-EFW | 0.2762 | 31% | 0.5693 | 63% | 0.0525 | 6% |
| 3.465 | 1.231 | Economic Organization closer to capitalist | -0.0779 | 15% | 0.4112 | 78% | 0.0386 | 7% |
| 4.845 | 2.327 | Price controls | 0.3026 | 24% | 0.5584 | 44% | 0.4165 | 33% |
| 31.444 | 13.990 | shadow economy as % of GDP-Schnider | -0.4183 | 33% | -0.5994 | 48% | -0.2380 | 19% |
| 6.967 | 1.750 | Executive Recruitment | 0.0146 | 1% | 0.0702 | 7% | 0.9088 | 91% |
| 7.804 | 2.455 | Political Competition | 0.2435 | 20% | 0.0792 | 6% | 0.8979 | 74% |
| 2.695 | 1.649 | Political Rights-FH | -0.3880 | 27% | -0.1415 | 10% | -0.8889 | 63% |
| 3.059 | 1.395 | Civil Liberties-FH | -0.5441 | 36% | -0.2106 | 14% | -0.7666 | 50% |
| 0.335 | 0.823 | Voice and Accountability-WGI | 0.5818 | 36% | 0.3172 | 20% | 0.7229 | 45% |
| 5.592 | 1.617 | Executive Constraints | 0.2072 | 16% | 0.1601 | 13% | 0.9051 | 71% |
| 7.119 | 2.267 | Military interference in rule of law and the political process | 0.8301 | 57% | 0.2952 | 20% | 0.3201 | 22% |
| 4.879 | 1.913 | Protection of property rights –EFW | 0.5518 | 37% | 0.6962 | 46% | 0.2524 | 17% |
| 62.238 | 18.739 | Property Rights-HF | 0.4346 | 30% | 0.6723 | 46% | 0.3493 | 24% |
| 0.290 | 0.973 | Rule of Law-WGI | 0.6402 | 38% | 0.6080 | 37% | 0.4170 | 25% |
| 6.000 | 1.775 | Impartial courts-EFW | 0.5563 | 39% | 0.6146 | 43% | 0.2708 | 19% |

| Variables | | | Factor loadings after Rotation[1] | | | | | |
|---|---|---|---|---|---|---|---|---|
| Mean | St. Dev. | Name | (Weights and correlations between each variable and the factor.) | | | | | |
| 4.235 | 3.142 | Equality of Citizens Under the Law and Access of Citizens to a Non-discriminatory Judiciary | 0.6659 | 45% | 0.3040 | 21% | 0.4952 | 34% |
| 5.146 | 2.094 | Physical Integrity Rights Index –CIIRII | 0.8158 | 63% | 0.1031 | 8% | 0.3740 | 29% |
| 0.765 | 0.096 | Political Stability & Absence of Violence/Terrorism- ICRG | 0.8593 | 76% | 0.1172 | 10% | 0.1531 | 14% |
| 0.080 | 0.867 | Political Stability & Absence of Violence/Terrorism - WGI | 0.8412 | 57% | 0.2530 | 17% | 0.3928 | 26% |

[1] Factors are extraction using Principal Component Analysis method, and Rotation is performed using Equamax method with Kaiser Normalization.

[2] Weight of factors are based on the amount of variance explained by each factor in proportion to of total variance explained by all retained factors.

| Test Statistics for the suitability of data for common factor analysis | | | | |
|---|---|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.922 | | |
| Bartlett's Test of Sphericity | Chi-Square | 3458.321 | | |
| | Df | 406 | | |
| | Sig. | 0.000 | | |

