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# International Benchmarking for Country Economic Diagnostics


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# International Benchmarking for Country Economic Diagnostics: A Stochastic Frontier Approach*

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**Abstract**

This paper discusses and illustrates the analytical foundations of international comparisons (or benchmarking) for assessing a country's potential for improvement along various dimensions of social and economic development. By providing a methodology for international benchmarking, discussing various alternatives and choices, and presenting a cross-country illustration, the paper can help practitioners be less arbitrary and more systematic in their approach to international comparisons, as well as more realistic in their expectations for a country's improvement. The paper presents the stochastic frontier approach and applies it to estimate feasible frontiers or benchmarks for each variable, country, and year. It then interprets a country's (one-sided) departure from the benchmark as inefficiency or potential for improvement. This contrasts with the literature that compares countries by looking at raw variables or indicators, without considering that countries differ in structural endowments that constrain the maximum performance that a country could achieve in a policy-relevant horizon. The Stochastic Frontier approach also improves upon the literature that uses regression residuals to measure performance. Regression residuals are hard to interpret as inefficiency, because they are mixed with noise and take positive and negative values. As an illustration, the paper uses a panel of 142 countries with yearly data for 2005–14 and considers a set of 10 development indicators. It finds that the potential for improvement does not follow a simple relationship with economic development, with some lower-income countries being closer to their own feasible frontier than more advanced countries are.

Keywords: Economic Development, Benchmarking, Country Diagnostics, Stochastic Frontier

JEL: O11, O40, O47, O57, C33, C51

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# International Benchmarking for Country Economic Diagnostics

## 1. Introduction

This paper discusses and illustrates the analytical foundations of international comparisons (or benchmarking) for assessing a country's potential along various dimensions of social and economic development. It can add value to the country economic diagnostics (or assessments) that are regularly produced by the worldwide community of development practitioners, including governments and international organizations.

The World Bank's Systematic Country Diagnostics (SCDs) is an example of an assessment that uses both international comparisons and detailed country-specific information. The SCDs, mandated for every country on a 3-5 yearly frequency, have become a valuable tool for assessing a country´s prospects for achieving the World Bank´s goals of eliminating poverty and promoting shared prosperity.

By providing a methodology for international benchmarking, discussing various alternatives and choices, and presenting a cross-country illustration, this paper can help practitioners and institutions be less arbitrary and more systematic in their approach to international comparisons, as well as more realistic regarding their expectations for improvement. Avoiding arbitrariness is an important consideration for international benchmarking. Practitioners may be tempted to manipulate the set of comparator countries to prove a point: by choosing a particular set of comparators, they can show that a country is deficient in a certain respect, while changing the comparator set can render the opposite conclusion. Another important consideration is that countries have different levels of development and different endowments. Assessing what improvements can be reasonably projected from a country at a point in time can guide policy decisions and moderate expectations. The present paper consists of two interrelated components. The first provides a conceptual framework where the rationale, principles, and challenges of international benchmarking are presented. It uses selected examples to make the discussion concrete. The second component proposes a methodology for systematic and realistic benchmarking. Among the various potential methodologies in the received literature, we select the stochastic frontier (SF) approach. This allows us to measure the inefficiency or room for improvement for a given development indicator while considering the structural endowments or predetermined conditions that can limit the indicator´s potential.

The paper illustrates the use of the SF benchmarking methodology by constructing and using a large cross-country panel data set, consisting of 142 countries, yearly data for 2005-14, and 10 development indicators. Despite its large scope, this exercise should be mainly considered as an illustration because it takes specific choices from the array of possibilities presented in the conceptual framework and assumes homogeneity of structural endowments across all indicators. Further work can strengthen the benchmarking exercise, focusing on a smaller set of development indicators and using more appropriate assumptions for their structural endowments and distribution functions.

The paper is organized as follows. After this introductory section, we discuss a conceptual framework for international benchmarking. Next, we present a selected review of the literature, where we consider the relative advantages of the stochastic frontier approach. We then present in detail the SF methodology and the cross-country panel data used for its application. Finally, we discuss the results on a set of development indicators and conclude by summarizing the paper´s contributions and proposing extensions for further research.

## 2. Conceptual Framework

The analytical foundation of a benchmarking exercise can be discussed in the context of three questions:

- *Why* is the country diagnostic undertaken?
- *What* indicators should be used to assess the country diagnostic?
- *How* should the international comparisons of these indicators be implemented?

The *why* and *what* questions should be addressed by well-defined objectives of social and economic development. In an econometric model, the objectives of social and economic development (the *why*) define the dependent or "left-hand side" variables of a regression equation. Correspondingly, the benchmarking indicators (the *what*) would correspond to the explanatory or "right-hand side" regression variables. The specific objectives of social and economic development would change from country to country and would depend on the priorities of the institution conducting the assessment. As an example, for illustration purposes, we can present these objectives as improved growth, poverty alleviation, and economic resilience. The *why* and *what* questions would then be informed by the literatures that have studied these objectives thoroughly:

- On economic growth: The sustained increase in per capita output and income; and its drivers, including innovation, education, infrastructure, trade openness, financial depth, and macroeconomic stability; and the roles of the private sector and the government to promote it. See, for instance, Barro and Sala-i-Martin (2004) and Loayza, Fajnzylber, and Calderon (2005).
- On poverty alleviation: The reduction in the extent and the severity of poverty and vulnerability; and its determinants given by the creation of jobs with higher wages and by the policies that can accelerate this process most effectively, such as social protection, health coverage, and public education. See, for instance, World Bank (2015) and Ravallion (2016).
- On economic resilience: The ability to recover from adverse shocks (such as natural disasters, negative terms of trade shocks, and international financial crises) and to take advantage of positive changes (such as technological innovation and market size expansion); and its drivers, including individual and social protection, market and social insurance, firm and labor flexibility, and macroeconomic stability. See World Bank (2013).

In this example, the existing literature on these three broad objectives can provide an analytical framework to make sense of the information provided by the benchmarking exercise. Moreover, they can guide the selection of indicators (the *what*) that are most relevant and robust in the empirical evidence. They would include both macroeconomic factors and (aggregated) microeconomic conditions (from household-, worker-, and firm-level data). They would include, for instance, fiscal deficits and price stability; financial depth and inclusion; international trade openness and diversification; labor and product market flexibility; quality of public education, health care, and social safety nets; and bureaucratic efficiency and avoidance of corruption.

We turn now to the *how* question. This calls for a procedure to systematize the comparison of a given indicator across countries. The issue has been considered in a number of papers, usually in the context of a specific theme or question; see, for instance, King, Honaker, Joseph, and Scheve (2001), Hausmann, Rodrik, and Velasco (2008), Kaufmann, Kraay, and Mastruzzi (2011), and Ravallion (2012).

Benchmarking requires defining a relevant norm of comparison, and benchmarking internationally requires placing an indicator corresponding to a country in the context of a cross-country comparison.

Some important objectives for establishing a systematic norm of comparison are, first, avoiding arbitrariness in the selection of comparator countries and, second, making the comparison relevant for policy analysis. For these purposes, this norm should be established in relation to the endowments or predetermined conditions of the country such as geographic conditions, population size, and proximity to international markets, among others, and consider —at least in the initial analysis—the widest possible array of countries.

For example, a commonly used norm of comparison (benchmark) is dictated by the "regression line" of a given indicator on the set of endowments or predetermined conditions. To consider statistical error (derived, for instance, from measurement errors and omitted control variables), the norm of comparison would also consider sensible confidence bands. Indicators could then be judged as "normal," "superior," or "deficient," according to whether they fall, respectively, within, above, or below the confidence band. The stochastic frontier approach used in this paper builds and improves on this basic idea.

Once the basic norm of comparison has been established, benchmarking could be adjusted to accommodate different objectives. For instance, benchmarking could be static or dynamic. Static benchmarking would simply reflect the distance with respect to the international norm given by predetermined conditions at a given point in time. Dynamic benchmarking would take into account a desired path of development for the future, as represented by countries or regions that serve as international models of best practice.

## 3. Review of the Literature

There are several attempts in the literature to benchmark countries in different areas: financial development (Barajas et al. 2013; Beck et al. 2008; and Čihák et al. 2012); education (Bogetoft, Heinesen, and Tranæs 2015); infrastructure endowment (Yepes, Pierce, and Foster 2009); economic growth (Hausmann, Rodrik, and Velasco 2008; Felipe and Usui 2008); firm and sectoral performance (Assaf 2012; Edvardsen and Førsund 2003; Kumbhakar and Lien 2017); electoral accountability and democratic parliaments (Kayser and Peress 2012; Staddon and Toornstra 2016); and health care systems (Anell and Willis 2000; Viberg et al. 2013).

Not only are benchmarking applications extensive, but their methodologies are also diverse. Broadly speaking, we can distinguish two classes of methodologies. The first is based on a *regression* approach, where the benchmark is established by an estimated regression line. The second is based on a *frontier* approach, where the benchmark is projected as the maximum attainable value.

*Regression approach*

Beck et al. (2008) present one of the most influential benchmarking exercises, applying the regression approach to assess financial development. In this study the notion of benchmarking resides in the view that there are some structural characteristics that determine the level of financial development a country can achieve. The main contribution of Beck et al. (2008) lays in pointing out that comparing raw indicators of financial development across countries could lead to arbitrary conclusions because different stages of economic development and structural characteristics dictate different expected degrees of financial development.

To make more reasonable comparisons across countries, Beck et al. (2008) propose to estimate the following regression:

$$FDI_{it} = X_{it}\beta + \varepsilon_{it}$$

The dependent variables are financial development indicators (FDIs) that include size, efficiency and reach of financial institutions (e.g. banks) and markets (e.g. equity and bonds). And the controls ($X_{it}$) represent structural characteristics rather than policy-based variables. Thus, these variables are either policy invariant (such as population size) or react with some lag to policy (such as the GDP per capita).[1] In this context, the authors argue that the regression residuals contain information about the unobserved quality of the policy environment and are comparable across countries.[2] Thus, the benchmark indicator is the residual. The authors use an OLS regression to estimate the regression equation, pooling data from all countries together.

Barajas et al. (2013) follow a similar approach as in Beck et al. (2008). The benchmark level of financial development is predicted for each country at each point in time by estimating a similar equation.[3] According to the authors, this would determine a financial possibility frontier, which "is the maximum sustainable depth (e.g., credit or deposit volumes), outreach (e.g., share of population reached), or breadth of a financial system (e.g., diversity of domestic sources of long-term finance) that can be realistically achieved at a given point in time." This frontier is country-specific and is computed for each type of financial service. Then, they define the *Gap* for a financial depth indicator as:

$$Gap_{it} = \widehat{FD}_{it} - FD_{it}$$

where a positive (negative) gap indicates under (over) performance.

A shortcoming of this simple regression-based empirical approach is that the frontier is not estimated with the constraints that underlie the maximum sustainable development a country can achieve. Consequently, the share of countries over- and under-performing are, by construction, 50 percent for the sample, which seems inconsistent with the idea of a frontier.[4]

Čihák et al. (2012) also benchmark financial systems but do so in a nonparametric way. To characterize financial systems, four aspects are studied: depth, access, efficiency and stability. This is done for financial institutions and financial markets (equity and bond markets). Thus, the study presents a 4x2 matrix of financial system characteristics. The choice of variables is based on what past literature has identified as relevant indicators. The criteria to select indicators is country coverage. Each indicator is normalized by the maximum and the minimum of the indicator. This can be interpreted as the percent distance between best and worst practices.

To make fair comparisons, clustering is used to assign similar countries into groups. The Euclidean distance is used to approximate the "similarity" of two countries regarding the four dimensions of financial systems.

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[1] The structural variables chosen in the paper are GDP per capita, population size, population density, offshore financial centers dummy, small country dummy, landlocked dummy and time dummies. Regional dummies are also included as a robustness check.

[2] It is important to note that unless these "unobserved quality" variables are uncorrelated with the regressors, the estimated coefficients based on the pooled OLS model are likely to be inconsistent. If so, the use of the residuals for policy purposes might be problematic.

[3] Controls are very similar to the ones used in Beck et al. (2008).

[4] However, the shares of countries over- and under-performing vary over time.

$$d(p,q) = \sqrt{\sum_{i=1}^{4}(q_i - p_i)^2}$$

Where $p_i$ and $q_i$ are the values of the *i*-th indicator for country *p* and *q*, respectively. The number of clusters is also relevant; the higher the number of clusters, the higher the similarity among countries within the cluster. However, a very high number of clusters reduces the scope of the benchmarking exercise. Therefore, the authors pick 3, 4, and 5 clusters per variable.

Finally, once the number of clusters is set, the clustering analysis finds an allocation of the world's countries into k clusters in order to minimize the sum of distances for all pairs of countries:

$$\min \sum_{c=1}^{k} \sum_{\forall p,q \in S_c} d(p,q)$$

where $S_c$ denotes an individual cluster, and p and q represent different countries.

The results are reported for the four clusters, in terms of regions and income groups. One of the main conclusions is that financial systems are multidimensional: a good performance on one indicator does not assure the same on others. A shortcoming of this method is that countries are defined to be similar in terms of financial development indicators, instead of structural characteristics. Therefore, it is not possible to identify what underlies the differences.

The regression approach (from simple OLS to quantile regressions and nonparametric methods) has two main problems. The first is that one cannot decompose the regression residual into pure noise and potential for improvement (inefficiency). The second problem is that the residuals are both positive and negative, with symmetry around zero by construction. If one is interested in assessing the potential for improvement (through policies, for instance) for each country and time period, then a one-sided gap is more directly informative.

*Frontier approach*

Benchmarking methods based on a frontier approach have been implemented in Assaf (2012); Bogetoft, Heinesen, and Tranæs (2015); Edvardsen and Førsund (2003); Kumbhakar and Lien (2017) among others. They are a combination of two research traditions. One has its origins in management science, mathematical programming, and operations research. This method is called *Data Envelopment Analysis* (DEA). The other research tradition has a more economics and econometrics-oriented background and is referred to as *Stochastic Frontier Analysis* (SFA). Both methods address the basic challenges in any benchmarking exercise, namely (a) defining a performance standard, and (b) evaluating achievements against the established standard. This is done by estimating a frontier function which is the maximum attainable value (the benchmark), and, therefore, departure from the benchmark can be viewed as slack (one-sided potential for improvement).

DEA uses mathematical programming methods to estimate the benchmark (the best practice production frontier) and evaluates the relative efficiency of different entities in comparison with the benchmark. In the DEA literature, these are typically called decision-making units (DMUs), such as firms. SFA mostly uses a parametric function to represent the underlying technology and uses econometric methods to estimate it. In SFA, the relationship between the inputs used and the output produced is assumed to be stochastic. Then, one advantage of the SFA model over the DEA approach is that deviations from the frontier reflect not only inefficiencies, as in the DEA approach, but also noise in the data. By addressing the stochastic nature of the benchmark, SFA produces inefficiency measures that in principle are not contaminated by the presence of the noise term.

Although SFA was initially developed to estimate productive efficiency (see, e.g., Kumbhakar and Lovell 2000; Kumbhakar, Wang and Horncastle 2015), one can view it as a tool to define benchmarks in many situations. For example, in analyzing health care delivery, the World Health Report (2000) measured and ranked the efficiency of the health systems of 191-member countries (Tandon *et al*. 2000). There, SFA is used to model and estimate the benchmark against which each country is compared and ranked. As in the traditional production function approach, maximizing health output is considered as the objective of a health system, given health expenditure and some other control variables. Based on this notion of health production function, the study judged the health systems for the 191 countries in terms of their efficiency (derived from SFA) in turning health expenditures into health services. In general, SFA can address questions such as the following. By how much a country's educational quality can be improved after controlling for its structural and country-specific characteristics. How much child mortality can be reduced given the resources of a country? How much a country can gain in terms of its growth rate by trade openness?

In summary, SFA estimates a benchmark as a stochastic frontier. This produces two advantages: the estimated inefficiency (gap with respect to the benchmark) is always one-sided and does not include the noise term. We now turn to a detailed description of the SFA methodology.

## 4. Methodology: Stochastic Frontier as a Benchmark

The basic stochastic frontier model for panel data is the following:

$$y_{it} = \beta_0 + x_{it}'\beta + z_i'\gamma - u_{it} + v_{it}$$

where $y_{it}$ is the indicator variable (usually in logs) for country $i$ at time $t$, $\beta_0$ is a common intercept, $x_{it}$ is the vector of structural variables; and $\beta$ is the associated vector of technology parameters to be estimated. The country-specific (time-invariant) variables are denoted by $z_i$, and $\gamma$ is the corresponding coefficient vector; $v_{it}$ is a random two-sided iid noise term. Finally, $u_i \geq 0$ is the non-negative one-sided inefficiency term, the gap between the observed indicator and the benchmark (stochastic frontier). The idea of separating the $x$ variables from the $z$ variables is that the former vary in both $i$ and $t$ dimensions while the latter is time-invariant. The parameters of the model are estimated by the maximum likelihood (ML) method based on distributional assumptions on the noise and the inefficiency terms.

The dependent variable ($y_{it}$) is the outcome variable being explained by the covariates ($x_{it}$ and $z_i$). The noise term $v_{it}$ captures the effect of unobserved factors that can affect the outcome variable both positively and negatively. Thus, the regression part of the above equation $y_{it}^* \equiv \beta_0 + x_{it}'\beta + z_i'\gamma + v_{it}$ can be viewed as the stochastic frontier (maximum or minimum value of the outcome variable, given the covariates, depending on the problem).[5] This frontier defines the benchmark. To allow for the possibility that a micro

[5] The component without the $v$ term can be viewed as the deterministic frontier.

or macro unit (firm, school, hospital, geographical region, country, etc.) fails to attain the benchmark, we add a one-sided term, which is negative if the problem has a natural maximum (as in, for example, production, investment, wage payment by firms, health care delivery, foreign direct investment, and educational quality for a country) or positive if the problem has a natural minimum (as in cost, crime, pollution, and inflation). The shortfall captured by the one-sided term, $u_{it}$, can be interpreted as a slack or inefficiency, which shows how much scope of improvement there is for the unit *i* at time *t*. So, in sum, the frontier or the benchmark is the maximum or minimum achievable theoretically, and the gap (slack, inefficiency) shows the potential for improvement.

For our present case, we have a variety of indicators (drivers of economic growth, poverty, and resilience), which are the outcome variables. These are used separately (one at a time) for the model outlined above. In most cases, the benchmark is the maximum value of the outcome variable, and we therefore consider $-u_{it}$in the model. For other indicators, the benchmark is defined by the minimum possible value of the outcome variable, in which case we adjust the SF model by having $+u_{it}$ instead of$-u_{it}$. The objective is to estimate the gap, defined as the shortfall from the benchmark which is stochastic. That is, if the gap is big for an indicator for a country in a particular year, we can say that it has potential for improvement. Alternatively, one can say that the country has some institutional or policy factors that might be forcing it not to operate it at the benchmark. If for a country $i$ in year$t$, $u_{it} = 0$ then, it attains the benchmark and there is no gap between actual and benchmark values. Note that the benchmark is not constant. It varies with $x_{it}$ and $z_i$ which are usually different for different countries. In any event, the gap cannot be both positive and negative, it is always one-sided by construction. And the estimation method in SF takes this one-sidedness into account.