**Table 5.** *Index of institutionalized social technology and its sub indices*

| Rank | Countries | Institutio-nalized Social Techno-logies (IIST) | Index of Institutionalized Social Technologies (IIST) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Factor of Risk reducing Techno-logies (SiiF1) | Rank | Factor of Institutional and Policy Rents (RiiF2) | Rank | Factor of Political rents (RpiF3) | Rank |
| 1 | NEW ZEALAND | 0.8116 | 0.7635 | 20 | 0.8169 | 5 | 0.8610 | 23 |
| 2 | NETHERLANDS | 0.8074 | 0.9189 | 3 | 0.6669 | 15 | 0.8341 | 39 |
| 3 | DENMARK | 0.8063 | 0.8317 | 9 | 0.7249 | 10 | 0.8665 | 21 |
| 4 | FINLAND | 0.8033 | 1.0000 | 1 | 0.6073 | 21 | 0.7929 | 49 |
| 5 | SWITZERLAND | 0.7952 | 0.8731 | 6 | 0.6714 | 13 | 0.8420 | 33 |
| 6 | UNITED STATES | 0.7891 | 0.6788 | 35 | 0.8525 | 4 | 0.8459 | 32 |
| 7 | CANADA | 0.7880 | 0.8200 | 10 | 0.6829 | 11 | 0.8670 | 20 |
| 8 | U.K. | 0.7848 | 0.6471 | 39 | 0.8636 | 3 | 0.8563 | 29 |
| 9 | SWEDEN | 0.7829 | 0.9152 | 4 | 0.5663 | 27 | 0.8694 | 18 |
| 10 | NORWAY | 0.7826 | 0.8922 | 5 | 0.5906 | 23 | 0.8679 | 19 |
| 11 | GERMANY | 0.7712 | 0.8044 | 12 | 0.6580 | 17 | 0.8576 | 27 |
| 12 | AUSTRALIA | 0.7705 | 0.7885 | 15 | 0.6713 | 14 | 0.8591 | 25 |
| 13 | IRELAND | 0.7658 | 0.7955 | 13 | 0.6734 | 12 | 0.8333 | 41 |
| 14 | AUSTRIA | 0.7588 | 0.8340 | 8 | 0.5544 | 32 | 0.8973 | 12 |
| 15 | BELGIUM | 0.7231 | 0.7308 | 27 | 0.5694 | 25 | 0.8833 | 13 |
| 16 | JAPAN | 0.7149 | 0.7387 | 24 | 0.5396 | 34 | 0.8805 | 14 |
| 17 | FRANCE | 0.7109 | 0.6867 | 31 | 0.5605 | 30 | 0.9043 | 11 |
| 18 | PORTUGAL | 0.7072 | 0.8559 | 7 | 0.3640 | 57 | 0.9139 | 10 |
| 19 | SPAIN | 0.6945 | 0.6864 | 32 | 0.4877 | 39 | 0.9315 | 9 |
| 20 | HUNGARY | 0.6944 | 0.7736 | 18 | 0.4609 | 43 | 0.8602 | 24 |
| 21 | CHILE | 0.6883 | 0.4797 | 61 | 0.7619 | 7 | 0.8468 | 31 |
| 22 | SLOVENIA | 0.6874 | 0.7744 | 17 | 0.4264 | 49 | 0.8748 | 17 |
| 23 | SINGAPORE | 0.6810 | 0.7710 | 19 | 1.0000 | 1 | 0.2267 | 78 |
| 24 | ESTONIA | 0.6736 | 0.6856 | 33 | 0.6377 | 19 | 0.6992 | 60 |
| 25 | CZECH REPUBLIC | 0.6693 | 0.6488 | 38 | 0.5006 | 38 | 0.8786 | 15 |