The panel SF model that we discussed above can be extended to accommodate some time-invariant unobserved country-specific institutional or policy environment that can explain the gap between the benchmark and the observed outcome. To accommodate it in the SF model, we decompose the gap as $u_{it} = \eta_i + \tau_{it}$, where both $\eta_i$ and $\tau_{it}$ are non-negative. The $\eta_i$ part is persistent, while the $\tau_{it}$ component is also country-specific but changes with time. The model is further generalized to accommodate random country heterogeneity which is uncorrelated with the $x_{it}$ and $z_i$ variables. One way of explaining this is to think of a country effect $c_i$ that combines the observed and unobserved effects, i.e. $c_i = z_i'\gamma + \alpha_i$, so that the country effects $c_i$ are correlated with the structural variables $x_{it}$ via correlation between the $x_{it}$ and the $z_i$ variables. In other words, the part of country effects that is explained by the variables is correlated with the structural variables. With this, we rewrite the extended SF model as

$$y_{it} = \beta_0 + x_{it}'\beta + c_i - u_{it} + v_{it} = \beta_0 + x_{it}'\beta + z_i'\gamma + \alpha_i - \eta_i - \tau_{it} + v_{it} \qquad (1)$$

Before addressing estimation of the above SF model, we note that if OLS or random effects panel estimators are applied, it is not possible to separate the inefficiency components from the noise and random country-effects,$\alpha_i$. To show this, we rewrite the above equation as

$$y_{it} = \beta_0^* + x_{it}'\beta + z_i'\gamma + \alpha_i + \varepsilon_{it} \qquad (2)$$

where $\varepsilon_{it} = [v_{it} - (\tau_{it} - a) - (\eta_i - b)], \beta_0^* = \beta_0 - (a + b)$ and $a = E(\tau_{it}), b = E(\eta_i)$.

We also assume that $E(\alpha_i) = 0$ and $E(v_{it}) = 0$. Note that the above regression is a random-effects (RE) panel model and can be estimated using generalized least squares (GLS). Although the GLS will give consistent estimates of the parameters, the use of the predicted values given by $\beta_0^* + x_{it}'\beta + z_i'\gamma + \alpha_i$ as the benchmark will have two problems which we already discussed. First, the residual of the above RE regression ($\hat{\varepsilon}_{it}$) will have both positive and negative values, and therefore cannot be viewed as the gap which can be attributed to the policy environment. Second, to estimate the gap and decompose it into persistent and time-varying components, we need to separate the residual from noise and the random country effect.

We consider several special cases of the above model, which we rewrite again,

$$y_{it} = \beta_0 + x_{it}'\beta + z_i'\gamma + \alpha_i - \eta_i - \tau_{it} + v_{it}$$

If we assume that there is no persistent, time-invariant gap, then $\eta_i = 0$; and the model reduces to,

$$y_{it} = \beta_0 + x_{it}'\beta + z_i'\gamma + \alpha_i - \tau_{it} + v_{it}$$

This is popularly known as the true random effects (TRE) model (Greene 2005) and is estimated using the following distributional assumptions: $v_{it}$ is iid normal with zero mean and constant variance, $\tau_{it}$ is iid half normal (or exponential) with zero mean and constant variance truncated at zero from the left, and $\alpha_i$ is iid normal with zero mean and constant variance. The drawback of this simplified model is that ignoring the persistent inefficiency component $\eta_i$ can bias the estimate of inefficiency. That is, one can mistakenly think that inefficiency is $\tau_{it}$ whereas the true ineffciency is $\tau_{it} + \eta_i$.

The model proposed by Colombi et al. (2014) and Kumbhakar, Lien and Hardaker (2014), among others, captures both components of inefficiency and separates them from random country effects $\alpha_i$. In Colombi et al. (2014), the model is estimated in a single step with the distributional assumptions that $\eta_i$ and $\tau_{it}$ are both iid half-normal; and $\alpha_i$ and $v_{it}$ are iid normal. The iid assumptions in Colombi et al. (2014) and Kumbhakar, Lien and Hardaker (2014) are relaxed in Badunenko and Kumbhakar (2017), and Lai and Kumbhakar (2018). Colombi et al. (2014), Badunenko and Kumbhakar (2017), and Lai and Kumbhakar (2018) use a single step ML method to estimate the parameters and the conditional mean (extension of the Jondrow et al. 1982 result) and then obtain both persistent and time-varying inefficiency. The multi-step approach proposed in Kumbhakar, Lien and Hardaker (2014) is used in this paper for its simplicity in estimation.

### *4.1 Estimation of the SF model*

Here, we first describe identification of all the parameters in the SF model. For this, we rewrite the model in (1) as,

$$y_{it} = \beta_0^* + x_{it}'\beta + z_i'\gamma + [\alpha_i - \tilde{\eta}_i] + [v_{it} - \tilde{\tau}_{it}] \equiv \beta_0^* + x_{it}'\beta + z_i'\gamma + \zeta_i + \chi_{it} \qquad (3)$$

where, $\zeta_i = \alpha_i - \tilde{\eta}_i \equiv \alpha_i - [\eta_i - E(\eta_i)]$, $\chi_{it} = v_{it} - \tilde{\tau}_{it} \equiv v_{it} - [\tau_{it} - E(\tau_{it})]$, and $\beta_0^* = \beta_0 - (E(\tau_{it}) + E(\eta_i))$.

In this formulation, $\zeta_i$ and $\chi_{it}$ have zero mean and constant variance. Now we show, following Kumbhakar, Lien and Hardaker (2014), how the parameters of (3) can be estimated.

***Step 1****:* Since (3) is the familiar RE panel data model, one can use a standard RE panel regression to estimate $\beta$ and $\gamma$ consistently. This procedure also gives the predicted values of $\zeta_i$ and $\chi_{it}$. One can stop here, if the interest lies in estimating only the $\beta$ and $\gamma$ parameters. For estimation (prediction) of $\tau_{it}$ and $\eta_i$, we consider the steps below.

***Step 2:*** Prediction of $\tau_{it}$. For this we need to estimate the parameters in $\tau_{it}$ and $v_{it}$.To do so we write:[6]

$$\chi_{it} = E(\tau_{it}) - \tau_{it} + v_{it} = a - \tau_{it} + v_{it} \quad (4)$$

which can be viewed as a SF model (with just an intercept). Recall that $a = E(\tau_{it})$ so that '$a$' is not a separate parameter under the assumption $\tau_{it}$ is $N^+(0, \sigma_\tau^2)$, $E(\tau_{it}) = a = \sqrt{2/\pi}\,\sigma_\tau$ which is a constant. Thus, the parameters of (4) are $\sigma_\tau$ and $\sigma_v$, which can be identified from the second and third moments of $\chi_{it}$, assuming that $v_{it}$ is $N(0,\sigma_v^2)$. Since the $\sigma_\tau$ and $\sigma_v$ parameters can be identified, we use the SF approach which uses the above distributional assumptions on $\tau$ and $v$.

Note that our primary interest is to predict $\tau_{it}$. For this we use the Jondrow et al. (1982) formula, which gives an estimate of $\tau_{it}$, conditional on the composed error term $(v_{it} - \tau_{it}$ That is, $\hat{\tau}_{it} = E\{\tau_{it} | (v_{it} - \tau_{it})\}$. In practice $(v_{it} - \tau_{it})$ is the residual from the SF model in (4).

***Step 3:*** To predict $\eta_i$, we need to make sure that $\eta_i$ can be separated from $\alpha_i$. For this, first we show that the parameters in $\eta_i$ and $\alpha_i$ can be identified. Since

$$\zeta_i = \alpha_i - \eta_i + E(\eta_i) = \alpha_i - \eta_i + b \quad (5)$$

where $E(\eta_i) = b = \sqrt{(2/\pi)}\sigma_\eta$, we can use the second and third moments of $\zeta_i$ (as argued before) to identify the parameters in $\eta_i$ and$\alpha_i$, assuming that $\alpha_i$ is $N(0,\sigma_\alpha^2)$.

To predict $\eta_i$ we treat (5) as a standard cross-sectional SF model, estimation of which will give predicted values of $\eta_i$ (thereby separating it from $\alpha_i$), using the Jondrow et al. (1982) procedure, discussed below.

### *4.2 Prediction of persistent and time-varying gap in the indicators*

Here we provide the details about the Jondrow et al. (1982) formula in predicting both $\tau_{it}$ and $\eta_i$.

Under the distributional assumption $\alpha_i \sim iid\ N(0, \sigma_\alpha^2)$ and $\eta_i \sim iid\ N^+(0, \sigma_\eta^2), \eta_i \geq 0$ (i.e. $\eta_i$ is distributed as half-normal), the distribution of $\eta_i$ conditional on $(\alpha_i - \eta_i)$ is truncated normal. The mean of this conditional distribution is used as a predictor of $\eta_i$ (see Kumbhakar, Wang, and Horncastle 2015). That is,

$$\hat{\eta}_i = E(\eta_i | (\alpha_i - \eta_i)) = \mu_i^* + \{\sigma^* \phi(\mu_i^*/\sigma^*)\}/\{\Phi(\mu_i^*/\sigma^*)\} \quad (6)$$

where $\mu_i^* = \{-\sigma_\eta^2(\alpha_i - \eta_i)\}/\{\sigma_\eta^2 + \sigma_\alpha^2\}$ and $\sigma^* = \sqrt{\sigma_\eta^2\sigma_\alpha^2/(\sigma_\eta^2 + \sigma_\alpha^2)}$.

In implementing this formula, we replace $(\alpha_i - \eta_i)$ by its estimate from the SF model in Step 3. Similarly, under the distributional assumption that $v_{it} \sim iid\ N(0, \sigma_v^2)$ and $\tau_{it} \sim iid N^+(0, \sigma_\tau^2)$ (i.e. $\tau_{it}$ is distributed as half-normal), the distribution of $\tau_{it}$ conditional on $(v_{it} - \tau_{it})$ is truncated normal. The mean of this conditional distribution is used as a predictor of $\tau_{it}$. The formula is exactly the same as in (6),

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[6] We ignore the difference between the true and predicted values of $\beta$ *and* $\gamma$ (which is standard practice in any two- or multi-step procedure in econometrics).

$\hat{\tau}_{it} = E(\tau_{it}|(v_{it} - \tau_{it})) = \mu_{it}^{\#} + \{\sigma^{\#}\phi(\mu_{it}^{\#}/\sigma^{\#})\}/\{\Phi(\mu_{it}^{\#}/\sigma^{\#})\}$ where $\mu_{it}^{\#} = \{-\sigma_u^2(\tau_{it} - v_{it})\}/\{\sigma_\tau^2 + \sigma_v^2\}$ and $\sigma^{\#} = \sqrt{\sigma_\tau^2\sigma_v^2/(\sigma_\tau^2 + \sigma_v^2)}$. In implementing this formula, we replace $\tau_{it} - v_{it}$ by its estimate from the SF model in Step 2. The overall gap is then predicted by summing the predicted values of $\eta_i$ and $\tau_{it}$.

Almost all the SF models are specified in log (or rates of change) form. In these formulations, inefficiency (shortfall from the potential outcome) can be interpreted as the percentage (when multiplied by 100) shortfall in the outcome variable, especially when inefficiency is small. However, the exact percentage shortfall is $1 - \exp(-\text{inefficiency})$, where $\exp(-\text{inefficiency})$ is the measure of efficiency. Since we have two components of inefficiency, we can obtain the corresponding estimates of the two efficiency components. Thus, persistent efficiency is $\exp(-\eta_i)$ and time-varying efficiency is $\exp(-\tau_{it})$. Then overall technical efficiency (OTE) is the product of the persistent and time-varying efficiency. Note that the overall technical inefficiency and OTE are closely related. For small values of inefficiency, the overall technical inefficiency ≈ 1- OTE.

For reporting purposes, for each indicator one can use either the mean of overall inefficiency for each country, which is $\bar{u}_i = \eta_i + \bar{\tau}_i$, or the average of OTE for each country. Either the average inefficiency or efficiency scores can be used to rank countries for each indicator. Note that the ranking shows the scope for improvement for each country and indicator. The inefficiency scores show potential for improvement for the indicator in question and not the value of the indicator, which might confuse some readers. We clarify this issue using a graph, which is used for illustration purposes.

Since the model we estimate for each indicator is $y_{it} = \beta_0 + x_{it}'\beta + z_i'\gamma + \alpha_i - \eta_i - \tau_{it} + v_{it}$, the country average is $\bar{y}_i = \beta_0 + \bar{x}_i'\beta + z_i'\gamma + \alpha_i - \eta_i - \bar{\tau}_i$ assuming $\bar{v}_i = 0$ since $E(v_{it}) = 0\ \forall i$. If we denote $\beta_0 + \bar{x}_i'\beta + z_i'\gamma + \alpha_i$ *by* $m_i$, $\bar{y}_i = m_i - \bar{u}_i$ where $\bar{u}_i = \eta_i + \bar{\tau}_i$. Now we use the information on $\bar{y}_i$ and $m_i$ in Figure 1 and measure the difference between them as the potential for improvement.

To be more specific, let us assume that $\bar{y}_i$ is educational quality, measured by the PISA reading performance, and the points A and B in figure 1 represent $\bar{y}_i$ for two countries, say Vietnam and the Republic of Korea. The points C and D represent their respective *m* values, that is, their own potential. Clearly both actual and potential values for Korea are higher than those of Vietnam. However, Vietnam is much closer to its frontier value (distance AC < BD) and therefore has smaller scope for improvement. Thus, if we rank the countries in terms of their improvement potential (efficiency), Vietnam will be ranked higher than Korea in terms of educational quality. This does not mean, however, that educational quality in Korea is lower than in Vietnam. Our ranking is in terms of efficiency, not in terms of the raw indicator. We discuss this in detail for various indicators in the results section.

## 5. Data

### *5.1 The indicators ($y_{it}$)*

Following the illustration presented in the conceptual framework, we draw on the theoretical and empirical literatures on economic growth, poverty reduction, and resilience to identify some variables that can be used as indicators of social and economic development (Foa 2013; Loayza, Fajnzylber, and Calderón 2005; World Bank 2013).

Initially, we built a database for 146 indicators covering 207 countries for the period 1950-2014. However, for practical reasons, we narrowed the number of indicators down to 10 indicators and the period of study to 2005-2014. This was done by applying the following selection criteria: (i) the relevance of the variables found in the empirical evidence; (ii) good cross-country and cross-time coverage. Table 1 gives the list of these indicators and related summary statistics. The sample covers, on average, 152 countries with variation across indicators. The coverage for 7 of the 10 indicators ranges from 144 to 203 countries, while for the remaining indicators (educational quality, old-age pension, and sanitation facilities) the coverage ranges from 66 to 81 countries. We decided to benchmark each indicator separately for clarity and to avoid arbitrariness regarding grouping them together.

In the econometric model presented in the methodological section, each of these 10 variables represents the dependent or "left-hand side" variable of the regression equation.

### *5.2 The structural variables ($x_{it}$ and $z_i$)*

As argued before, in order to improve comparability of performance across countries, it is necessary to control for countries' endowments, structural, or predetermined conditions. Table 2 reports the list of variables we selected, along with their summary statistics. Note that we include a 10 year-lag of the GDP per capita in this group to help account for the countries' predetermined conditions. These are the explanatory or "right-hand-side" variables in the SF model outlined in the methodological section. Table 3 reports pairwise correlations between all variables. The degree of correlation varies across indicators, but we conclude that the correlations between indicators and predetermined conditions are not negligible and the correlation among predetermined conditions is not so high as to make any of them irrelevant.

## 6. Illustrative Results

We are interested in assessing the potential for improvement in various development indicators for a large group of countries. The SF model gives us estimates of persistent and time-varying (in)efficiency (and its confidence intervals) for each indicator, country, and year. The estimated (in)efficiency levels can be used to rank countries, measure the scope for improvement, and identify the countries that are close to the efficiency frontier (the benchmark).

In the appendix, we report detailed estimates by indicator and country. We present the results as they are introduced in the methodological section. For each indicator, we show the country's time-invariant inefficiency ($\eta_i$), time-varying inefficiency components in the first and last year of the period ($\tau_{i0}$ $and$ $\tau_{iT}$), and the percentage change in inefficiency between the final and the initial years. The amount of information in the appendix can be overwhelming. To illustrate the results, in what follows we highlight some comparisons across countries and regions.

For each of the 10 indicators, we compute the overall technical efficiency (OTE) for each country and year. The OTE is the ratio of the observed level of an indicator to the maximum possible (frontier) that could be achieved given a country's structural characteristics. For example, if the OTE for an indicator is 0.95, then we can say that the country in question has attained 95% of its potential in that indicator. Countries at the top of the efficiency ranking are countries closer to their own frontier and therefore have smaller scope for improvement. As explained in the methodological section, a ranking of countries in terms of their efficiency could differ from a ranking based on their raw indicator. Table 4 reports the correlations between the efficiency ranking and the raw indicator ranking. The correlation coefficient is low for the access to finance index; high for educational quality, income inequality, and fiscal balance;

and medium for the rest. The lower the correlation, the more informational value can be obtained from the SF approach to determine efficiency with respect to own benchmark.

In Table 5, we report the top 5 and bottom 5 countries according to OTE for each indicator. For illustration, let's consider some specific examples. For access to finance, the SF model places Mongolia at the top 1, while the raw indicator places Norway as the best. The raw indicator is right in absolute terms, since almost 100% of the population in Norway has an account at a financial institution. However, Mongolia appears to be the country that is doing its best considering its structural characteristics: 85% of the population in Mongolia has an account at a financial institution, which is outstanding considering that Mongolia's GDP per capita is only 2% of Norway's and that Mongolia is the second country with lowest population density. Mongolia's high OTE and ranking does not mean that it is better than, say, Norway. Rather, it tells us that given its structural characteristics, Mongolia is operating close to the frontier and does not have much slack (scope for improvement) regarding financial inclusion.

Consider another example. While for educational quality there is high correlation between the OTE and the raw indicator, inspection of the SF outcomes reveals some surprising results. The SF model places Vietnam as second while Korea is ranked seventh. However, according to the raw PISA indicators for reading performance, this second position is occupied by Korea, while Vietnam is number 17. The SF model tells us that Vietnam has been more efficient in reaching its frontier for educational quality considering that its overall level of development is way below Korea – Vietnam's GDP per capita is only about 5% of Korea's GDP per capita. Note again that we are not comparing the performance of one country with another; rather, we are comparing each country with its potential.

A third example relates to the indicator of financial depth. The raw indicator suggests that the United States is top 2 in the world with a financial depth ratio of 190% of GDP, while Fiji is placed number 39 with a financial depth ratio of 79% of GDP. In contrast, the SF model places Fiji as the top 2. That is, considering that Fiji is a small state with GDP per capita only 7% that of the United States, Fiji is operating close to its potential.

The ranking comparisons can be done for different country groupings. These comparisons may add some insight regarding a country's OTE relative to its peers. For instance, Table 6 presents top 5 and bottom 5 countries for each indicator by geographic location. Alternative groupings –by income level, for example—are also possible.

Next, we present a broad perspective on where countries stand regarding their OTE for each indicator. We do so by showing a color-coded world map for each indicator. We group countries into five categories according to OTE (high, medium-high, medium, medium-low, and low) and assign a color for each category. Figure 2 presents this collection of world maps, one for each indicator. Let's consider a couple of examples. The measles immunization map shows that countries with more scope for improvement are concentrated in Africa and South Asia. The same pattern is observed for life expectancy. The income inequality map shows that countries with more scope for improvement are in Latin America and Sub-Saharan Africa. Within Latin America, the countries with more scope for improvement are Honduras, Colombia, Guatemala and Brazil. While in Sub-Saharan, the countries with more scope for improvement are South Africa, Eswatini, Lesotho, and Rwanda.

Not only individual countries but also groups of countries can be compared using the outcomes from the SF approach. One possibility is to explore how particular groups of countries fare regarding their average level and within-group diversity. As an example, Table 7 presents OTE means and standard deviations by geographic region for each of the indicators. Let's consider a few comparisons. Regarding life expectancy, Europe and Central Asia is the region that shows the highest average and lowest dispersion in OTE, while Sub-Saharan Africa is at the other end of the spectrum, with the lowest average and highest standard deviation. Knowing these regions' levels of development, this result may not be very surprising. More surprising may be the similarity in average OTE across all regions regarding fiscal balance, although with differences regarding within-region dispersion. Also surprising may be the result regarding measles immunization, for which the Americas is the region with the highest average and lowest dispersion in OTE. This good regional performance contrasts with its poor performance regarding other indicators, such as trade openness or income inequality.

So far, we have concentrated the discussion on overall technical efficiency (OTE). The Stochastic Frontier approach allows for separation of persistent and time-varying components. While persistent components are associated with longer-run factors requiring deeper reforms to change, time-varying components are linked to shorter-run developments. As mentioned before, these are presented in the Appendix Tables, following the way they are introduced in the methodological section. For illustration, consider the following example applied to access to finance. For Australia, the persistent component of *inefficiency* is 35.1% and the time-varying component of inefficiency increased from 8.8% to 18.8%. The country worsened over the period considered, with the overall potential for improvement for Australia rising from 43.9% (35.1% + 8.8%) in the initial year to 53.9% (35.1%+18.8%) in the final year. In contrast, for Indonesia, persistent inefficiency at 60.4% is higher than Australia's, but Indonesia's time-varying component went down from 26.4% to 7.7%, signaling an improvement over time.

## 7. Conclusion

To assess a country's performance in terms of a relevant set of development indicators, we need a benchmark against which these indicators can be compared. If the benchmark is measured as a feasible frontier, then departure from the benchmark can be viewed as inefficiency, slack, or potential for improvement. This paper focuses on international benchmarking for assessing a country's realistic potential for improvement on various social and economic dimensions.

We use the stochastic frontier (SF) approach to estimate a country-, time-, and indicator-specific benchmark and (one-sided) inefficiency. Our approach contrasts with the literature that compare countries by looking at raw indicators without taking into account the structural endowments or predetermined conditions that constrain the maximum performance that countries can achieve in a policy-relevant horizon. The SF approach also improves on the literature that uses OLS regression residuals to measure performance. Although the residuals can give some idea about a country's performance, they cannot be interpreted as inefficiency because they are mixed with noise and can take both positive and negative values.

To illustrate the SF methodology, we apply it to 10 indicators of economic and social performance, using panel data of 142 countries for the period 2005-2014. We compute benchmarks, as well as persistent and time-varying inefficiency measures. To facilitate the discussion of results, we introduce the concept of overall technical efficiency (OTE), the inverse of inefficiency. Not surprisingly, we find that countries' overall technical efficiency varies across indicators, with no country or region dominating the rest. More interestingly, we find that the potential for improvement does not follow a simple relationship with economic development, with some lower-income countries being closer to their own feasible frontier than other more advanced countries. This result does not imply that developing countries do not have much to make progress towards in the long run: they do, but their realistic potential for improvement is limited by their structural or predetermined conditions in the short term.

One caveat on our study is that we have used a homogeneous set of structural or predetermined conditions across indicators. We have done so for simplicity, convenience, and comparability. The SF approach presented in this paper can be extended and improved if one focuses on a smaller set of indicators, selecting for each of them a more appropriate set of structural endowments or predetermined conditions. The SF application can also be improved by using distribution functions (e.g., exponential vs. half-normal) and variations of the econometric model that are more appropriate for specific indicators. Finally, if detailed information is available, the model can be extended to include variables that can possibly explain why some countries are more inefficient than others.

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**Table 1: Selected Indicators, Definitions, and Summary Statistics**

| Variable | Definition | Mean | SD | Min | Max | Obs | Years | Source |
|---|---|---|---|---|---|---|---|---|
| **Macroeconomy** | | | | | | | | |
| Trade openness | Sum of exports and imports of goods and services to GDP ratio. | 96.2 | 61.8 | 0.2 | 860.8 | 1,894 | 2005-2014 | World Development Indicators |
| Financial depth | Domestic credit to private sector refers to financial resources provided to the private sector by financial corporations as a percent of GDP. | 52.1 | 45.3 | 0.4 | 312.1 | 1,753 | 2005-2014 | World Development Indicators |
| Fiscal balance | General government net lending/borrowing as a percent of GDP. It is calculated as revenue minus total expenditure. | 0.1 | 6.8 | -40.3 | 123.5 | 1,820 | 2005-2014 | World Economic Outlook |
| **Human Capital** | | | | | | | | |
| Measles immunization | Child immunization, measles, measures the percentage of children ages 12-23 months who received the measles vaccination before 12 months or at any time before the survey. | 87.0 | 13.9 | 22.0 | 99.0 | 1,903 | 2005-2014 | Health, Nutrition and Population |
| Sanitation facilities | Access to improved sanitation facilities refers to the percentage of the population using improved sanitation facilities. | 64.2 | 29.1 | 5.5 | 100.0 | 808 | 2005-2014 | World Development Indicators |
| Life expectancy | Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life. | 70.2 | 8.8 | 43.6 | 85.4 | 1,992 | 2005-2014 | World Development Indicators |
| Educational quality | PISA's reading performance score measures the capacity to understand, use and reflect on written texts. | 462.9 | 51.5 | 284.7 | 569.6 | 634 | 2005-2014 | OECD |
| **Social Inclusion** | | | | | | | | |
| Access to finance | The percentage of respondents, as a percentage of total population 15 years or older, who report having an account (by themselves or together with someone else) at a bank or another type of financial institution or report personally using a mobile money service in the past 12 months. | 49.6 | 32.2 | 0.4 | 100.0 | 284 | 2011 & 2014 | Global Findex |
| Old-age pension | Active contributors to pension schemes as a percentage of working-age population. | 27.5 | 32.7 | 0.0 | 481.6 | 313 | 2005-2013 | International Labour Organization |
| Income inequality | Measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution. | 36.8 | 8.6 | 16.6 | 64.8 | 736 | 2005-2014 | World Development Indicators |

**Table 2: Selected Predetermined Conditions, Definitions, and Summary Statistics**

| Variable | Definition | Mean | SD | Min | Max | Obs | Years | Source |
|---|---|---|---|---|---|---|---|---|
| Population | All residents regardless of legal status or citizenship in millions. | 32 | 128 | 0.01 | 1360 | 2,127 | 2005-2014 | Penn World Table |
| Population density | Total population divided by land area in square kilometers. | 391 | 1850 | 0.14 | 19073 | 2,120 | 2005-2014 | World Development Indicators |
| Offshore dummy | 1 if a country is an offshore center, where the bulk of financial sector activity is offshore on both sides of the balance sheet, where the transactions are initiated elsewhere, and where the majority of the institutions involved are controlled by non-residents. | 0.2 | 0.4 | 0 | 1 | 2,130 | 2005-2014 | IMF |
| Small states dummy | 1 if a country has less than 1,500,000 inhabitants. | 0.3 | 0.5 | 0 | 1 | 2,130 | 2005-2014 | World Development Indicators |
| Landlocked countries | 1 if the country is entirely enclosed by land, or whose only coastlines lie on closed seas. | 0.2 | 0.4 | 0 | 1 | 2,130 | 2005-2014 | World Development Indicators |
| GDP per capita (level) | GDP per capita is gross domestic product divided population in constant 2010 U.S. dollars. | 12 | 18 | 0.14 | 159 | 1,904 | 2005-2014 | World Development Indicators |

**Table 3: Correlations between Indicators and Predetermined Conditions**

| Variable | GDP per capita | Population | Density | Landlocked | Small | Offshore |
|---|---|---|---|---|---|---|
| Trade openness | 0.27 | -0.16 | 0.29 | -0.02 | 0.28 | 0.34 |
| Financial depth | 0.66 | 0.12 | 0.12 | -0.22 | 0.06 | 0.27 |
| Fiscal balance | 0.11 | -0.04 | 0.02 | -0.03 | 0.01 | 0.03 |
| Measles immunization | 0.26 | -0.01 | 0.09 | -0.06 | 0.05 | 0.15 |
| Sanitation facilities | 0.60 | -0.06 | 0.13 | 0.08 | 0.17 | 0.14 |
| Life expectancy | 0.59 | 0.01 | 0.19 | -0.29 | 0.15 | 0.29 |
| Educational quality | 0.54 | 0.14 | 0.19 | -0.13 | 0.02 | 0.13 |
| Access to finance | 0.74 | 0.03 | 0.21 | -0.24 | 0.17 | 0.24 |
| Old-age pension | 0.38 | -0.05 | 0.07 | -0.14 | 0.21 | 0.32 |
| Income inequality | -0.43 | 0.11 | -0.17 | -0.13 | -0.13 | 0.08 |

**Table 4: Correlation between Overall Technical Efficiency (OTE) and Raw Indicator – Average Score and Ranking**

| Indicator | Average Score | Ranking |
|---|---|---|
| Trade openness | 75.9 | 71.6 |
| Financial depth | 73.7 | 69.1 |
| Fiscal balance | 91.5 | 87.3 |
| Measles immunization | 89.0 | 77.3 |
| Sanitation facilities | 90.3 | 72.8 |
| Life expectancy | 83.9 | 67.6 |
| Educational quality | 89.6 | 88.4 |
| Access to finance | 59.1 | 35.2 |
| Old-age pension | 69.2 | 65.1 |
| Income inequality | -91.7 | 92.2 |

**Table 5: Top 5 and Bottom 5 Countries for Each Indicator**

| Indicator | Top 5 | Bottom 5 | Indicator | Top 5 | Bottom 5 |
|---|---|---|---|---|---|
| **Trade openness** | Hong Kong SAR, China | Myanmar | **Life expectancy** | Iceland | Nigeria |
| | Singapore | Bermuda | | Greenland | Sierra Leone |
| | Vietnam | Japan | | Australia | Côte d'Ivoire |
| | Liberia | Brazil | | Canada | Eswatini |
| | Thailand | United States | | San Marino | Lesotho |
| **Financial depth** | South Africa | Iraq | **Educational quality** | China | Kyrgyz Rep. |
| | Fiji | Congo, Rep. | | Vietnam | Qatar |
| | Iceland | Equa. Guinea | | Finland | Peru |
| | China | Congo, Dem. Rep. | | Estonia | Panama |
| | Vietnam | Guinea | | Canada | Macedonia, FYR |
| **Fiscal balance** | Kuwait | Eritrea | **Access to finance** | Mongolia | Turkmenistan |
| | Brunei Darussalam | Tuvalu | | Kenya | Niger |
| | Qatar | Botswana | | Sri Lanka | Yemen, Rep. |
| | Congo, Rep. | Kiribati | | Rwanda | Iraq |
| | Norway | Libya | | North Macedonia | Guinea |
| **Measles immunization** | Mongolia | Chad | **Old-age pension** | Ukraine | Angola |
| | Guyana | Nigeria | | Moldova | Lao PDR |
| | Kyrgyz Rep. | Equatorial Guinea | | Latvia | Oman |
| | Eritrea | Central African Rep. | | China | Bangladesh |
| | Turkmenistan | Vanuatu | | Belize | El Salvador |
| **Sanitation facilities** | Greenland | Tuvalu | **Income inequality** | Azerbaijan | South Africa |
| | Latvia | Niger | | Algeria | Eswatini |
| | Belarus | Hong Kong SAR, China | | Ukraine | Lesotho |
| | Jordan | Venezuela, RB | | Timor-Leste | Rwanda |
| | Kuwait | Colombia | | Belarus | Namibia |

Source: Based on authors’ calculation of efficiency estimates.

## Table 6: Top 5 and Bottom 5 Countries for Each Indicator by Region[7]

| Region | Americas | | East & South Asia | | Europe & Central Asia | | Middle East & North Africa | | Sub-Saharan Africa | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Indicator** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** |
| **Trade openness** | Honduras | Bermuda | Hong Kong SAR, China | Myanmar | Luxembourg | Greece | Malta | Israel | Liberia | Central African Rep. |
| | Guyana | Brazil | Singapore | Japan | Belarus | Italy | Jordan | Iran, Islamic Rep. | Congo, Rep. | Eritrea |
| | Panama | United States | Vietnam | Australia | Kyrgyz Rep. | Armenia | United Arab Emirates | Qatar | Angola | Rwanda |
| | Nicaragua | Argentina | Thailand | Guam | Ukraine | Kosovo | Tunisia | Kuwait | Mauritania | Burundi |
| | Paraguay | Cuba | Malaysia | Tonga | Belgium | Norway | Libya | Egypt, Arab Rep. | Mozambique | Sudan |
| **Financial depth** | Canada | Argentina | Fiji | Afghanistan | Iceland | Belgium | Jordan | Iraq | South Africa | Congo, Rep. |
| | Guyana | Uruguay | China | Myanmar | Cyprus | Azerbaijan | Tunisia | Yemen, Rep. | Namibia | Equa Guinea |
| | United States | Venezuela, RB | Vietnam | Macao | Estonia | Turkey | Morocco | Libya | São Tomé and Príncipe | Congo, Dem. Rep. |
| | Chile | Mexico | Mongolia | Brunei Darussalam | Montenegro | Romania | Djibouti | Qatar | Cabo Verde | Guinea |
| | Bolivia | Dominican Rep. | Thailand | Singapore | Portugal | Kyrgyz Rep. | Iran, Islamic Rep. | United Arab Emirates | Ethiopia | Chad |
| **Fiscal balance** | Jamaica | Venezuela | Brunei Darussalam | Tuvalu | Norway | Ireland | Kuwait | Libya | Congo | Eritrea |
| | St. Kitts and Nevis | United States | Singapore | Kiribati | Azerbaijan | United Kingdom | Qatar | Egypt, Arab Rep. | Seychelles | Botswana |
| | Trinidad and Tobago | Antigua and Barbuda | Solomon Islands | Japan | Uzbekistan | Spain | United Arab Emirates | Jordan | Gabon | Cabo Verde |
| | Bolivia | Honduras | Philippines | Australia | Kazakhstan | Portugal | Saudi Arabia | Djibouti | Comoros | São Tomé and Príncipe |
| | Peru | Guyana | Tonga | Mongolia | Belarus | Greece | Oman | Yemen, Rep. | Equa. Guinea | Ghana |
| **Measles immunization** | Guyana | Haiti | Mongolia | Vanuatu | Kyrgyz Rep. | San Marino | Libya | Iraq | Eritrea | Chad |
| | Nicaragua | Barbados | Bhutan | Lao PDR | Turkmenistan | Austria | Morocco | Lebanon | Botswana | Nigeria |
| | Belize | Dominican Rep. | Sri Lanka | Samoa | Kazakhstan | United Kingdom | Jordan | Malta | Tanzania | Equa. Guinea |
| | Bolivia | Venezuela, RB | Solomon Islands | Papua New Guinea | Uzbekistan | Switzerland | Tunisia | Yemen, Rep. | Gambia, The | Central African Rep. |
| | Cuba | United States | Fiji | Pakistan | Belarus | Denmark | Oman | Djibouti | Rwanda | Ethiopia |
| **Sanitation facilities** | Uruguay | Venezuela, RB | Malaysia | Tuvalu | Greenland | Turkey | Jordan | Lebanon | Senegal | . |
| | Canada | Colombia | New Zealand | Hong Kong SAR, China | Latvia | Bosnia and Herzegovina | Kuwait | Algeria | Niger | . |
| | Chile | Bolivia | Singapore | Palau | Belarus | Serbia | United Arab Emirates | Iraq | . | . |
| | United States | Peru | Korea, Rep. | China | Finland | Romania | Tunisia | Libya | . | . |
| | Ecuador | Brazil | Australia | Japan | Slovak Rep. | Cyprus | Qatar | Morocco | . | . |

Source: Based on authors' calculation of efficiency estimates.

[7] "Americas" combines countries in the Latin America & the Caribbean and North America World Bank regions. "East and South Asia" combines countries in East Asia & Pacific and South Asia World Bank regions.

## Table 6: Top 5 and Bottom 5 Countries for Each Indicator by Region (cont.)[8]

| **Region** | **Americas** | | **East & South Asia** | | **Europe & Central Asia** | | **Middle East & North Africa** | | **Sub-Saharan Africa** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Indicator** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** | **Top 5** | **Bottom 5** |
| **Life expectancy** | Canada | Haiti | Australia | India | Iceland | Ukraine | Oman | Djibouti | Mauritania | Nigeria |
| | Paraguay | Barbados | New Zealand | Pakistan | Greenland | Russian Fed. | Algeria | Bahrain | Cabo Verde | Sierra Leone |
| | Chile | Trinidad and Tobago | Mongolia | Singapore | San Marino | Turkey | Libya | Yemen, Rep. | Seychelles | Cote d'Ivoire |
| | Suriname | Grenada | Bhutan | Bangladesh | Norway | Romania | Tunisia | Iraq | Gabon | Swaziland |
| | Cuba | St. Vincent and the Grenadines | Solomon Islands | Philippines | Sweden | Netherlands | Saudi Arabia | United Arab Emirates | São Tomé and Príncipe | Lesotho |
| **Educational quality** | Canada | Peru | China | Indonesia | Finland | Kyrgyz Rep. | Israel | Qatar | Mauritius | . |
| | United States | Panama | Vietnam | Malaysia | Estonia | Macedonia | Malta | . | . | . |
| | Costa Rica | Argentina | New Zealand | Thailand | Hungary | Azerbaijan | Jordan | . | . | . |
| | Chile | Brazil | Korea, Rep. | Macao SAR, China | Ireland | Albania | United Arab Emirates | . | . | . |
| | Uruguay | Colombia | Australia | Japan | Latvia | Georgia | Tunisia | . | . | . |
| **Access to finance** | Jamaica | El Salvador | Mongolia | Pakistan | Macedonia | Turkmenistan | Iran, Islamic Rep. | Yemen, Rep. | Kenya | Niger |
| | Bolivia | Mexico | Sri Lanka | Cambodia | Belarus | Tajikistan | Morocco | Iraq | Rwanda | Guinea |
| | Costa Rica | Puerto Rico | Lao PDR | Japan | Serbia | Kyrgyz Rep. | Oman | Egypt, Arab Rep. | Namibia | Central African Rep. |
| | Belize | Peru | China | Afghanistan | Latvia | Luxembourg | Algeria | Qatar | Ethiopia | Senegal |
| | Brazil | Nicaragua | Nepal | Indonesia | Bosnia and H. | Armenia | Malta | Djibouti | Liberia | Madagascar |
| **Old-age pension** | Belize | El Salvador | China | Lao PDR | Cyprus | Slovenia | Tunisia | Oman | Kenya | Angola |
| | Trinidad and Tobago | Mexico | Vietnam | Bangladesh | Turkey | Portugal | Algeria | Bahrain | Zimbabwe | Congo, Rep. |
| | Peru | Paraguay | Mongolia | Indonesia | Czech Rep. | Czech Rep. | Jordan | Saudi Arabia | Mauritius | Togo |
| | Bolivia | Argentina | Korea, Rep. | Pakistan | Portugal | Turkey | Israel | . | Burundi | Burkina Faso |
| | Nicaragua | Colombia | India | Singapore | Slovenia | Cyprus | Morocco | . | Zambia | Cameroon |
| **Income inequality** | Canada | Honduras | Timor-Leste | Tuvalu | Azerbaijan | Macedonia | Algeria | Israel | Mauritania | South Africa |
| | Uruguay | Colombia | Pakistan | Micronesia, Fed. Sts. | Ukraine | Turkey | Iraq | Djibouti | Liberia | Eswatini |
| | Argentina | Guatemala | Mongolia | Philippines | Belarus | Portugal | Egypt, Arab Rep. | Iran, Islamic Rep. | Sierra Leone | Lesotho |
| | United States | Brazil | Vanuatu | China | Slovenia | United Kingdom | Lebanon | Morocco | Sudan | Rwanda |
| | Haiti | Paraguay | Australia | Malaysia | Iceland | Italy | Malta | Tunisia | São Tomé and Príncipe | Namibia |

Source: Based on authors' calculation of efficiency estimates.