| Rank | Countries | Institutio-nalized Social Techno-logies (IIST) | Index of Institutionalized Social Technologies (IIST) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Factor of Risk reducing Techno-logies (SiiF1) | Rank | Factor of Institutional and Policy Rents (RiiF2) | Rank | Factor of Political rents (RpiF3) | Rank |
| 26 | ISRAEL | 0.6662 | 0.1699 | 80 | 0.9354 | 2 | 0.9400 | 8 |
| 27 | COSTA RICA | 0.6652 | 0.7910 | 14 | 0.2838 | 68 | 0.9404 | 7 |
| 28 | TAIWAN | 0.6631 | 0.6653 | 36 | 0.6531 | 18 | 0.6715 | 63 |
| 29 | ITALY | 0.6612 | 0.7253 | 28 | 0.3344 | 63 | 0.9470 | 6 |
| 30 | POLAND | 0.6507 | 0.7355 | 26 | 0.3892 | 53 | 0.8411 | 35 |
| 31 | BOTSWANA | 0.6459 | 0.7515 | 23 | 0.3897 | 52 | 0.8066 | 46 |
| 32 | GREECE | 0.6373 | 0.6429 | 41 | 0.3345 | 62 | 0.9640 | 2 |
| 33 | LITHUANIA | 0.6187 | 0.5870 | 46 | 0.3479 | 60 | 0.9529 | 3 |
| 34 | SOUTH AFRICA | 0.6137 | 0.3556 | 71 | 0.6624 | 16 | 0.8565 | 28 |
| 35 | KOREA, SOUTH | 0.6120 | 0.5740 | 47 | 0.4526 | 44 | 0.8312 | 44 |
| 36 | SLOVAKIA | 0.6100 | 0.7372 | 25 | 0.3149 | 66 | 0.7885 | 50 |
| 37 | NAMIBIA | 0.6045 | 0.7625 | 21 | 0.3653 | 55 | 0.6862 | 61 |
| 38 | ARGENTINA | 0.5997 | 0.4299 | 66 | 0.5573 | 31 | 0.8414 | 34 |
| 39 | JAMAICA | 0.5962 | 0.5029 | 57 | 0.4483 | 46 | 0.8660 | 22 |
| 40 | LATVIA | 0.5944 | 0.6254 | 43 | 0.3414 | 61 | 0.8373 | 38 |
| 41 | MALAYSIA | 0.5815 | 0.5416 | 52 | 0.7295 | 9 | 0.4643 | 68 |
| 42 | THAILAND | 0.5669 | 0.4828 | 60 | 0.4823 | 40 | 0.7568 | 55 |
| 43 | PANAMA | 0.5509 | 0.5368 | 53 | 0.3091 | 67 | 0.8333 | 40 |
| 44 | BULGARIA | 0.5509 | 0.6260 | 42 | 0.1932 | 77 | 0.8581 | 26 |
| 45 | PHILIPPINES | 0.5485 | 0.4129 | 68 | 0.4330 | 48 | 0.8314 | 42 |
| 46 | BRAZIL | 0.5482 | 0.3365 | 74 | 0.5119 | 36 | 0.8313 | 43 |
| 47 | EL SALVADOR | 0.5459 | 0.4530 | 63 | 0.4456 | 47 | 0.7631 | 53 |
| 48 | INDIA | 0.5417 | 0.2503 | 79 | 0.5633 | 29 | 0.8526 | 30 |
| 49 | TURKEY | 0.5380 | 0.0815 | 82 | 0.7420 | 8 | 0.8379 | 37 |
| 50 | JORDAN | 0.5364 | 0.7798 | 16 | 0.5008 | 37 | 0.2960 | 73 |
| 51 | ROMANIA | 0.5328 | 0.6434 | 40 | 0.2193 | 73 | 0.7508 | 56 |
| 52 | DOMINICAN REP. | 0.5011 | 0.6211 | 44 | 0.1515 | 79 | 0.7481 | 57 |
| 53 | SRI LANKA | 0.5002 | 0.0462 | 83 | 0.7619 | 6 | 0.7335 | 59 |
| 54 | VENEZUELA | 0.4988 | 0.3037 | 76 | 0.3589 | 59 | 0.8768 | 16 |
| 55 | TUNISIA | 0.4980 | 0.6924 | 30 | 0.5658 | 28 | 0.2002 | 80 |
| 56 | MADAGASCAR | 0.4942 | 0.4969 | 58 | 0.2019 | 76 | 0.8127 | 45 |
| 57 | MEXICO | 0.4923 | 0.4877 | 59 | 0.3642 | 56 | 0.6386 | 65 |
| 58 | BOLIVIA | 0.4919 | 0.5207 | 55 | 0.0000 | 84 | 1.0000 | 1 |
| 59 | CROATIA | 0.4891 | 0.8104 | 11 | 0.2720 | 69 | 0.3590 | 71 |
| 60 | ECUADOR | 0.4882 | 0.4494 | 65 | 0.1082 | 80 | 0.9509 | 4 |
| 61 | MALI | 0.4881 | 0.5295 | 54 | 0.2126 | 75 | 0.7436 | 58 |
| 62 | PERU | 0.4880 | 0.3600 | 70 | 0.5189 | 35 | 0.6009 | 66 |
| 63 | COLOMBIA | 0.4865 | 0.0000 | 84 | 0.5746 | 24 | 0.9482 | 5 |
| 64 | MALAWI | 0.4820 | 0.6067 | 45 | 0.3248 | 65 | 0.5117 | 67 |
| 65 | NICARAGUA | 0.4805 | 0.5069 | 56 | 0.1630 | 78 | 0.7997 | 48 |
| 66 | PARAGUAY | 0.4703 | 0.4009 | 69 | 0.2376 | 72 | 0.8059 | 47 |
| 67 | HONDURAS | 0.4677 | 0.5438 | 49 | 0.0516 | 83 | 0.8381 | 36 |
| 68 | MOROCCO | 0.4676 | 0.7610 | 22 | 0.4502 | 45 | 0.1499 | 82 |
| 69 | ZAMBIA | 0.4675 | 0.6792 | 34 | 0.2565 | 71 | 0.4565 | 69 |
| 70 | GUATEMALA | 0.4660 | 0.3018 | 77 | 0.3667 | 54 | 0.7639 | 52 |
| 71 | UKRAINE | 0.4635 | 0.5519 | 48 | 0.0884 | 81 | 0.7746 | 51 |
| 72 | PAKISTAN | 0.4564 | 0.2860 | 78 | 0.4631 | 42 | 0.6448 | 64 |
| 73 | RUSSIA | 0.4440 | 0.3396 | 73 | 0.2672 | 70 | 0.7587 | 54 |
| 74 | BANGLADESH | 0.4405 | 0.4522 | 64 | 0.2170 | 74 | 0.6730 | 62 |
| 75 | UGANDA | 0.4303 | 0.3540 | 72 | 0.6122 | 20 | 0.3179 | 72 |
| 76 | CHINA | 0.4229 | 0.6527 | 37 | 0.5675 | 26 | 0.0000 | 84 |
| 77 | EGYPT | 0.4225 | 0.7085 | 29 | 0.4180 | 50 | 0.0990 | 83 |

| Rank | Countries | Institutionalized Social Technologies (IIST) | Index of Institutionalized Social Technologies (IIST) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Factor of Risk reducing Technologies (SiiF1) | Rank | Factor of Institutional and Policy Rents (RiiF2) | Rank | Factor of Political rents (RpiF3) | Rank |
| 78 | TANZANIA | 0.4191 | 0.9382 | 2 | 0.0651 | 82 | 0.2123 | 79 |
| 79 | ZIMBABWE | 0.4091 | 0.5419 | 51 | 0.4056 | 51 | 0.2605 | 76 |
| 80 | INDONESIA | 0.4070 | 0.3273 | 75 | 0.5919 | 22 | 0.2952 | 75 |
| 81 | KENYA | 0.4033 | 0.4255 | 67 | 0.4784 | 41 | 0.2952 | 74 |
| 82 | ALGERIA | 0.3629 | 0.1559 | 81 | 0.5453 | 33 | 0.4001 | 70 |
| 83 | CAMEROON | 0.3594 | 0.4533 | 62 | 0.3610 | 58 | 0.2500 | 77 |
| 84 | NIGERIA | 0.3559 | 0.5422 | 50 | 0.3301 | 64 | 0.1704 | 81 |

**Table 6.** *Descriptive statistics*

| | Mean | Max | Min | Std. Dev. | Skewness | Kurtosis | Obs. |
|---|---|---|---|---|---|---|---|
| E9000CRS | 1.772 | 4.379 | 1.013 | 0.733 | 1.718 | 6.018 | 78 |
| BCE9000CRS | 1.872 | 5.033 | 1.070 | 0.818 | 1.982 | 7.107 | 78 |
| E9000VRS | 1.604 | 3.541 | 1.000 | 0.552 | 1.305 | 4.632 | 78 |
| BCE9000VRS | 1.727 | 3.908 | 1.066 | 0.599 | 1.581 | 5.674 | 78 |
| IIST | 0.585 | 0.812 | 0.356 | 0.129 | 0.206 | 1.893 | 84 |
| SiiF1 | 0.589 | 1.000 | 0.000 | 0.216 | -0.574 | 2.926 | 84 |
| RpiF2 | 0.467 | 1.000 | 0.000 | 0.209 | 0.078 | 2.730 | 84 |
| RiiF3 | 0.712 | 1.000 | 0.000 | 0.248 | -1.299 | 3.407 | 84 |
| TRADEBAL | -0.0269 | 0.139 | -0.244 | 0.069 | -0.527 | 4.017 | 83 |
| GOVBAL | -0.756 | 15.729 | -6.537 | 4.018 | 2.612 | 10.978 | 61 |
| INFLATION | 53.439 | 770.072 | 1.037 | 147.198 | 4.187 | 20.022 | 81 |