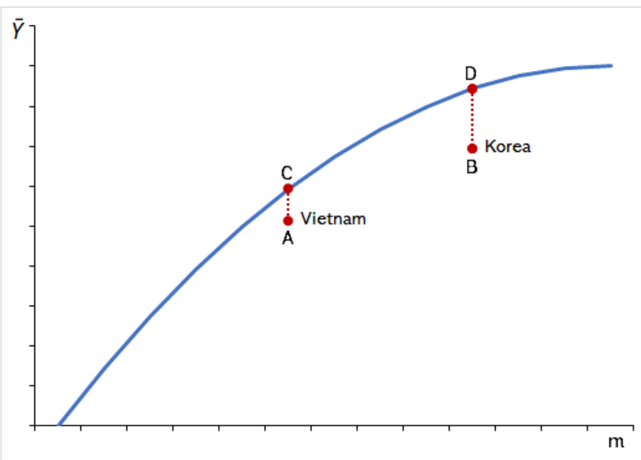
[8] "Americas" combines countries in the Latin America & the Caribbean and North America World Bank regions. "East and South Asia" combines countries in East Asia & Pacific and South Asia World Bank regions.

## Table 7: Average and Dispersion in OTE for Each Indicator by Region

| | Americas | | East & South Asia | | Europe & Central Asia | | Middle East & North Africa | | Sub-Saharan Africa | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Indicator** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **Trade openness** | 0.621 | 0.122 | 0.674 | 0.169 | 0.712 | 0.091 | 0.738 | 0.076 | 0.691 | 0.112 |
| **Financial depth** | 0.544 | 0.127 | 0.569 | 0.150 | 0.590 | 0.079 | 0.475 | 0.167 | 0.462 | 0.144 |
| **Fiscal balance** | 0.833 | 0.020 | 0.834 | 0.031 | 0.829 | 0.021 | 0.851 | 0.047 | 0.836 | 0.029 |
| **Measles immunization** | 0.799 | 0.068 | 0.736 | 0.108 | 0.781 | 0.074 | 0.769 | 0.088 | 0.704 | 0.127 |
| **Sanitation facilities** | 0.332 | 0.167 | 0.426 | 0.226 | 0.564 | 0.121 | 0.492 | 0.201 | 0.174 | 0.106 |
| **Life expectancy** | 0.912 | 0.038 | 0.889 | 0.044 | 0.935 | 0.020 | 0.899 | 0.040 | 0.788 | 0.058 |
| **Educational quality** | 0.773 | 0.066 | 0.865 | 0.081 | 0.834 | 0.063 | 0.745 | 0.051 | 0.754 | . |
| **Access to finance** | 0.562 | 0.093 | 0.613 | 0.150 | 0.576 | 0.141 | 0.484 | 0.158 | 0.543 | 0.171 |
| **Old-age pension** | 0.524 | 0.168 | 0.446 | 0.225 | 0.684 | 0.164 | 0.470 | 0.262 | 0.394 | 0.207 |
| **Income inequality** | 0.619 | 0.056 | 0.716 | 0.047 | 0.759 | 0.041 | 0.739 | 0.068 | 0.666 | 0.083 |

Source: Authors' calculation of efficiency estimates.

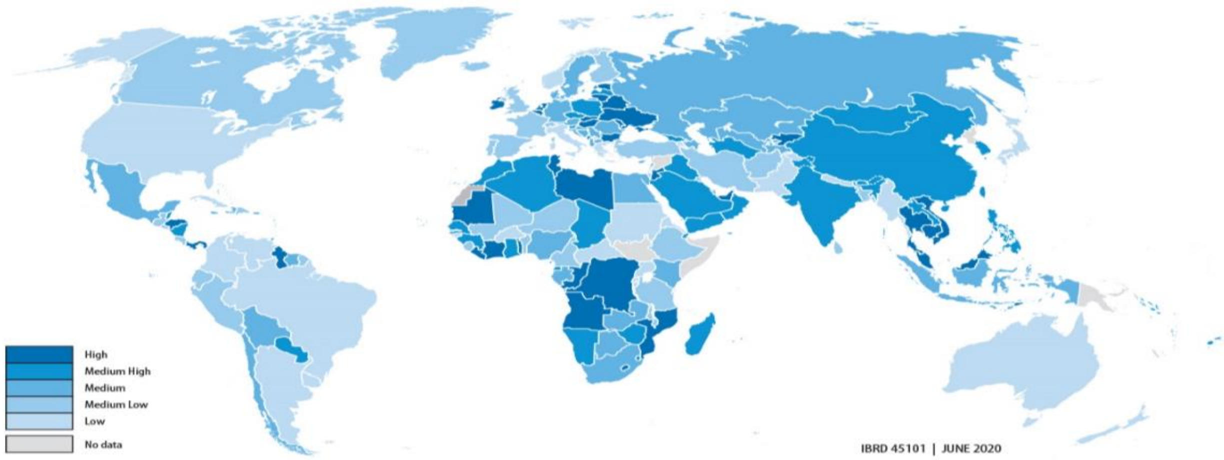
## Figure 1: Frontier and Efficiency Gap for Educational Quality



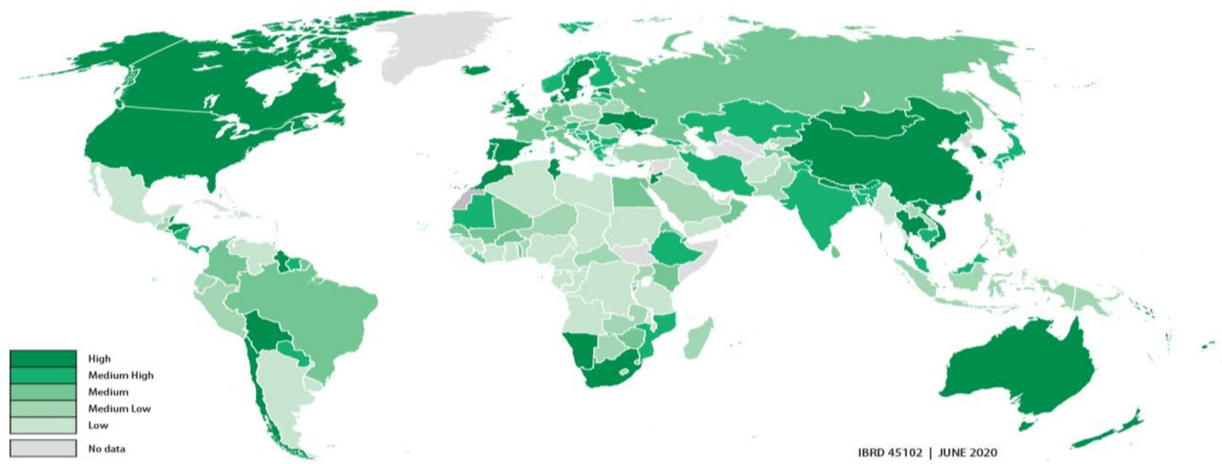

Source: Authors' own illustration.

**Figure 2: Maps of Efficiency (OTE) by Indicator**

a. Trade openness




b. Financial depth




c. Fiscal balance

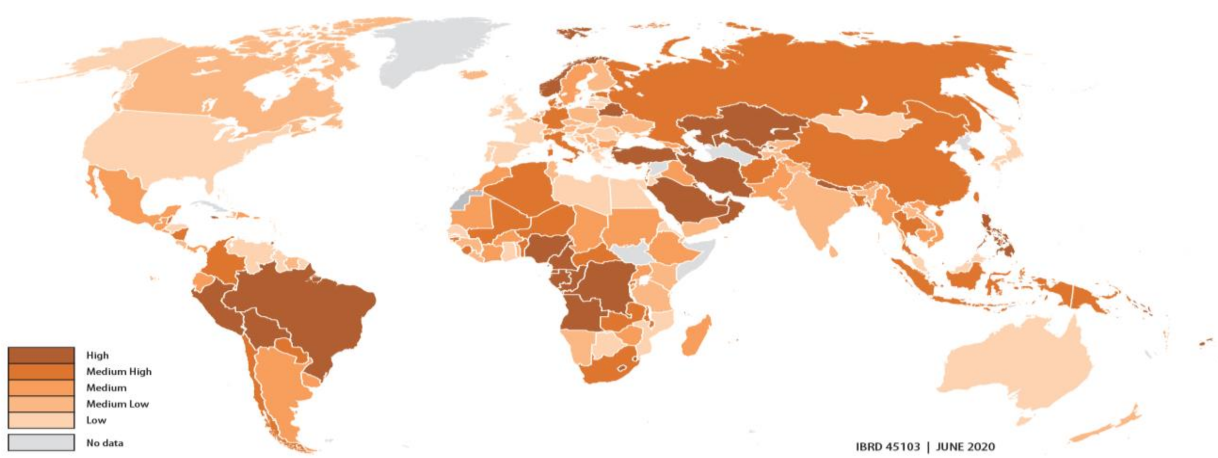
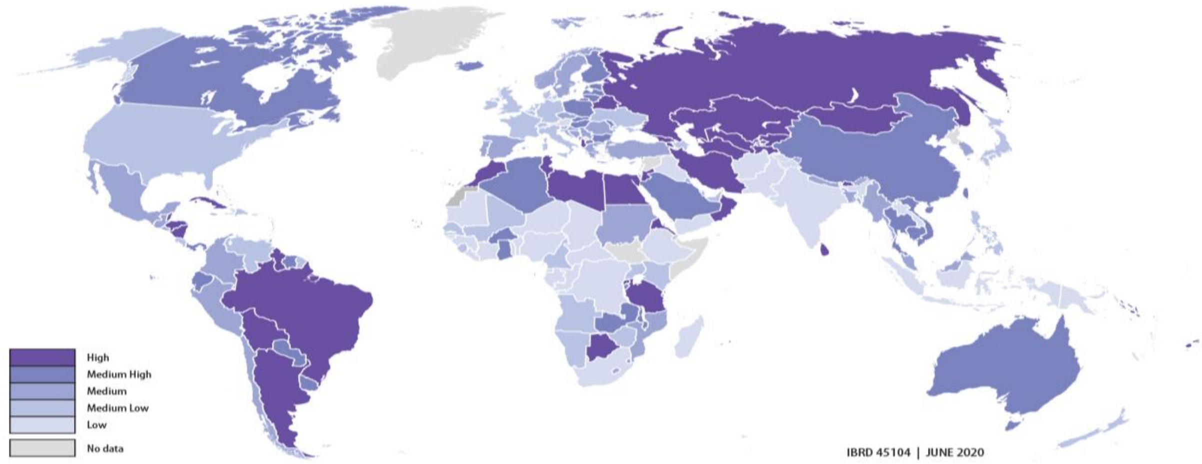
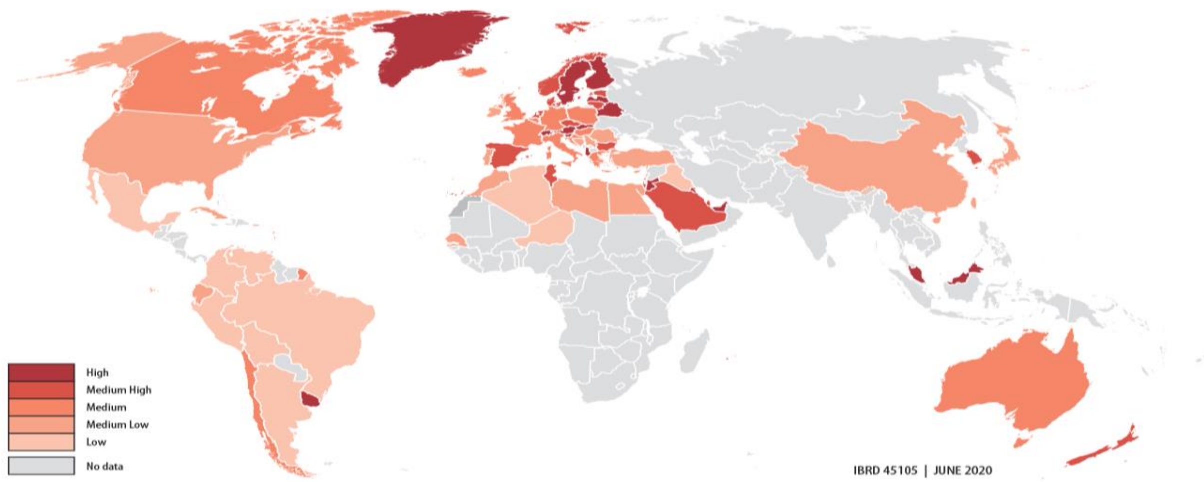


**Figure 2: Efficiency Results for Each Indicator (cont.)**

d. Measles immunization




e. Sanitization facilities




f. Life expectancy

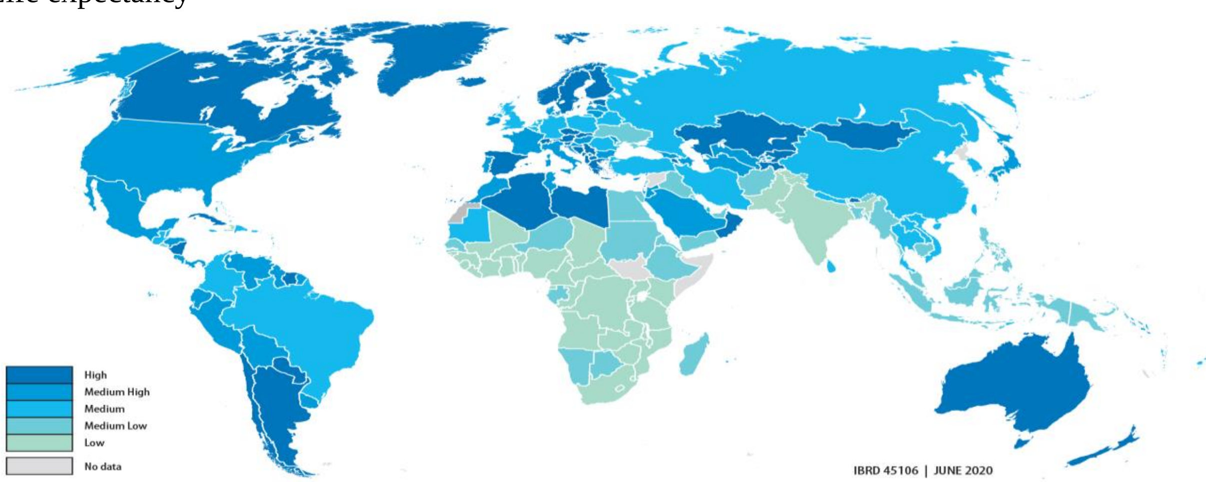
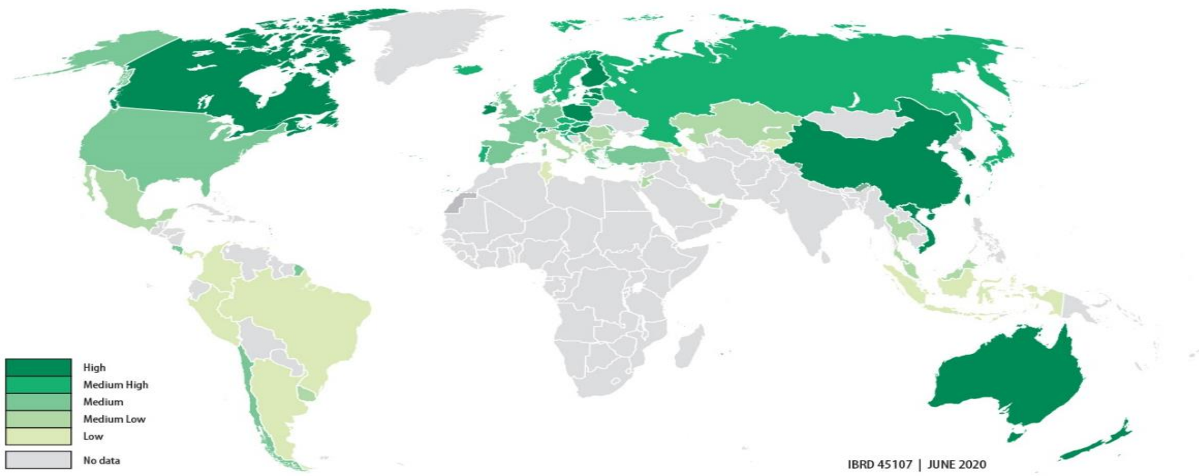
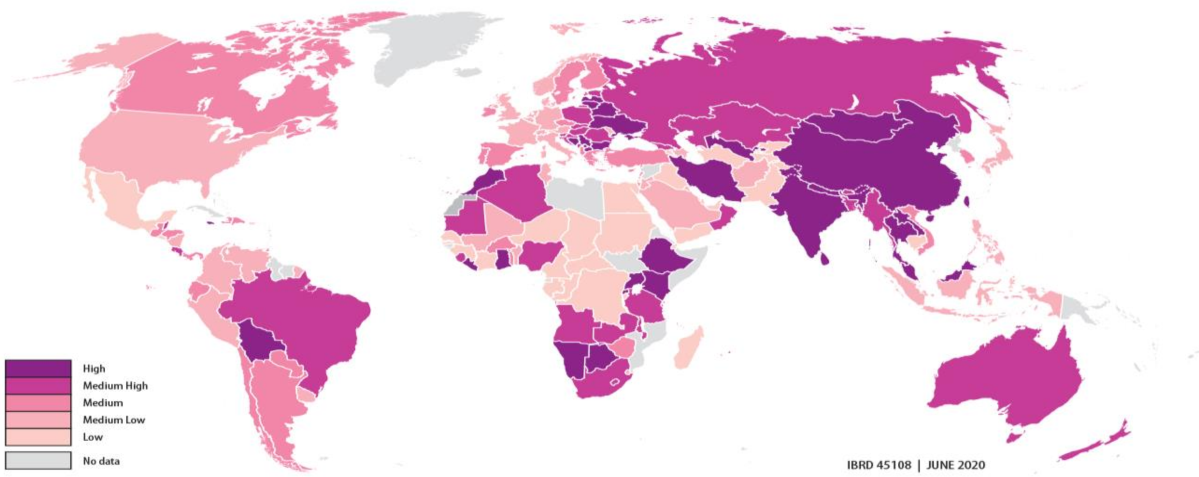