**Table 7.** *Correlation coefficient matrix*

| | BCE9000 VRS | E9000 VRS | BCE9000 CRS | E9000 CRS | GOV-BAL | TRADE-BAL | INFLA-TION | SiiF1 | RiiF2 | RpiF3 | IIST |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BCE9000VRS | 1 | | | | | | | | | | |
| E9000VRS | 0.993 | 1 | | | | | | | | | |
| BCE9000CRS | 0.889 | 0.847 | 1 | | | | | | | | |
| E9000CRS | 0.917 | 0.883 | 0.995 | 1 | | | | | | | |
| GOVBAL | -0.206 | -0.207 | -0.215 | -0.220 | 1 | | | | | | |
| TRADEBAL | -0.173 | -0.153 | -0.266 | -0.264 | 0.530 | 1 | | | | | |
| INFLATION | 0.216 | 0.248 | 0.147 | 0.177 | -0.100 | 0.003 | 1 | | | | |
| SiiF1 | -0.287 | -0.305 | -0.187 | -0.217 | 0.293 | 0.138 | -0.180 | 1 | | | |
| RiiF2 | -0.386 | -0.382 | -0.424 | -0.442 | 0.286 | 0.425 | -0.177 | 0.000 | 1 | | |
| RpiF3 | -0.297 | -0.237 | -0.405 | -0.379 | -0.092 | 0.152 | 0.012 | 0.000 | 0.000 | 1 | |
| IIST | -0.561 | -0.535 | -0.585 | -0.598 | 0.271 | 0.404 | -0.195 | 0.590 | 0.550 | 0.591 | 1 |

## 6. Regression results and analysis

Before analysing regression results, Table 7 provided information about their correlations coefficient. There is a strong and positive correlation of 0.92 among inefficiency indices. As expected, the Institutional indices observed a negative correlation with inefficiency indices. This effect is stronger in IIST as compared to its sub-indices. This shows there is a considerable impact of the quality of institutions on workers' efficiencies. Inefficiency indices are also negatively correlated with government balance and trade balance but positively with inflation.

Institutions are also positively correlated with government and trade balances and negatively correlated with inflation. Government balance is positively correlated with trade balance, and negatively linked with inflation. Institutional sub-indices are uncorrelated with one another. This is because factors extracted through Principal Component Analysis provide orthogonal factor solution. Therefore, our indices allow for a clear sense of the dimensionality that is lacking in other established indices particularly WGI.

Regression results reported in Table 8 show the truncated regression of average efficiency estimates of 1990 and 2000 in level form on institutional indices and other explanatory variables. Both pure efficiency (P) through VRS assumption and simple efficiency applying CRS assumption are used as dependent variables.

The regressions provide a reasonably good fit and the estimation results clearly indicate a robust positive (negative) impact of institutional variables on workers' efficiency (inefficiency) levels under both CRS and VRS assumptions as their coefficients are significant and positive. Their impact on efficiency under CRS assumption is comparatively higher as compared to efficiency under VRS assumptions as they have considerably higher coefficients.

Among the three types of institutions, Factor of institutional and policy rents (RiiF2) seems to have a more significant impact on efficiency as compared to others. However their combined coefficient (IIST) is much larger than any of its sub-indices, showing some degree of complementarities among institutions. Among other variables, inflation has expected positive sign, implying that an increase in inflation will result in higher inefficiency. In other words, macroeconomic instability has a negative effect on efficiency as the increased variability of the inflation rate is likely to involve social cost that concerns inefficiency in production. Friedman (1977) mentioned *"The growing volatility of inflation and growing departure of relative prices from the values alone shall set combine to render the economic system less efficient".*

Negative coefficient of government and trade balance indicated that countries with either budget deficit or trade deficit or both, are inefficient which may happen directly or the inflation may increase the trade deficit and hence increase inefficiency. For instance, Bussière et al. (2005) showed that budget deficit may produce an adverse impact on current account and efficiency. Similarly, trade surplus may directly contribute to efficiency as it leads to reallocation of resources from less to more efficient sectors (Melitz, 2002; Bernard et al., 2003). It also improves efficiency by raising the skill levels of the labor force, generating economies of scale, and cutting costs due to international competition (Egan and Mody, 1992; Clerides et al., 1998). Furthermore, it also serves as a conduit for technology and knowledge spillover (Grossman and Helpman, 1991). These coefficients retain their relationship in all forms of regression meaning they are robust to biasness of efficiency estimates as well as in regression with environmental variables.