**Figure 2: Efficiency Results for Each Indicator (cont.)**

g. Educational quality




h. Access to finance




i. Old-age pension

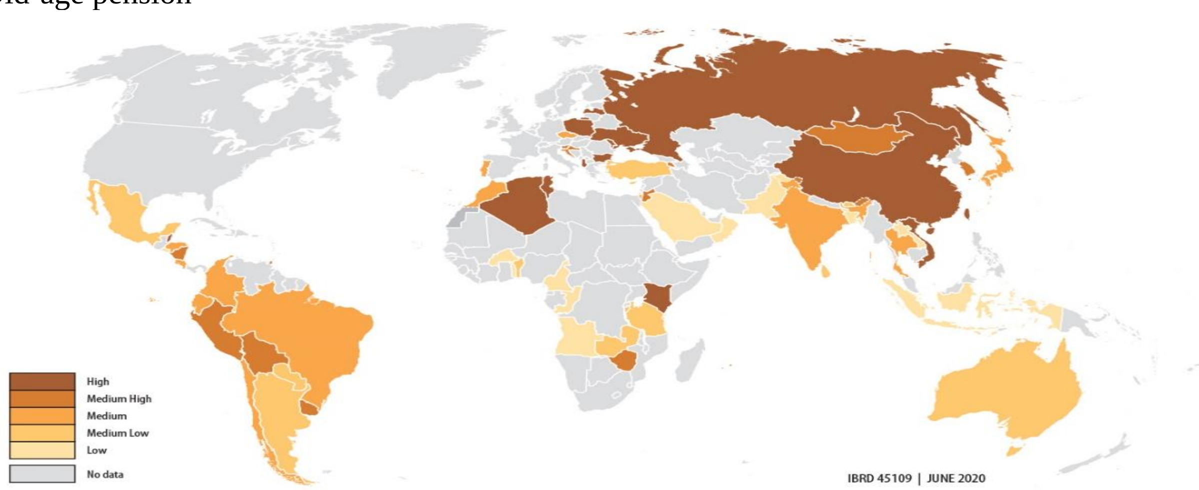
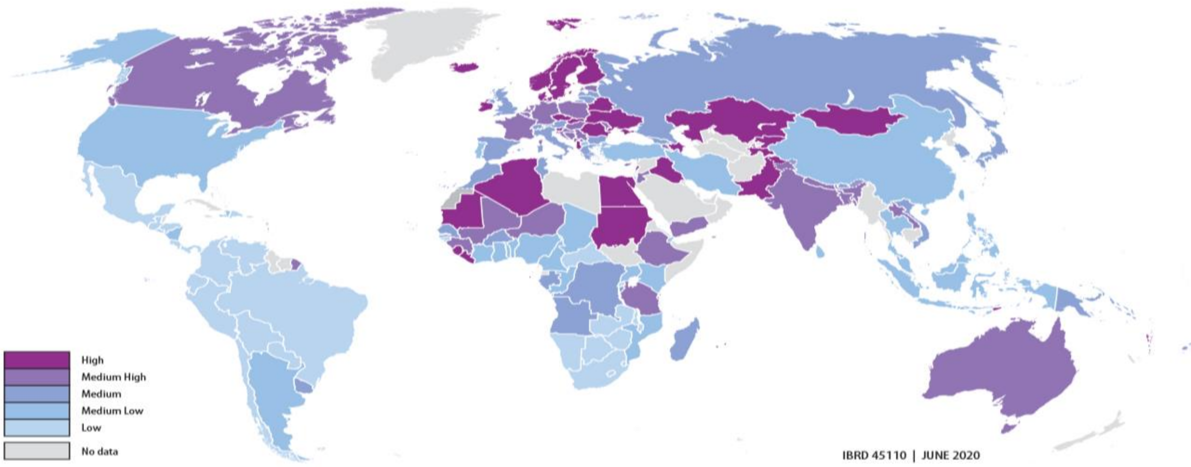


**Figure 2: Efficiency Results for Each Indicator (cont.)**

j. Income inequality




Source: Authors' illustration based on their calculation of efficiency estimates.

## Appendix A.1. Persistent and Time-Varying Inefficiency in Trade Openness

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AFG | 52.2 | 0.0419 | 0.0418 | -0.11 | DOM | 54.2 | 0.0418 | 0.0419 | 0.1 | KSV | 59.0 | 0.0418 | 0.0419 | 0.1 | PRY | 30.3 | 0.0418 | 0.0419 | 0.11 |
| AGO | 17.2 | 0.0418 | 0.0419 | 0.26 | DZA | 31.9 | 0.0418 | 0.0419 | 0.1 | KWT | 44.3 | 0.0419 | 0.0418 | 0.0 | QAT | 47.8 | 0.0419 | 0.0418 | -0.06 |
| ALB | 42.6 | 0.0419 | 0.0419 | 0.01 | ECU | 47.7 | 0.0419 | 0.0419 | 0.0 | LAO | 33.0 | 0.0419 | 0.0418 | -0.2 | ROM | 35.9 | 0.0418 | 0.0418 | -0.01 |
| ARE | 22.9 | 0.0419 | 0.0418 | -0.27 | EGY | 42.5 | 0.0418 | 0.0419 | 0.3 | LBN | 40.9 | 0.0418 | 0.0419 | 0.1 | RUS | 41.7 | 0.0418 | 0.0419 | 0.14 |
| ARG | 78.0 | 0.0418 | 0.0419 | 0.22 | ERI | 79.9 | 0.0417 | 0.0419 | 0.3 | LBR | 12.0 | 0.0417 | 0.0419 | 0.4 | RWA | 78.1 | 0.0419 | 0.0418 | -0.12 |
| ARM | 59.5 | 0.0418 | 0.0418 | 0.03 | ESP | 55.2 | 0.0419 | 0.0418 | -0.1 | LBY | 24.0 | 0.0418 | 0.0419 | 0.1 | SAU | 29.1 | 0.0419 | 0.0419 | 0.02 |
| ASM | 31.0 | 0.0418 | 0.0418 | -0.01 | EST | 20.4 | 0.0419 | 0.0418 | 0.0 | LCA | 58.1 | 0.0418 | 0.0419 | 0.2 | SDN | 70.1 | 0.0418 | 0.0420 | 0.54 |
| ATG | 57.0 | 0.0418 | 0.0419 | 0.11 | ETH | 52.6 | 0.0418 | 0.0419 | 0.1 | LKA | 48.6 | 0.0418 | 0.0419 | 0.3 | SEN | 32.4 | 0.0419 | 0.0418 | -0.03 |
| AUS | 76.7 | 0.0419 | 0.0419 | -0.02 | FIN | 46.6 | 0.0418 | 0.0419 | 0.0 | LSO | 21.9 | 0.0418 | 0.0419 | 0.2 | SGP | 9.7 | 0.0418 | 0.0419 | 0.11 |
| AUT | 43.5 | 0.0419 | 0.0418 | -0.03 | FJI | 25.6 | 0.0418 | 0.0419 | 0.0 | LTU | 21.3 | 0.0419 | 0.0418 | -0.1 | SLB | 26.4 | 0.0419 | 0.0418 | -0.15 |
| AZE | 37.6 | 0.0418 | 0.0419 | 0.34 | FRA | 55.3 | 0.0419 | 0.0418 | 0.0 | LUX | 15.9 | 0.0419 | 0.0418 | -0.1 | SLE | 44.9 | 0.0419 | 0.0418 | -0.30 |
| BDI | 70.9 | 0.0419 | 0.0419 | 0.01 | FSM | 45.3 | 0.0419 | 0.0419 | 0.0 | LVA | 30.0 | 0.0419 | 0.0418 | -0.1 | SLV | 45.8 | 0.0418 | 0.0419 | 0.03 |
| BEL | 19.5 | 0.0419 | 0.0418 | -0.05 | GAB | 39.7 | 0.0418 | 0.0419 | 0.1 | MAC | 50.5 | 0.0418 | 0.0419 | 0.1 | SRB | 43.0 | 0.0419 | 0.0418 | -0.12 |
| BEN | 45.8 | 0.0419 | 0.0418 | -0.28 | GBR | 55.5 | 0.0419 | 0.0419 | 0.0 | MAR | 28.0 | 0.0419 | 0.0418 | -0.1 | SUR | 33.6 | 0.0419 | 0.0419 | -0.12 |
| BFA | 63.4 | 0.0419 | 0.0418 | -0.28 | GEO | 29.9 | 0.0419 | 0.0418 | -0.1 | MDA | 23.3 | 0.0418 | 0.0419 | 0.1 | SVK | 20.2 | 0.0419 | 0.0418 | -0.07 |
| BGD | 51.0 | 0.0419 | 0.0418 | -0.12 | GHA | 26.8 | 0.0418 | 0.0418 | 0.1 | MDG | 25.5 | 0.0418 | 0.0418 | 0.0 | SVN | 26.4 | 0.0419 | 0.0418 | -0.07 |
| BGR | 22.0 | 0.0419 | 0.0418 | -0.12 | GMB | 43.1 | 0.0418 | 0.0418 | 0.1 | MDV | 24.5 | 0.0418 | 0.0418 | 0.1 | SWE | 38.3 | 0.0419 | 0.0419 | 0.02 |
| BHR | 29.8 | 0.0419 | 0.0418 | -0.09 | GNB | 63.9 | 0.0419 | 0.0418 | 0.0 | MEX | 38.0 | 0.0419 | 0.0418 | -0.1 | SWZ | 33.3 | 0.0418 | 0.0419 | 0.15 |
| BHS | 57.9 | 0.0418 | 0.0419 | 0.05 | GNQ | 25.2 | 0.0418 | 0.0419 | 0.3 | MHL | 43.6 | 0.0419 | 0.0418 | 0.0 | SYC | 25.6 | 0.0419 | 0.0419 | 0.01 |
| BIH | 33.7 | 0.0418 | 0.0419 | 0.17 | GRC | 64.3 | 0.0419 | 0.0418 | -0.1 | MKD | 39.0 | 0.0419 | 0.0418 | -0.1 | TCD | 29.8 | 0.0418 | 0.0419 | 0.09 |
| BLR | 17.7 | 0.0419 | 0.0419 | 0.09 | GRD | 75.3 | 0.0419 | 0.0418 | -0.2 | MLI | 46.9 | 0.0419 | 0.0418 | 0.0 | TGO | 22.5 | 0.0418 | 0.0418 | -0.04 |
| BLZ | 32.0 | 0.0419 | 0.0418 | -0.02 | GRL | 47.2 | 0.0418 | 0.0419 | 0.1 | MLT | 14.9 | 0.0419 | 0.0419 | -0.1 | THA | 13.9 | 0.0418 | 0.0419 | 0.05 |
| BMU | 101.2 | 0.0418 | 0.0419 | 0.08 | GTM | 45.3 | 0.0418 | 0.0419 | 0.1 | MMR | 336.3 | 0.0422 | 0.0410 | -2.8 | TJK | 36.0 | 0.0418 | 0.0419 | 0.24 |
| BOL | 37.0 | 0.0419 | 0.0418 | -0.11 | GUM | 76.1 | 0.0419 | 0.0419 | 0.0 | MNE | 32.2 | 0.0418 | 0.0419 | 0.2 | TKM | 24.8 | 0.0418 | 0.0419 | 0.02 |
| BRA | 93.1 | 0.0418 | 0.0419 | 0.07 | GUY | 18.7 | 0.0417 | 0.0419 | 0.3 | MNG | 24.7 | 0.0418 | 0.0419 | 0.1 | TMP | 24.2 | 0.0418 | 0.0419 | 0.30 |
| BRB | 65.1 | 0.0418 | 0.0419 | 0.05 | HKG | 9.2 | 0.0419 | 0.0418 | -0.1 | MNP | 52.7 | 0.0419 | 0.0418 | 0.0 | TON | 69.0 | 0.0418 | 0.0419 | 0.03 |
| BRN | 55.4 | 0.0419 | 0.0419 | 0.00 | HND | 18.4 | 0.0418 | 0.0419 | 0.1 | MOZ | 19.8 | 0.0419 | 0.0418 | -0.2 | TTO | 35.6 | 0.0418 | 0.0419 | 0.06 |
| BTN | 33.4 | 0.0419 | 0.0419 | 0.09 | HRV | 41.9 | 0.0418 | 0.0418 | 0.0 | MRT | 19.2 | 0.0418 | 0.0419 | 0.1 | TUN | 23.8 | 0.0419 | 0.0419 | -0.03 |
| BWA | 41.7 | 0.0419 | 0.0418 | -0.12 | HTI | 41.1 | 0.0419 | 0.0418 | -0.1 | MUS | 34.8 | 0.0418 | 0.0419 | 0.1 | TUR | 54.7 | 0.0419 | 0.0418 | -0.05 |
| CAF | 85.3 | 0.0419 | 0.0418 | -0.19 | HUN | 19.8 | 0.0419 | 0.0418 | -0.1 | MWI | 48.2 | 0.0419 | 0.0418 | -0.1 | TZA | 43.6 | 0.0419 | 0.0418 | -0.11 |
| CAN | 44.0 | 0.0418 | 0.0419 | 0.08 | IDN | 39.2 | 0.0418 | 0.0419 | 0.1 | MYS | 14.1 | 0.0418 | 0.0419 | 0.2 | UGA | 58.0 | 0.0419 | 0.0419 | -0.08 |
| CHE | 45.1 | 0.0419 | 0.0418 | -0.07 | IND | 29.0 | 0.0419 | 0.0419 | 0.0 | NAM | 25.9 | 0.0419 | 0.0419 | -0.1 | UKR | 19.4 | 0.0418 | 0.0419 | 0.05 |
| CHL | 39.5 | 0.0418 | 0.0419 | 0.09 | IRL | 19.7 | 0.0419 | 0.0418 | -0.2 | NER | 44.0 | 0.0419 | 0.0418 | -0.1 | URY | 73.1 | 0.0418 | 0.0419 | 0.13 |
| CHN | 27.5 | 0.0418 | 0.0419 | 0.24 | IRN | 51.5 | 0.0418 | 0.0419 | 0.1 | NGA | 41.4 | 0.0418 | 0.0420 | 0.3 | USA | 89.9 | 0.0419 | 0.0418 | -0.07 |
| CIV | 24.2 | 0.0418 | 0.0419 | 0.24 | IRQ | 28.4 | 0.0418 | 0.0419 | 0.3 | NIC | 24.8 | 0.0419 | 0.0418 | -0.2 | UZB | 41.7 | 0.0418 | 0.0419 | 0.19 |
| CMR | 45.3 | 0.0419 | 0.0419 | -0.03 | ISL | 50.0 | 0.0419 | 0.0418 | -0.1 | NLD | 21.8 | 0.0419 | 0.0418 | -0.1 | VCT | 68.1 | 0.0418 | 0.0419 | 0.08 |
| COG | 16.5 | 0.0418 | 0.0418 | -0.01 | ISR | 54.8 | 0.0418 | 0.0419 | 0.2 | NOR | 58.3 | 0.0418 | 0.0419 | 0.0 | VEN | 58.2 | 0.0418 | 0.0419 | 0.14 |
| COL | 73.6 | 0.0419 | 0.0419 | -0.01 | ITA | 60.4 | 0.0419 | 0.0418 | 0.0 | NPL | 63.7 | 0.0419 | 0.0418 | -0.1 | VIR | 38.3 | 0.0418 | 0.0418 | -0.03 |
| COM | 58.1 | 0.0419 | 0.0418 | -0.22 | JAM | 38.7 | 0.0418 | 0.0419 | 0.1 | NZL | 67.4 | 0.0418 | 0.0419 | 0.1 | VNM | 10.7 | 0.0419 | 0.0418 | -0.11 |
| CPV | 40.7 | 0.0418 | 0.0419 | 0.06 | JOR | 16.8 | 0.0418 | 0.0419 | 0.1 | OMN | 32.7 | 0.0419 | 0.0418 | -0.1 | VUT | 44.7 | 0.0418 | 0.0419 | 0.02 |
| CRI | 51.0 | 0.0418 | 0.0419 | 0.19 | JPN | 97.4 | 0.0419 | 0.0418 | -0.2 | PAK | 64.2 | 0.0418 | 0.0419 | 0.1 | WSM | 62.8 | 0.0419 | 0.0419 | 0.02 |
| CUB | 77.9 | 0.0419 | 0.0419 | 0.04 | KAZ | 36.6 | 0.0418 | 0.0419 | 0.3 | PAN | 21.7 | 0.0418 | 0.0419 | 0.1 | YEM | 33.0 | 0.0418 | 0.0419 | 0.27 |
| CYP | 41.9 | 0.0418 | 0.0418 | -0.02 | KEN | 38.7 | 0.0418 | 0.0419 | 0.1 | PER | 49.5 | 0.0419 | 0.0419 | 0.0 | ZAF | 40.1 | 0.0419 | 0.0418 | -0.08 |
| CZE | 25.4 | 0.0419 | 0.0418 | -0.12 | KGZ | 19.3 | 0.0419 | 0.0419 | -0.1 | PHL | 26.8 | 0.0418 | 0.0419 | 0.3 | ZAR | 21.7 | 0.0420 | 0.0418 | -0.34 |
| DEU | 34.5 | 0.0419 | 0.0418 | -0.08 | KHM | 14.5 | 0.0418 | 0.0418 | 0.1 | PLW | 51.7 | 0.0419 | 0.0418 | -0.1 | ZMB | 41.1 | 0.0419 | 0.0418 | -0.13 |
| DJI | 27.2 | 0.0419 | 0.0418 | -0.21 | KIR | 41.6 | 0.0418 | 0.0418 | 0.1 | POL | 30.1 | 0.0419 | 0.0418 | -0.1 | ZWE | 32.4 | 0.0419 | 0.0419 | 0.07 |
| DMA | 65.8 | 0.0419 | 0.0418 | -0.13 | KNA | 77.0 | 0.0418 | 0.0418 | -0.1 | PRI | 34.8 | 0.0418 | 0.0419 | 0.1 | | | | | |
| DNK | 39.3 | 0.0419 | 0.0418 | -0.05 | KOR | 28.6 | 0.0419 | 0.0418 | -0.1 | PRT | 50.0 | 0.0419 | 0.0418 | -0.1 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.2. Persistent and Time-Varying Inefficiency in Financial Depth