Our model assumes normal distribution of efficiency scores in terms of population. This assumption is statistically verified with high sigma values in all cases (not reported).

Overall, these findings prove robust positive relationship between institutions and efficiencies. Their estimates are large showing that marginal improvement in institutional qualities would produce huge impact on workers' efficiency.

## 7. Conclusion

This paper analyses the role of institutions in enhancing economic efficiencies across countries in a two stage analysis Double Bootstrap DEA based on nonparametric frontier analysis as proposed by Simar and Wilson (2007). In the first stage, cross country workers' efficiency was estimated using a bootstrapped DEA approach over the period of 1990-2000 for 78 countries. We used the dataset developed by Baier et al. (2006) including physical and human capital as inputs. Output orientated efficiency estimates were then calculated under both CRS and VRS assumptions. The effect of institutions on cross country efficiency level was estimated using truncated regression. These efficiency estimates were improved adding stochastic elements using bootstrap procedure with 10,000 replications. To further improve the results, bias corrected estimates were used in truncated regression to re-estimate the marginal effect of institutions and other environmental variables. And lastly, the second (double) parametric bootstrap was performed on the above regression with 1600 replications, thus producing bias correct regression coefficients and standard errors. Institutions are classified into three distinct dimensions as identified by Siddiqui and Ahmed (2013). Twenty-nine institutional indicators from the same period have been used to extract three orthogonal factors based on principal component analysis. These factors namely institutional and policy rents, political rents and risk reducing technologies, along with their aggregated index are used as institutional variable.

The findings suggest that across countries, efficiency showed a decline during the period of study. North America seems to be the most efficient region, whereas South Asia and Africa are the least efficient regions. The study also found that efficient regions witnessed a decline in efficiency, whereas Africa and South Asia witnessed an increase, showing some signs of convergence.

Findings from second stage of regression analysis suggest that inefficiencies in the Economy were reduced where institutions are strong and the institutions also help to increase the scale of operation and enjoy the economies of scale. Their impact on efficiency under CRS assumption is comparatively high as compared to efficiency under VRS assumptions. This study also shows that among the two types of institutions, institutions that curb corruption, bureaucratic inefficiencies, lax regulations and unfriendly business policies seem to have a larger impact on efficiency as compared to the other two indices that curb political rents and those that reduce transactional risks. Overall, these results suggest that institutional reforms might play a pivotal role in improving efficiency level of workers.

**Table 8.** *The determinants of inefficiencies (second stage bootstrapped truncated regression)*

**1. Constant returns to scale assumption**

Dependent Variables: Farrell's Output Oriented (Biased and Bias-corrected) Inefficiency scores

| | E9000CRS (Biased) | BCE9000CRS (Bias-corrected) | | | BCE9000CRS (Bias-corrected) | | | | E9000CRS (Biased) | BCE9000CRS (Bias-corrected) | | | BCE9000CRS (Bias-corrected) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables | | | 95% confidence interval | | Bias-adjusted coefficients | 95% Bootstrap confidence interval | | | | | 95% confidence intervals | | Bias-adjusted coefficients | 95% Bootstrap confidence intervals | |
| | Coefficients (unadjusted) | Coefficients (unadjusted) | Low | High | | Low | High | | Coefficients (unadjusted) | Coefficients (unadjusted) | Low | High | | Low | High |
| IIST | -9.887606*** | -9.606565*** | -16.76387 | -2.449264 | -10.1623*** | -17.37829 | -4.0936 | | | | | | | | |
| SiiF1 | | | | | | | | | -3.400254** | -3.074815** | -6.065814 | -.0838155 | -3.437128*** | -5.749178 | -0.6480873 |
| RiiF2 | | | | | | | | | -5.317727 *** | -5.048202** | -9.016133 | -1.080272 | -5.447193*** | -8.899967 | -2.047062 |
| RpiF3 | | | | | | | | | -2.216371*** | -2.400686** | -4.548812 | -.2525608 | -2.61387*** | -4.320647 | -0.5080191 |
| INFLATION | .0008982 | 0.0007236 | -.001293 | .0027402 | .0008436 | -0.0016536 | 0.0025054 | | .0002617 | .0001961 | -.0018469 | .002239 | .0002902 | -0.0021503 | 0.0018653 |
| TRADEBAL | -4.411812 | -4.048425 | -12.35 | 4.253154 | -4.324976 | -11.12113 | 3.065394 | | -4.681686 | -3.817005 | -12.45789 | 4.823874 | -4.312796 | -10.15646 | 3.635156 |
| GOVBAL | -.0687651 | -.0617199 | -.2525223 | .1290824 | 0.0505907 | -0.2718129 | 0.0882555 | | -.0617611 | -.0613233 | -.2506359 | .1279894 | -.0626982 | -0.2573352 | 0.0889847 |

*, **, *** Significance at the 10%, 5%, and 1% level respectively.
Bias-adjusted coefficients and their Confidence intervals obtained from 1600 bootstraping interactions.
Constants and sigma not reported.