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AFG | 140.2 | 11.7 | 15.5 | 33.0 | DZA | 100.0 | 10.7 | 9.9 | -7.2 | KWT | 69.8 | 11.1 | 14.1 | 27.9 | ROM | 67.6 | 22.1 | 18.8 | -15.1 |
| AGO | 83.1 | 43.0 | 7.0 | -83.6 | ECU | 77.7 | 10.4 | 11.9 | 14.5 | LAO | 73.6 | 15.5 | 4.3 | -72.0 | RUS | 47.8 | 18.7 | 9.6 | -48.7 |
| ALB | 52.3 | 29.8 | 12.5 | -58.0 | EGY | 48.2 | 4.2 | 29.9 | 607.9 | LBN | 54.2 | 10.4 | 10.0 | -4.3 | RWA | 65.9 | 10.8 | 8.4 | -22.3 |
| ARE | 104.0 | 13.8 | 14.1 | 1.9 | ERI | 47.9 | 4.7 | 29.8 | 533.9 | LBR | 57.2 | 17.8 | 7.6 | -57.1 | SAU | 67.4 | 9.2 | 11.5 | 24.5 |
| ARG | 125.5 | 11.7 | 13.2 | 12.8 | ESP | 27.3 | 9.5 | 22.5 | 137.8 | LBY | 113.5 | 17.5 | 5.6 | -68.1 | SDN | 91.7 | 8.1 | 33.0 | 304.6 |
| ARM | 54.4 | 43.4 | 4.7 | -89.1 | EST | 23.7 | 12.3 | 22.6 | 83.7 | LCA | 32.5 | 11.9 | 16.4 | 38.6 | SEN | 48.6 | 12.0 | 9.1 | -24.3 |
| ATG | 46.3 | 9.5 | 19.9 | 108.9 | ETH | 32.8 | 7.5 | 19.6 | 160.4 | LKA | 58.8 | 6.9 | 12.9 | 86.9 | SGP | 94.6 | 9.5 | 10.2 | 7.5 |
| AUS | 25.2 | 8.9 | 13.8 | 54.9 | FIN | 40.0 | 10.3 | 12.8 | 23.5 | LSO | 79.6 | 20.4 | 6.7 | -67.0 | SLB | 29.8 | 16.7 | 7.9 | -52.9 |
| AUT | 40.3 | 7.5 | 18.0 | 138.2 | FJI | 18.7 | 9.8 | 15.3 | 56.8 | LTU | 51.3 | 7.0 | 18.9 | 169.5 | SLE | 126.3 | 20.4 | 20.0 | -1.7 |
| AZE | 75.1 | 22.1 | 6.2 | -71.8 | FRA | 50.5 | 9.9 | 14.5 | 46.3 | LUX | 61.2 | 10.8 | 16.2 | 49.3 | SLV | 50.8 | 7.4 | 14.1 | 89.4 |
| BDI | 52.2 | 10.5 | 14.3 | 36.8 | FSM | 60.6 | 8.7 | 13.5 | 56.0 | LVA | 34.8 | 5.6 | 24.0 | 330.3 | SRB | 42.6 | 15.4 | 13.7 | -10.9 |
| BEL | 80.7 | 6.9 | 16.6 | 141.2 | GAB | 125.4 | 8.4 | 8.5 | 1.3 | MAC | 116.5 | 12.7 | 9.1 | -27.9 | STP | 30.2 | 9.1 | 20.0 | 121.3 |
| BEN | 61.5 | 15.9 | 11.5 | -27.6 | GBR | 31.5 | 9.6 | 23.0 | 138.9 | MAR | 28.9 | 13.6 | 12.6 | -7.2 | SUR | 44.1 | 11.1 | 9.8 | -11.6 |
| BFA | 49.1 | 9.9 | 7.2 | -27.6 | GEO | 45.3 | 28.5 | 7.2 | -74.7 | MDA | 34.7 | 17.8 | 14.3 | -20.1 | SVK | 56.8 | 12.9 | 11.6 | -10.1 |
| BGD | 44.7 | 11.7 | 11.4 | -2.4 | GHA | 83.2 | 7.4 | 9.6 | 29.7 | MDG | 77.7 | 9.7 | 11.5 | 18.9 | SVN | 45.7 | 12.9 | 26.4 | 104.4 |
| BGR | 34.6 | 17.6 | 16.3 | -7.3 | GIN | 143.2 | 5.9 | 4.9 | -16.2 | MDV | 69.1 | 7.2 | 18.9 | 161.8 | SWE | 31.5 | 10.4 | 13.2 | 26.6 |
| BHR | 85.6 | 14.4 | 13.9 | -3.3 | GMB | 72.5 | 9.7 | 19.7 | 103.9 | MEX | 101.0 | 15.2 | 9.4 | -38.3 | SWZ | 54.2 | 10.4 | 13.9 | 33.4 |
| BHS | 46.1 | 9.1 | 22.0 | 141.3 | GNB | 124.6 | 59.2 | 4.6 | -92.2 | MKD | 40.1 | 22.1 | 9.6 | -56.4 | SYC | 107.5 | 6.5 | 13.7 | 109.4 |
| BIH | 33.8 | 6.2 | 15.8 | 155.2 | GNQ | 162.2 | 13.2 | 8.8 | -33.4 | MLI | 49.6 | 11.2 | 8.6 | -23.4 | TCD | 130.1 | 18.5 | 5.4 | -70.8 |
| BLR | 61.7 | 18.9 | 22.5 | 19.3 | GRC | 37.5 | 13.4 | 11.2 | -16.2 | MLT | 44.3 | 9.3 | 19.6 | 110.8 | TGO | 47.9 | 24.7 | 6.6 | -73.4 |
| BLZ | 28.9 | 8.9 | 18.2 | 105.0 | GRD | 38.1 | 10.8 | 20.2 | 87.3 | MMR | 128.4 | 10.1 | 3.6 | -64.2 | THA | 21.8 | 11.8 | 9.8 | -16.8 |
| BOL | 25.5 | 6.4 | 9.9 | 55.3 | GTM | 66.4 | 9.0 | 10.8 | 20.6 | MNE | 24.7 | 6.2 | 21.4 | 245.2 | TJK | 51.2 | 23.9 | 9.5 | -60.2 |
| BRA | 49.8 | 18.9 | 8.4 | -55.5 | GUY | 21.9 | 4.3 | 9.9 | 132.0 | MNG | 20.9 | 16.1 | 7.7 | -52.0 | TMP | 63.4 | 12.5 | 11.6 | -7.3 |
| BRB | 49.9 | 10.0 | 13.1 | 30.9 | HKG | 55.9 | 11.2 | 8.6 | -23.3 | MOZ | 40.8 | 21.3 | 6.3 | -70.4 | TON | 33.5 | 5.0 | 25.6 | 411.2 |
| BRN | 104.5 | 6.3 | 16.7 | 165.3 | HND | 31.4 | 12.4 | 12.1 | -2.4 | MRT | 35.9 | 7.2 | 14.1 | 96.6 | TTO | 66.9 | 5.9 | 19.6 | 229.7 |
| BTN | 22.8 | 23.0 | 9.4 | -59.2 | HRV | 41.4 | 11.0 | 14.1 | 28.2 | MUS | 37.9 | 9.0 | 11.7 | 29.9 | TUN | 28.3 | 9.1 | 11.7 | 27.6 |
| BWA | 65.6 | 12.8 | 11.4 | -11.1 | HTI | 88.0 | 11.0 | 8.3 | -23.9 | MWI | 89.9 | 36.4 | 10.0 | -72.7 | TUR | 68.4 | 25.2 | 6.2 | -75.2 |
| CAF | 64.0 | 14.1 | 6.3 | -55.4 | HUN | 47.8 | 10.5 | 23.8 | 126.2 | MYS | 36.3 | 7.7 | 12.9 | 67.0 | TZA | 82.8 | 13.9 | 12.1 | -13.4 |
| CAN | 20.3 | 7.0 | 21.2 | 202.7 | IDN | 69.1 | 10.2 | 9.3 | -8.7 | NAM | 26.3 | 7.0 | 15.3 | 119.7 | UGA | 74.8 | 14.9 | 11.5 | -22.4 |
| CHE | 46.2 | 8.6 | 13.4 | 56.0 | IND | 36.7 | 10.0 | 14.6 | 46.4 | NER | 64.8 | 34.2 | 8.1 | -76.4 | UKR | 27.6 | 31.4 | 13.0 | -58.5 |
| CHL | 25.8 | 10.8 | 12.2 | 13.2 | IRL | 47.7 | 6.9 | 37.6 | 445.5 | NGA | 91.7 | 12.8 | 26.6 | 108.1 | URY | 110.1 | 8.9 | 11.4 | 28.6 |
| CHN | 19.5 | 7.3 | 13.1 | 79.1 | IRN | 44.5 | 11.6 | 13.9 | 19.4 | NIC | 44.7 | 11.8 | 11.2 | -4.9 | USA | 24.8 | 7.5 | 14.7 | 95.9 |
| CIV | 86.5 | 19.1 | 8.9 | -53.6 | IRQ | 209.2 | 35.3 | 5.9 | -83.3 | NLD | 48.6 | 7.3 | 14.7 | 102.3 | VCT | 49.5 | 9.1 | 15.5 | 70.0 |
| CMR | 101.7 | 10.8 | 9.6 | -11.3 | ISL | 14.3 | 4.1 | 40.4 | 877.2 | NOR | 34.8 | 8.9 | 13.1 | 46.8 | VEN | 105.7 | 22.2 | 6.8 | -69.3 |
| COG | 156.1 | 34.5 | 3.1 | -90.9 | ISR | 62.6 | 6.3 | 16.9 | 166.9 | NPL | 23.3 | 20.6 | 9.1 | -55.7 | VNM | 19.8 | 14.4 | 13.2 | -8.5 |
| COL | 50.3 | 15.8 | 9.2 | -41.5 | ITA | 56.2 | 11.2 | 14.2 | 26.6 | NZL | 23.0 | 10.5 | 13.6 | 29.7 | VUT | 27.5 | 13.4 | 9.3 | -30.7 |
| COM | 65.9 | 19.4 | 6.2 | -67.9 | JAM | 82.3 | 13.9 | 12.7 | -8.3 | OMN | 59.4 | 11.6 | 11.1 | -4.4 | WSM | 32.1 | 19.5 | 10.1 | -48.4 |
| CPV | 33.4 | 12.6 | 13.0 | 3.0 | JOR | 24.3 | 6.1 | 20.6 | 237.8 | PAK | 69.5 | 4.9 | 29.9 | 508.9 | YEM | 138.5 | 6.9 | 21.7 | 213.7 |
| CRI | 73.6 | 12.2 | 11.1 | -9.0 | JPN | 35.9 | 7.2 | 14.9 | 105.8 | PAN | 37.9 | 7.3 | 14.8 | 102.3 | ZAF | 18.2 | 8.5 | 14.6 | 72.0 |
| CYP | 22.1 | 13.9 | 11.3 | -19.3 | KAZ | 32.9 | 9.1 | 27.7 | 204.2 | PER | 67.4 | 11.8 | 10.6 | -10.1 | ZAR | 148.2 | 55.8 | 6.5 | -88.4 |
| CZE | 64.5 | 16.5 | 11.9 | -28.2 | KEN | 46.6 | 8.5 | 9.6 | 13.0 | PHL | 61.6 | 8.8 | 10.0 | 14.2 | ZMB | 77.0 | 22.3 | 7.3 | -67.4 |
| DEU | 55.7 | 6.1 | 19.9 | 225.5 | KGZ | 66.7 | 16.7 | 6.2 | -62.5 | PNG | 64.9 | 14.5 | 9.3 | -35.9 | | | | | |
| DJI | 32.6 | 15.0 | 10.8 | -27.7 | KHM | 41.0 | 42.9 | 4.3 | -90.0 | POL | 63.5 | 18.4 | 11.1 | -39.9 | | | | | |
| DMA | 43.1 | 8.9 | 14.9 | 67.2 | KNA | 52.4 | 8.6 | 16.3 | 88.3 | PRT | 26.6 | 9.8 | 18.6 | 89.9 | | | | | |
| DNK | 28.3 | 9.8 | 16.6 | 68.8 | KOR | 31.9 | 9.7 | 15.8 | 63.4 | PRY | 42.9 | 29.1 | 5.2 | -82.0 | | | | | |
| DOM | 91.5 | 8.0 | 11.4 | 42.7 | KSV | 46.5 | 10.1 | 13.6 | 34.6 | QAT | 109.6 | 9.7 | 11.2 | 15.1 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.3. Persistent and Time-Varying Inefficiency in Fiscal Balance

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AFG** | 15.2 | 1.9 | 2.1 | 8.8 | **ECU** | 15.8 | 1.9 | 2.6 | 38.0 | **LBN** | 14.9 | 2.1 | 1.8 | -17.3 | **SAU** | 8.5 | 1.2 | 4.4 | 259.1 |
| **AGO** | 12.9 | 1.3 | 3.4 | 154.5 | **EGY** | 19.1 | 2.1 | 2.2 | 0.1 | **LBR** | 17.5 | 1.8 | 1.8 | -2.2 | **SDN** | 16.4 | 2.2 | 1.8 | -17.9 |
| **ALB** | 16.8 | 2.0 | 2.1 | 2.5 | **ERI** | 28.2 | 3.9 | 2.1 | -45.9 | **LBY** | 21.9 | 1.8 | 15.2 | 744.8 | **SEN** | 18.3 | 1.7 | 1.9 | 11.0 |
| **ARE** | 8.1 | 1.3 | 2.6 | 101.4 | **ESP** | 19.4 | 1.5 | 1.9 | 24.9 | **LCA** | 17.4 | 2.6 | 1.7 | -36.3 | **SGP** | 12.0 | 1.9 | 2.2 | 15.8 |
| **ARG** | 16.4 | 1.7 | 2.4 | 37.3 | **EST** | 15.5 | 2.0 | 1.8 | -8.1 | **LKA** | 16.7 | 2.2 | 1.9 | -17.0 | **SLB** | 12.4 | 2.8 | 1.9 | -31.5 |
| **ARM** | 17.6 | 2.1 | 1.7 | -17.3 | **ETH** | 16.2 | 2.4 | 1.9 | -20.4 | **LSO** | 12.9 | 1.7 | 2.0 | 19.6 | **SLE** | 14.5 | 2.0 | 2.3 | 13.4 |
| **ATG** | 19.2 | 4.2 | 1.6 | -62.6 | **FIN** | 17.2 | 1.9 | 2.4 | 27.2 | **LTU** | 18.6 | 1.9 | 1.5 | -16.8 | **SLV** | 16.5 | 2.1 | 1.9 | -13.0 |
| **AUS** | 19.1 | 1.8 | 2.0 | 9.1 | **FJI** | 14.3 | 2.4 | 2.1 | -11.7 | **LUX** | 16.2 | 2.4 | 1.8 | -24.1 | **SMR** | 17.6 | 2.4 | 1.6 | -34.9 |
| **AUT** | 17.1 | 2.2 | 1.9 | -10.7 | **FRA** | 18.1 | 2.0 | 1.9 | -7.0 | **LVA** | 17.9 | 2.1 | 1.8 | -13.3 | **SRB** | 17.5 | 1.7 | 2.1 | 28.2 |
| **AZE** | 9.7 | 2.7 | 2.3 | -15.9 | **FSM** | 14.8 | 3.2 | 1.0 | -69.5 | **MAR** | 16.5 | 2.5 | 2.0 | -17.9 | **STP** | 19.5 | 2.7 | 1.8 | -33.6 |
| **BDI** | 16.1 | 2.1 | 2.0 | -3.2 | **GAB** | 11.0 | 1.6 | 2.2 | 41.3 | **MDA** | 16.0 | 1.7 | 1.9 | 12.3 | **SUR** | 17.0 | 2.0 | 2.9 | 47.8 |
| **BEL** | 15.7 | 2.1 | 2.0 | -3.1 | **GBR** | 20.0 | 1.9 | 1.9 | -2.1 | **MDG** | 16.2 | 2.1 | 1.9 | -5.8 | **SVK** | 18.7 | 2.1 | 1.7 | -17.2 |
| **BEN** | 15.6 | 2.4 | 2.1 | -14.4 | **GEO** | 15.9 | 1.7 | 2.0 | 15.6 | **MDV** | 18.6 | 2.2 | 2.2 | 3.0 | **SVN** | 19.0 | 1.8 | 2.0 | 6.0 |
| **BFA** | 16.3 | 2.8 | 1.9 | -34.3 | **GHA** | 19.6 | 1.7 | 2.1 | 25.6 | **MEX** | 16.1 | 1.9 | 2.1 | 9.4 | **SWE** | 16.4 | 1.9 | 2.2 | 16.3 |
| **BGD** | 15.1 | 2.2 | 1.8 | -16.6 | **GIN** | 16.8 | 1.8 | 2.1 | 15.0 | **MHL** | 16.2 | 8.6 | 1.6 | -80.8 | **SWZ** | 14.4 | 2.3 | 1.9 | -16.6 |
| **BGR** | 15.7 | 1.8 | 2.4 | 37.7 | **GMB** | 15.5 | 1.9 | 2.5 | 33.0 | **MKD** | 17.1 | 1.9 | 2.2 | 15.7 | **SYC** | 10.7 | 2.0 | 1.8 | -9.7 |
| **BHR** | 16.0 | 1.6 | 2.4 | 44.6 | **GNB** | 15.6 | 2.3 | 2.0 | -13.2 | **MLI** | 15.2 | 2.6 | 2.3 | -14.5 | **TCD** | 16.2 | 2.1 | 2.3 | 12.2 |
| **BHS** | 18.4 | 2.1 | 2.1 | 0.9 | **GNQ** | 12.1 | 0.9 | 3.7 | 299.2 | **MLT** | 15.3 | 2.1 | 1.8 | -12.0 | **TGO** | 17.3 | 2.1 | 2.1 | 1.9 |
| **BIH** | 17.1 | 1.8 | 2.0 | 12.9 | **GRC** | 19.1 | 2.0 | 1.6 | -21.3 | **MMR** | 16.4 | 2.2 | 1.5 | -30.6 | **THA** | 14.8 | 1.9 | 2.0 | 2.1 |
| **BLR** | 14.2 | 2.1 | 1.8 | -13.4 | **GRD** | 17.9 | 1.7 | 1.8 | 6.2 | **MNE** | 16.6 | 1.2 | 1.7 | 48.9 | **TJK** | 16.8 | 2.3 | 1.6 | -29.3 |
| **BLZ** | 14.5 | 2.1 | 2.3 | 12.6 | **GTM** | 16.2 | 2.1 | 1.8 | -13.9 | **MNG** | 18.9 | 1.6 | 3.1 | 93.5 | **TON** | 13.4 | 1.9 | 1.9 | -3.8 |
| **BOL** | 13.9 | 2.4 | 2.6 | 6.4 | **GUY** | 18.6 | 2.7 | 2.0 | -25.8 | **MOZ** | 18.1 | 2.0 | 3.0 | 55.4 | **TTO** | 13.0 | 1.6 | 2.5 | 58.3 |
| **BRA** | 14.0 | 2.0 | 2.2 | 14.5 | **HKG** | 14.9 | 2.3 | 1.6 | -30.9 | **MRT** | 16.4 | 2.5 | 2.2 | -9.3 | **TUN** | 16.6 | 2.1 | 2.0 | -5.7 |
| **BRB** | 17.3 | 2.0 | 2.0 | -1.0 | **HND** | 18.9 | 1.9 | 1.9 | 0.7 | **MUS** | 15.2 | 2.3 | 2.0 | -14.7 | **TUR** | 14.3 | 1.8 | 1.9 | 8.1 |
| **BRN** | 5.4 | 1.7 | 3.4 | 96.9 | **HRV** | 18.7 | 2.2 | 1.9 | -10.6 | **MWI** | 14.5 | 1.9 | 1.9 | 0.6 | **TUV** | 26.2 | 3.1 | 0.4 | -86.9 |
| **BTN** | 14.6 | 3.4 | 2.1 | -38.8 | **HTI** | 17.6 | 2.1 | 2.3 | 11.5 | **MYS** | 18.6 | 2.1 | 1.7 | -18.0 | **TZA** | 17.3 | 2.2 | 1.8 | -19.2 |
| **BWA** | 26.6 | 1.7 | 1.7 | 1.5 | **HUN** | 17.0 | 2.7 | 1.6 | -40.4 | **NAM** | 16.6 | 2.0 | 2.3 | 16.1 | **UGA** | 15.9 | 1.9 | 1.9 | 4.6 |
| **CAF** | 15.3 | 3.0 | 1.5 | -48.2 | **IDN** | 14.6 | 1.9 | 2.0 | 8.1 | **NER** | 14.2 | 2.6 | 3.5 | 32.8 | **UKR** | 17.4 | 2.1 | 1.8 | -15.2 |
| **CAN** | 17.9 | 1.8 | 1.8 | 1.8 | **IND** | 16.9 | 2.1 | 1.8 | -12.2 | **NGA** | 13.8 | 1.5 | 2.2 | 45.0 | **URY** | 16.0 | 1.9 | 2.2 | 17.0 |
| **CHE** | 16.6 | 2.3 | 2.0 | -12.7 | **IRL** | 23.3 | 1.3 | 1.4 | 4.1 | **NIC** | 15.4 | 2.1 | 2.0 | -6.1 | **USA** | 20.5 | 1.8 | 1.7 | -7.8 |
| **CHL** | 14.8 | 1.8 | 2.3 | 31.5 | **IRN** | 14.5 | 1.8 | 2.2 | 19.7 | **NLD** | 17.1 | 1.9 | 1.9 | 2.3 | **UZB** | 11.5 | 2.5 | 2.1 | -18.5 |
| **CHN** | 14.9 | 2.3 | 1.9 | -16.4 | **IRQ** | 15.6 | 1.7 | 2.8 | 63.0 | **NOR** | 8.3 | 1.8 | 2.4 | 30.1 | **VCT** | 16.9 | 2.3 | 1.9 | -17.1 |
| **CIV** | 15.7 | 2.1 | 2.0 | -5.0 | **ISL** | 17.7 | 1.5 | 1.4 | -1.6 | **NPL** | 14.3 | 2.1 | 1.7 | -19.4 | **VEN** | 21.8 | 1.0 | 3.1 | 198.0 |
| **CMR** | 12.9 | 1.9 | 3.0 | 62.2 | **ISR** | 15.5 | 2.0 | 2.0 | 3.0 | **NZL** | 17.4 | 1.6 | 1.8 | 17.1 | **VNM** | 16.6 | 1.9 | 2.2 | 14.3 |
| **COG** | 7.2 | 1.3 | 5.7 | 353.5 | **ITA** | 15.3 | 2.3 | 1.8 | -21.0 | **OMN** | 11.6 | 1.5 | 3.3 | 117.6 | **VUT** | 16.0 | 1.9 | 1.7 | -9.0 |
| **COL** | 15.3 | 2.0 | 1.9 | -3.9 | **JAM** | 10.4 | 1.7 | 1.7 | -0.8 | **PAK** | 16.2 | 1.9 | 1.7 | -11.5 | **YEM** | 16.7 | 2.0 | 1.6 | -20.5 |
| **COM** | 11.8 | 2.4 | 2.2 | -7.4 | **JOR** | 18.5 | 2.2 | 1.5 | -31.6 | **PAN** | 15.8 | 2.2 | 2.3 | 3.4 | **ZAF** | 15.7 | 1.8 | 2.0 | 7.7 |
| **CPV** | 19.9 | 2.2 | 2.0 | -6.5 | **JPN** | 21.7 | 2.1 | 1.9 | -8.7 | **PER** | 14.0 | 2.3 | 2.1 | -9.2 | **ZAR** | 12.9 | 2.1 | 1.8 | -15.2 |
| **CRI** | 17.2 | 1.9 | 2.3 | 21.7 | **KAZ** | 13.7 | 1.9 | 2.1 | 13.8 | **PHL** | 12.6 | 2.0 | 1.8 | -11.7 | **ZMB** | 15.3 | 2.3 | 2.5 | 10.6 |
| **CYP** | 16.6 | 2.1 | 1.6 | -23.5 | **KEN** | 17.0 | 1.9 | 2.3 | 21.7 | **PNG** | 15.0 | 1.7 | 2.9 | 65.9 | **ZWE** | 16.0 | 2.7 | 1.9 | -31.4 |
| **CZE** | 17.9 | 2.3 | 1.8 | -22.9 | **KGZ** | 17.5 | 2.2 | 1.9 | -14.2 | **POL** | 17.6 | 2.1 | 1.8 | -14.3 | | | | | |
| **DEU** | 15.3 | 2.4 | 1.8 | -27.1 | **KHM** | 16.4 | 2.0 | 1.8 | -8.5 | **PRT** | 19.2 | 2.4 | 1.9 | -20.4 | | | | | |
| **DJI** | 17.3 | 1.7 | 3.7 | 112.5 | **KIR** | 23.4 | 3.5 | 0.5 | -85.2 | **PRY** | 14.9 | 2.0 | 2.0 | 0.3 | | | | | |
| **DMA** | 15.7 | 1.6 | 2.4 | 47.9 | **KNA** | 11.1 | 2.6 | 1.3 | -51.3 | **QAT** | 6.6 | 2.2 | 1.2 | -45.7 | | | | | |
| **DNK** | 15.7 | 1.6 | 1.8 | 12.5 | **KOR** | 14.9 | 2.0 | 2.0 | 0.8 | **ROM** | 17.9 | 1.8 | 1.7 | -8.5 | | | | | |
| **DOM** | 16.3 | 2.0 | 1.8 | -5.7 | **KWT** | 0.0 | 1.5 | 1.9 | 26.1 | **RUS** | 14.8 | 1.4 | 2.2 | 54.2 | | | | | |
| **DZA** | 14.6 | 1.1 | 3.6 | 224.0 | **LAO** | 17.8 | 2.4 | 2.1 | -12.4 | **RWA** | 14.8 | 1.9 | 2.2 | 16.4 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.4. Persistent and Time-Varying Inefficiency in Measles Immunization

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADO | 22.5 | 5.1 | 6.0 | 17.7 | DOM | 28.5 | 6.8 | 4.2 | -38.4 | LAO | 51.8 | 28.0 | 0.9 | -97.0 | RUS | 8.2 | 4.1 | 6.2 | 52.3 |
| AFG | 47.7 | 9.2 | 3.7 | -60.0 | DZA | 13.4 | 9.2 | 4.7 | -49.1 | LBN | 42.9 | 15.3 | 4.4 | -71.5 | RWA | 10.9 | 6.5 | 4.6 | -29.4 |
| AGO | 29.1 | 38.9 | 2.8 | -92.7 | ECU | 13.8 | 5.1 | 12.4 | 143.6 | LBR | 32.3 | 8.7 | 18.1 | 107.4 | SAU | 13.5 | 4.4 | 5.5 | 24.1 |
| ALB | 10.0 | 4.3 | 5.9 | 36.2 | EGY | 12.0 | 3.4 | 7.1 | 109.1 | LBY | 8.9 | 4.5 | 7.1 | 57.3 | SDN | 21.4 | 13.1 | 3.9 | -69.8 |
| ARE | 27.1 | 4.5 | 5.6 | 25.1 | ERI | 3.1 | 5.1 | 5.3 | 3.3 | LCA | 16.4 | 5.2 | 4.7 | -10.4 | SEN | 24.5 | 8.2 | 6.4 | -22.0 |
| ARG | 12.2 | 3.5 | 6.2 | 79.3 | ESP | 20.6 | 4.2 | 6.3 | 50.5 | LKA | 11.5 | 4.0 | 5.7 | 41.4 | SGP | 33.6 | 4.0 | 6.3 | 57.0 |
| ARM | 11.9 | 4.5 | 5.6 | 24.8 | EST | 13.8 | 3.7 | 7.1 | 91.5 | LSO | 18.2 | 5.9 | 3.7 | -38.3 | SLB | 10.7 | 5.5 | 3.9 | -28.8 |
| ATG | 14.7 | 4.1 | 6.1 | 47.3 | ETH | 55.8 | 26.6 | 1.6 | -94.0 | LTU | 14.7 | 3.6 | 7.3 | 102.2 | SLE | 27.5 | 7.1 | 4.7 | -33.6 |
| AUS | 16.3 | 4.2 | 6.4 | 52.5 | FIN | 16.5 | 4.3 | 6.1 | 41.4 | LUX | 25.8 | 4.9 | 5.1 | 4.8 | SLV | 17.1 | 3.0 | 6.0 | 96.7 |
| AUT | 44.8 | 5.7 | 7.0 | 22.2 | FJI | 12.1 | 5.7 | 5.5 | -2.9 | LVA | 14.2 | 3.2 | 6.0 | 87.2 | SMR | 47.8 | 1.7 | 26.3 | 1491.9 |
| AZE | 25.1 | 17.1 | 2.2 | -87.4 | FRA | 30.5 | 5.3 | 5.5 | 3.7 | MAR | 9.5 | 4.3 | 5.2 | 21.4 | SRB | 18.5 | 3.1 | 9.7 | 209.9 |
| BDI | 12.9 | 6.3 | 4.5 | -28.5 | FSM | 18.5 | 2.6 | 4.7 | 83.2 | MDA | 13.2 | 3.3 | 7.8 | 133.7 | STP | 13.3 | 4.8 | 5.0 | 4.8 |
| BEL | 27.8 | 7.2 | 5.0 | -30.2 | GAB | 49.8 | 12.3 | 8.4 | -31.3 | MDG | 38.0 | 2.3 | 8.8 | 276.4 | SUR | 15.8 | 2.8 | 6.4 | 126.2 |
| BEN | 42.4 | 8.8 | 9.5 | 8.5 | GBR | 33.2 | 7.7 | 4.0 | -47.3 | MDV | 18.8 | 6.1 | 4.9 | -20.0 | SVK | 16.4 | 4.3 | 6.6 | 53.1 |
| BFA | 12.9 | 6.4 | 6.6 | 2.9 | GEO | 12.5 | 5.1 | 6.6 | 30.5 | MEX | 16.4 | 4.2 | 5.3 | 27.2 | SVN | 19.9 | 4.6 | 6.6 | 41.8 |
| BGD | 20.8 | 4.6 | 5.9 | 28.5 | GHA | 16.1 | 7.5 | 4.8 | -36.2 | MHL | 23.8 | 4.6 | 10.5 | 127.6 | SWE | 18.3 | 4.5 | 5.8 | 29.1 |
| BGR | 13.8 | 4.1 | 7.2 | 76.0 | GIN | 57.1 | 9.5 | 11.0 | 16.0 | MKD | 13.4 | 4.3 | 7.4 | 70.9 | SWZ | 18.0 | 3.3 | 8.0 | 145.2 |
| BHR | 22.7 | 4.2 | 5.9 | 40.0 | GMB | 10.4 | 4.4 | 4.5 | 2.4 | MLI | 29.0 | 4.4 | 3.3 | -26.8 | SYC | 13.9 | 4.1 | 5.4 | 33.5 |
| BHS | 20.8 | 7.6 | 5.6 | -25.6 | GNB | 34.0 | 2.6 | 7.4 | 178.8 | MLT | 34.4 | 4.5 | 2.4 | -46.1 | TCD | 82.9 | 33.3 | 1.4 | -95.8 |
| BIH | 17.3 | 3.4 | 7.0 | 107.8 | GNQ | 77.8 | 2.0 | 14.0 | 616.7 | MMR | 17.5 | 4.2 | 5.6 | 35.2 | TGO | 35.7 | 5.1 | 2.2 | -56.8 |
| BLR | 8.0 | 3.9 | 6.0 | 51.8 | GRC | 17.7 | 5.2 | 6.7 | 29.0 | MNE | 18.7 | 4.5 | 6.0 | 34.9 | THA | 13.3 | 5.0 | 5.3 | 6.3 |
| BLZ | 6.1 | 4.8 | 6.9 | 43.2 | GRD | 15.6 | 3.4 | 7.2 | 112.1 | MNG | 0.0 | 4.2 | 5.6 | 32.3 | TJK | 11.5 | 6.8 | 3.3 | -51.7 |
| BOL | 10.3 | 5.4 | 4.4 | -18.0 | GTM | 21.1 | 3.0 | 24.1 | 702.6 | MOZ | 18.8 | 4.8 | 4.0 | -16.4 | TKM | 4.3 | 4.2 | 5.8 | 39.8 |
| BRA | 11.9 | 4.1 | 6.4 | 55.8 | GUY | 1.9 | 5.7 | 4.4 | -22.9 | MRT | 32.8 | 6.9 | 1.6 | -76.8 | TMP | 37.5 | 7.6 | 3.2 | -57.2 |
| BRB | 28.2 | 3.3 | 3.8 | 13.1 | HND | 11.1 | 3.8 | 9.8 | 155.4 | MUS | 15.5 | 4.4 | 6.2 | 41.3 | TON | 41.1 | 1.9 | 9.1 | 389.3 |
| BRN | 18.9 | 4.0 | 5.6 | 41.0 | HRV | 17.2 | 4.0 | 6.7 | 66.2 | MWI | 16.0 | 7.4 | 7.6 | 2.9 | TTO | 22.4 | 3.6 | 4.3 | 21.3 |
| BTN | 5.8 | 4.6 | 5.0 | 7.2 | HTI | 54.3 | 7.1 | 15.4 | 118.3 | MYS | 17.5 | 3.9 | 6.5 | 64.3 | TUN | 11.0 | 4.4 | 5.4 | 22.3 |
| BWA | 8.0 | 5.1 | 5.3 | 2.3 | HUN | 15.9 | 4.3 | 6.0 | 39.6 | NAM | 29.4 | 5.0 | 2.7 | -46.1 | TUR | 16.8 | 6.6 | 7.1 | 7.9 |
| CAF | 62.1 | 1.4 | 8.2 | 480.5 | IDN | 33.1 | 5.3 | 7.1 | 33.8 | NER | 39.4 | 24.6 | 2.8 | -88.7 | TUV | 19.8 | 27.1 | 3.3 | -88.0 |
| CAN | 16.1 | 4.5 | 5.8 | 27.4 | IND | 34.4 | 10.7 | 3.5 | -66.9 | NGA | 77.9 | 15.2 | 5.3 | -65.4 | TZA | 8.0 | 5.0 | 3.8 | -23.9 |
| CHE | 32.9 | 6.3 | 5.0 | -19.9 | IRL | 28.5 | 6.7 | 4.6 | -30.6 | NIC | 5.0 | 5.1 | 5.6 | 9.7 | UGA | 31.4 | 9.6 | 3.4 | -64.1 |
| CHL | 17.8 | 5.0 | 5.1 | 1.2 | IRN | 11.3 | 5.8 | 5.5 | -5.7 | NLD | 27.0 | 4.3 | 5.9 | 36.3 | UKR | 28.0 | 1.6 | 7.5 | 385.1 |
| CHN | 13.0 | 9.3 | 5.1 | -45.6 | IRQ | 45.1 | 4.1 | 18.7 | 358.3 | NOR | 23.2 | 5.4 | 5.4 | -1.0 | URY | 13.8 | 4.4 | 5.3 | 19.9 |
| CIV | 42.6 | 1.3 | 10.3 | 688.7 | ISL | 14.6 | 5.2 | 7.3 | 41.6 | NPL | 21.5 | 11.2 | 4.3 | -61.5 | USA | 25.7 | 4.2 | 6.3 | 49.8 |
| CMR | 29.3 | 10.6 | 4.5 | -57.8 | ISR | 23.6 | 5.2 | 6.1 | 15.5 | NZL | 25.3 | 7.4 | 3.9 | -47.6 | UZB | 6.6 | 3.8 | 5.5 | 41.9 |
| COG | 38.7 | 19.4 | 2.1 | -89.0 | ITA | 31.4 | 5.4 | 7.9 | 44.9 | OMN | 11.1 | 4.2 | 5.7 | 35.2 | VCT | 12.9 | 4.6 | 5.5 | 19.6 |
| COL | 17.1 | 3.2 | 6.4 | 97.5 | JAM | 25.2 | 6.4 | 4.1 | -36.6 | PAK | 48.7 | 2.1 | 8.2 | 285.9 | VEN | 27.4 | 10.4 | 4.1 | -60.7 |
| COM | 33.4 | 10.1 | 3.6 | -64.3 | JOR | 10.9 | 4.9 | 5.4 | 11.5 | PAN | 14.0 | 3.2 | 9.1 | 182.0 | VNM | 12.7 | 3.9 | 4.9 | 27.4 |
| CPV | 12.0 | 4.7 | 6.7 | 42.1 | JPN | 26.9 | 3.8 | 4.9 | 29.6 | PER | 16.2 | 12.9 | 6.5 | -49.8 | VUT | 64.9 | 4.6 | 6.1 | 32.6 |
| CRI | 24.0 | 4.0 | 3.4 | -16.0 | KAZ | 6.2 | 3.9 | 6.1 | 54.9 | PHL | 23.0 | 3.1 | 5.8 | 90.4 | WSM | 47.6 | 11.5 | 1.0 | -91.6 |
| CUB | 11.2 | 4.3 | 5.6 | 29.9 | KEN | 23.4 | 14.1 | 7.7 | -45.1 | PLW | 26.8 | 1.6 | 5.9 | 272.0 | YEM | 34.5 | 3.2 | 4.9 | 52.5 |
| CYP | 30.0 | 4.6 | 6.4 | 39.2 | KGZ | 2.9 | 3.8 | 7.0 | 82.9 | PNG | 50.4 | 3.8 | 3.7 | -1.1 | ZAF | 45.2 | 9.5314 | 5.9237 | -37.85 |
| CZE | 18.8 | 4.6 | 5.4 | 17.2 | KHM | 14.0 | 9.1 | 3.7 | -59.7 | POL | 15.4 | 4.2 | 6.0 | 42.4 | ZAR | 32.9 | 12.3475 | 2.8719 | -76.74 |
| DEU | 24.1 | 4.7 | 5.7 | 20.9 | KIR | 21.8 | 3.9 | 3.1 | -20.2 | PRT | 20.1 | 5.6 | 5.1 | -10.4 | ZMB | 16.0 | 4.8462 | 6.8553 | 41.46 |
| DJI | 27.1 | 13.7 | 9.9 | -28.1 | KNA | 15.4 | 3.9 | 8.6 | 121.7 | PRY | 13.7 | 4.6 | 6.4 | 39.1 | ZWE | 25.4 | 15.1212 | 2.1271 | -85.93 |
| DMA | 11.4 | 4.0 | 7.5 | 86.8 | KOR | 22.4 | 3.6 | 5.2 | 43.3 | QAT | 23.5 | 4.9 | 5.3 | 8.1 | | | | | |
| DNK | 31.9 | 2.7 | 5.3 | 96.5 | KWT | 20.8 | 4.1 | 8.8 | 113.8 | ROM | 16.6 | 3.6 | 9.2 | 157.3 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.5. Persistent and Time-Varying Inefficiency in Sanitation Facilities