**2. Variable returns to scale assumption**

Dependent Variables: Farrell's Output Oriented (Biased and Bias-corrected) Inefficiency scores

| | E9000VRS (Biased) | BCE9000VRS (Bias-corrected) | | | BCE9000VRS (Bias-corrected) | | | | E9000VRS (Biased) | BCE9000VRS (Bias-corrected) | | | BCE9000VRS (Bias-corrected) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variables | Coefficients | Coefficients | 95% confidence interval | | Bias-adjusted | 95% Bootstrap confidence interval | | | Coefficients | Coefficients | 95% confidence intervals | | Bias-adjusted | 95% Bootstrap confidence intervals | |
| | (unadjusted) | (unadjusted) | Low | High | coefficients | Low | High | | (unadjusted) | (unadjusted) | Low | High | coefficients | Low | High |
| IIST | -6.935712*** | -6.782711*** | -11.35932 | -2.206107 | -7.108316*** | -11.76578 | -3.074856 | | | | | | | | |
| SiiF1 | | | | | | | | | -1.537942** | -1.906032*** | -3.293678 | -.5183851 | -2.001528*** | -3.344196 | -0.6698034 |
| RiiF2 | | | | | | | | | -2.579436*** | -2.502012*** | -4.030183 | -.9738403 | -2.581115*** | -4.119636 | -1.203033 |
| RpiF3 | | | | | | | | | -1.610319*** | -1.600231*** | -2.634928 | -.5655335 | -1.642743*** | -2.618622 | -0.6507304 |
| INFLATION | .0007304 | .0006688 | -.0008218 | .0021593 | .000734 | -0.0009879 | 0.0020053 | | .0005507 | .0006119 | -.0006624 | .0018862 | .0006498 | -0.0008421 | 0.0017643 |
| TRADEBAL | -3.17806 | -2.582262 | -8.650506 | 3.485981 | -2.736824 | -7.85327 | 2.76581 | | | | | | | | |
| GOVBAL | -.0356972 | -.0349054 | -.1670816 | .0972708 | -.0319167 | -0.1735115 | 0.0697059 | | | | | | | | |

*, **, *** Significance at the 10%, 5%, and 1% level respectively.
Bias-adjusted coefficients and their Confidence intervals obtained from 1600 bootstraping interactions.
Constants and sigma not reported.

## Notes

(1) They identified three channels through which institutions influence growth. First kind of Institutions limits rent-seeking opportunities that divert innovation and resources from productive avenues. Second kind that includes justice and law reduces transactional risk through proper enforcement of property rights. Whereas the third kind which includes political competition and participation raises the opportunity cost to monopoly thereby increasing bargaining power of the society in favor of growth.

(2) The approach offers several advantages as compared to one stage analysis (Coelli et al., 1999; Pastor, 2002).

(3) See Simar and Wilson (2007) for survey of two-stage procedure for analysis on determinants of DEA scores.

(4) See Aigner et al. (1977) for efficiency measurement using this technique.

(5) Especially popular in efficiency analysis of banking industries. See Berger and Humphrey (1997) for a detailed survey.

(6) DEA was first developed by Charnes, Cooper and Rhodes (1978) with constant returns to scale (CRS) assumptions. However it was later refined by Banker, Charnes and Cooper (1984) accommodating variable returns to scale (VRS) in their analysis.

(7) STATA codes for bootstrap truncated regression were based on the algorithm used in Wolszczak-Derlacz and Parteka (2011).

(8) The EM algorithm is an iterative method for finding maximum likelihood estimates of missing values given predictor variables. See (Dempster et al., 1977; McLachlan and Krishnan, 1997) for detailed discussion on EM and its applications.

(9) See Siddiqui and Ahmed (2013) for details.

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