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ADO** | 29.9 | 65.3 | 5.3 | -91.9 | **EST** | 28.8 | 18.9 | 26.2 | 38.4 | **MYS** | 18.6 | 19.5 | 25.9 | 32.9 |
| **ALB** | 17.0 | 23.1 | 23.5 | 1.5 | **FIN** | 12.6 | 18.7 | 26.4 | 41.3 | **NER** | 209.6 | 38.4 | 8.5 | -77.9 |
| **ARE** | 18.2 | 13.3 | 27.8 | 108.9 | **FRA** | 43.2 | 20.6 | 24.4 | 18.4 | **NLD** | 32.8 | 18.7 | 25.8 | 38.4 |
| **ARG** | 123.9 | 17.3 | 28.0 | 61.6 | **GBR** | 39.2 | 18.5 | 26.5 | 42.8 | **NOR** | 29.3 | 19.3 | 25.4 | 32.0 |
| **AUS** | 37.4 | 23.1 | 22.1 | -4.5 | **GRC** | 36.9 | 19.6 | 25.7 | 31.2 | **NZL** | 20.4 | 18.9 | 26.5 | 40.6 |
| **AUT** | 17.3 | 18.9 | 25.9 | 37.1 | **GRL** | 4.7 | 19.0 | 25.9 | 36.4 | **PER** | 124.6 | 39.2 | 8.2 | -79.1 |
| **BEL** | 39.2 | 31.3 | 14.5 | -53.7 | **HKG** | 198.3 | 18.6 | 28.1 | 51.6 | **PLW** | 131.2 | 25.3 | 25.5 | 0.8 |
| **BGR** | 29.7 | 4.6 | 44.7 | 874.3 | **HRV** | 38.3 | 18.5 | 26.2 | 42.0 | **POL** | 38.0 | 20.7 | 24.2 | 16.7 |
| **BIH** | 111.5 | 7.4 | 29.4 | 294.5 | **HUN** | 35.6 | 35.4 | 15.3 | -56.9 | **PRI** | 117.5 | 19.3 | 26.1 | 35.3 |
| **BLR** | 9.5 | 14.5 | 31.8 | 119.4 | **IRL** | 50.0 | 35.8 | 9.7 | -72.8 | **PRT** | 55.9 | 19.9 | 24.3 | 22.2 |
| **BOL** | 129.4 | 26.1 | 19.4 | -25.7 | **IRQ** | 117.2 | 30.8 | 15.6 | -49.5 | **QAT** | 22.0 | 19.8 | 25.8 | 30.3 |
| **BRA** | 124.3 | 31.3 | 14.2 | -54.5 | **ISL** | 43.2 | 17.7 | 26.9 | 51.5 | **ROM** | 64.9 | 31.0 | 15.6 | -49.8 |
| **CAN** | 34.9 | 20.5 | 25.5 | 24.5 | **ISR** | 26.9 | 23.4 | 21.5 | -8.0 | **SAU** | 26.8 | 30.4 | 19.8 | -35.0 |
| **CHE** | 17.6 | 19.4 | 25.6 | 32.1 | **ITA** | 39.7 | 19.5 | 25.4 | 30.2 | **SEN** | 116.8 | 27.1 | 19.1 | -29.5 |
| **CHL** | 39.8 | 49.2 | 0.0 | -100.0 | **JOR** | 10.4 | 17.2 | 29.0 | 69.2 | **SGP** | 24.0 | 16.9 | 28.3 | 67.3 |
| **CHN** | 104.5 | 40.5 | 6.5 | -84.1 | **JPN** | 48.5 | 20.6 | 24.8 | 20.2 | **SMR** | 45.3 | 18.8 | 25.8 | 37.5 |
| **COL** | 162.5 | 24.4 | 22.1 | -9.6 | **KOR** | 34.0 | 22.0 | 23.5 | 6.9 | **SRB** | 108.9 | 12.0 | 34.6 | 188.2 |
| **CUB** | 98.1 | 16.5 | 28.9 | 74.8 | **KWT** | 11.8 | 17.2 | 30.5 | 77.3 | **SVK** | 14.7 | 18.1 | 27.0 | 49.0 |
| **CYP** | 57.0 | 17.9 | 27.4 | 53.2 | **LBN** | 151.3 | 26.4 | 20.2 | -23.4 | **SVN** | 18.9 | 19.9 | 25.9 | 29.9 |
| **CZE** | 20.9 | 16.6 | 28.9 | 73.6 | **LBY** | 100.3 | 19.6 | 26.8 | 36.7 | **SWE** | 17.1 | 18.7 | 26.5 | 41.7 |
| **DEU** | 43.8 | 19.5 | 25.4 | 30.4 | **LTU** | 29.5 | 21.9 | 24.2 | 10.3 | **TUN** | 19.7 | 25.5 | 20.5 | -19.5 |
| **DNK** | 22.0 | 19.0 | 25.8 | 35.3 | **LUX** | 44.8 | 17.4 | 27.7 | 59.6 | **TUR** | 117.0 | 44.8 | 3.7 | -91.8 |
| **DZA** | 143.8 | 15.2 | 31.2 | 105.9 | **LVA** | 9.4 | 21.3 | 24.5 | 15.3 | **TUV** | 210.1 | 31.3 | 19.4 | -38.1 |
| **ECU** | 70.3 | 19.4 | 26.9 | 38.9 | **MAR** | 87.8 | 23.4 | 22.3 | -5.1 | **URY** | 16.8 | 20.7 | 23.4 | 13.0 |
| **EGY** | 50.7 | 21.7 | 23.3 | 7.1 | **MEX** | 120.2 | 42.3 | 4.3 | -89.9 | **USA** | 54.4 | 18.6 | 26.3 | 41.1 |
| **ESP** | 29.1 | 19.7 | 24.6 | 24.9 | **MLT** | 36.3 | 18.2 | 26.4 | 45.1 | **VEN** | 167.3 | 23.6 | 23.0 | -2.8 |

Source: Based on authors' calculation of inefficiency estimates.
Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.6. Persistent and Time-Varying Inefficiency in Life Expectancy

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AFG | 13.7 | 0.9520 | 0.8726 | -8.34 | DZA | 4.7 | 0.7972 | 1.1292 | 41.65 | KSV | 7.7 | 0.8012 | 0.9271 | 15.7 | QAT | 9.0 | 0.6972 | 1.1353 | 62.8 |
| AGO | 24.3 | 2.9005 | 0.4246 | -85.36 | ECU | 6.1 | 0.6408 | 1.2258 | 91.29 | KWT | 11.3 | 0.4965 | 1.7330 | 249.0 | ROM | 8.8 | 0.9167 | 0.9557 | 4.3 |
| ALB | 4.9 | 0.7359 | 1.0328 | 40.34 | EGY | 11.7 | 0.6155 | 1.2732 | 106.85 | LAO | 8.6 | 1.0836 | 0.8112 | -25.1 | RUS | 9.8 | 1.6206 | 0.7726 | -52.3 |
| ARE | 12.8 | 0.4473 | 1.4948 | 234.20 | ERI | 17.9 | 1.3911 | 0.6707 | -51.78 | LBN | 11.4 | 0.7543 | 1.1759 | 55.9 | RWA | 18.6 | 4.1570 | 0.3599 | -91.3 |
| ARG | 4.7 | 0.6268 | 1.2224 | 95.03 | ESP | 4.8 | 0.7503 | 0.9934 | 32.41 | LBR | 19.9 | 1.6679 | 0.5766 | -65.4 | SAU | 6.2 | 0.5579 | 1.3659 | 144.8 |
| ARM | 4.1 | 0.5856 | 1.3203 | 125.46 | EST | 4.7 | 1.0121 | 0.8045 | -20.51 | LBY | 4.7 | 0.6532 | 1.1799 | 80.6 | SDN | 16.4 | 0.9462 | 0.9105 | -3.8 |
| ATG | 9.9 | 0.6239 | 1.2756 | 104.45 | ETH | 16.3 | 2.8207 | 0.4166 | -85.23 | LCA | 11.8 | 0.7370 | 1.2002 | 62.8 | SEN | 17.1 | 1.5936 | 0.6247 | -60.8 |
| AUS | 2.1 | 0.5851 | 1.3548 | 131.56 | FIN | 3.3 | 0.6723 | 1.0987 | 63.42 | LKA | 9.6 | 0.5594 | 1.3705 | 145.0 | SGP | 18.5 | 0.6525 | 1.2276 | 88.1 |
| AUT | 3.3 | 0.7053 | 1.1603 | 64.52 | FJI | 8.6 | 0.6484 | 1.2230 | 88.62 | LSO | 32.1 | 2.8426 | 0.3939 | -86.1 | SLB | 6.2 | 1.1493 | 0.7643 | -33.5 |
| AZE | 6.4 | 0.8301 | 1.2239 | 47.44 | FRA | 5.7 | 0.7437 | 1.1044 | 48.50 | LTU | 7.4 | 0.8134 | 0.8542 | 5.0 | SLE | 41.6 | 3.3343 | 0.3581 | -89.3 |
| BDI | 28.4 | 1.1739 | 0.6884 | -41.35 | FSM | 10.6 | 0.6553 | 1.2798 | 95.31 | LUX | 5.3 | 0.6495 | 1.0566 | 62.7 | SLV | 12.2 | 0.8010 | 0.9971 | 24.5 |
| BEL | 8.0 | 0.6828 | 1.1000 | 61.09 | GAB | 13.8 | 1.2951 | 0.5886 | -54.55 | LVA | 6.4 | 0.7893 | 1.0148 | 28.6 | SRB | 4.3 | 0.7954 | 1.0769 | 35.4 |
| BEN | 23.9 | 0.9170 | 1.0039 | 9.48 | GBR | 8.1 | 0.6840 | 1.1450 | 67.40 | MAC | 17.1 | 0.6839 | 1.3756 | 101.1 | STP | 14.0 | 0.7620 | 1.0783 | 41.5 |
| BFA | 21.3 | 1.8730 | 0.5293 | -71.74 | GEO | 6.7 | 0.4703 | 1.5881 | 237.70 | MAR | 7.3 | 0.9720 | 0.9410 | -3.2 | SUR | 3.8 | 0.7737 | 1.1357 | 46.8 |
| BGD | 18.1 | 0.9775 | 0.8568 | -12.35 | GHA | 23.6 | 1.0189 | 0.9214 | -9.58 | MDA | 6.7 | 0.9577 | 0.8313 | -13.2 | SVK | 4.7 | 0.7450 | 0.9468 | 27.1 |
| BGR | 7.3 | 0.7242 | 1.1668 | 61.11 | GIN | 26.2 | 1.8697 | 0.5654 | -69.76 | MDG | 15.2 | 1.0179 | 0.7776 | -23.6 | SVN | 4.7 | 0.8024 | 0.9131 | 13.8 |
| BHR | 17.8 | 0.5084 | 1.4177 | 178.86 | GMB | 23.4 | 0.7455 | 1.0726 | 43.89 | MDV | 10.6 | 0.7917 | 1.0216 | 29.0 | SWE | 3.2 | 0.6141 | 1.2517 | 103.8 |
| BHS | 8.2 | 0.6164 | 1.2684 | 105.78 | GNB | 27.4 | 0.9433 | 0.7959 | -15.6 | MEX | 7.2 | 0.5863 | 1.2932 | 120.6 | SWZ | 31.8 | 3.9205 | 0.2238 | -94.3 |
| BIH | 5.0 | 0.4344 | 1.3778 | 217.17 | GNQ | 26.3 | 0.4468 | 1.5073 | 237.4 | MKD | 3.7 | 0.6144 | 1.1958 | 94.6 | SYC | 12.0 | 0.6406 | 1.4537 | 126.9 |
| BLR | 8.7 | 0.9245 | 0.7832 | -15.29 | GRC | 4.8 | 0.6693 | 1.1133 | 66.3 | MLI | 20.1 | 1.5530 | 0.6701 | -56.8 | TCD | 27.2 | 1.2133 | 0.6989 | -42.4 |
| BLZ | 8.7 | 0.5597 | 1.5281 | 173.01 | GRD | 13.5 | 0.6692 | 1.1941 | 78.4 | MLT | 11.1 | 0.6933 | 1.0254 | 47.9 | TGO | 27.1 | 1.4289 | 0.5768 | -59.6 |
| BMU | 12.6 | 0.7015 | 1.1857 | 69.01 | GRL | 1.9 | 0.8162 | 0.8998 | 10.2 | MMR | 15.4 | 0.7531 | 1.1521 | 53.0 | THA | 9.9 | 0.8542 | 1.0632 | 24.5 |
| BOL | 5.7 | 1.2451 | 0.6809 | -45.31 | GTM | 11.0 | 0.7945 | 0.9709 | 22.2 | MNE | 4.4 | 0.9037 | 0.8803 | -2.6 | TJK | 4.9 | 0.8891 | 1.1389 | 28.1 |
| BRA | 7.7 | 0.8413 | 0.9783 | 16.29 | GUM | 6.6 | 0.8615 | 0.9322 | 8.2 | MNG | 2.9 | 0.9714 | 0.8915 | -8.2 | TKM | 5.7 | 0.7975 | 1.0922 | 36.9 |
| BRB | 14.8 | 0.6321 | 1.2332 | 95.11 | GUY | 6.0 | 0.5811 | 1.3181 | 126.8 | MOZ | 27.6 | 1.5954 | 0.5499 | -65.5 | TMP | 10.3 | 0.8140 | 0.9403 | 15.5 |
| BRN | 8.6 | 0.5649 | 1.4841 | 162.71 | HKG | 16.3 | 0.7400 | 1.1922 | 61.1 | MRT | 10.5 | 0.7360 | 1.1028 | 49.8 | TON | 7.0 | 0.6139 | 1.2696 | 106.8 |
| BTN | 4.3 | 1.1267 | 0.8158 | -27.59 | HND | 7.2 | 0.6354 | 1.2437 | 95.7 | MUS | 16.4 | 0.6118 | 1.1280 | 84.4 | TTO | 14.5 | 0.5905 | 1.3682 | 131.7 |
| BWA | 16.9 | 4.7780 | 0.2294 | -95.20 | HRV | 6.0 | 0.6992 | 1.0847 | 55.1 | MWI | 24.8 | 4.7817 | 0.2292 | -95.2 | TUN | 6.1 | 0.5626 | 1.3858 | 146.3 |
| CAF | 30.2 | 2.2752 | 0.3462 | -84.78 | HTI | 25.3 | 1.0558 | 0.7813 | -26.0 | MYS | 12.8 | 0.5944 | 1.2959 | 118.0 | TUR | 9.9 | 0.7784 | 1.0757 | 38.2 |
| CAN | 2.4 | 0.6019 | 1.2346 | 105.10 | HUN | 5.6 | 0.8357 | 0.9301 | 11.3 | NAM | 17.4 | 2.8249 | 0.2714 | -90.4 | TZA | 21.3 | 2.4433 | 0.4211 | -82.8 |
| CHE | 5.5 | 0.6530 | 1.1853 | 81.51 | IDN | 17.0 | 0.6755 | 1.2257 | 81.5 | NER | 17.0 | 1.9089 | 0.5143 | -73.1 | UGA | 25.2 | 2.3240 | 0.5522 | -76.2 |
| CHL | 3.7 | 0.5719 | 1.3270 | 132.05 | IND | 22.1 | 0.9114 | 0.9318 | 2.2 | NGA | 43.3 | 1.4676 | 0.7347 | -49.9 | UKR | 12.0 | 0.9683 | 0.9483 | -2.1 |
| CHN | 9.7 | 0.6341 | 1.3465 | 112.33 | IRL | 7.2 | 0.6436 | 1.2201 | 89.6 | NIC | 5.4 | 0.7886 | 1.0128 | 28.4 | URY | 6.0 | 0.6327 | 1.1964 | 89.1 |
| CIV | 39.4 | 1.7083 | 0.5147 | -69.87 | IRN | 7.7 | 0.8722 | 0.9251 | 6.1 | NLD | 8.7 | 0.7157 | 1.1112 | 55.3 | USA | 6.5 | 0.6221 | 1.3638 | 119.2 |
| CMR | 29.5 | 1.2754 | 0.7234 | -43.28 | IRQ | 13.4 | 0.4533 | 1.3313 | 193.7 | NOR | 3.1 | 0.6247 | 1.1462 | 83.5 | UZB | 6.1 | 0.7628 | 1.1036 | 44.7 |
| COG | 18.8 | 3.2135 | 0.3738 | -88.37 | ISL | 1.6 | 0.5291 | 1.2303 | 132.5 | NPL | 9.7 | 1.0445 | 0.8122 | -22.2 | VCT | 13.3 | 0.6845 | 1.2474 | 82.2 |
| COL | 7.7 | 0.6733 | 1.2143 | 80.34 | ISR | 6.4 | 0.6587 | 1.2590 | 91.1 | NZL | 2.9 | 0.6165 | 1.2941 | 109.9 | VEN | 7.6 | 0.5946 | 1.2928 | 117.4 |
| COM | 22.0 | 0.8880 | 0.9056 | 1.98 | ITA | 6.3 | 0.6935 | 1.0800 | 55.7 | OMN | 3.9 | 0.6275 | 1.4447 | 130.2 | VIR | 6.7 | 0.8618 | 0.9376 | 8.8 |
| CPV | 10.9 | 0.4908 | 1.5307 | 211.90 | JAM | 8.7 | 0.7865 | 1.0879 | 38.3 | PAK | 20.7 | 0.7368 | 1.1105 | 50.7 | VNM | 8.4 | 0.5857 | 1.3366 | 128.2 |
| CRI | 7.0 | 0.5813 | 1.3156 | 126.32 | JOR | 7.0 | 0.5827 | 1.4189 | 143.5 | PAN | 7.0 | 0.6027 | 1.2754 | 111.6 | VUT | 7.9 | 0.7410 | 1.0743 | 45.0 |
| CUB | 4.5 | 0.6335 | 1.3243 | 109.05 | JPN | 7.3 | 0.6647 | 1.1797 | 77.5 | PER | 5.7 | 0.6901 | 1.1810 | 71.1 | WSM | 8.3 | 0.8815 | 0.9426 | 6.9 |
| CYP | 7.5 | 0.5976 | 1.2876 | 115.47 | KAZ | 4.6 | 1.0734 | 0.5651 | -47.4 | PHL | 17.9 | 0.5782 | 1.3953 | 141.3 | YEM | 17.3 | 0.7907 | 1.0713 | 35.5 |
| CZE | 4.3 | 0.7769 | 0.9855 | 26.84 | KEN | 21.0 | 3.9547 | 0.3345 | -91.5 | PNG | 12.4 | 0.7325 | 1.1809 | 61.2 | ZAF | 31.6 | 2.1728 | 0.2590 | -88.1 |
| DEU | 8.3 | 0.7100 | 1.0570 | 48.88 | KGZ | 4.4 | 0.6786 | 1.0508 | 54.8 | POL | 8.0 | 0.6847 | 0.9715 | 41.9 | ZAR | 25.0 | 1.7884 | 0.6103 | -65.9 |
| DJI | 18.2 | 1.2570 | 0.7150 | -43.12 | KHM | 13.4 | 1.4121 | 0.7781 | -44.9 | PRI | 8.4 | 0.5602 | 1.1856 | 111.6 | ZMB | 21.0 | 4.4403 | 0.2595 | -94.2 |
| DNK | 6.7 | 0.7319 | 0.9404 | 28.49 | KIR | 13.4 | 0.5757 | 1.2994 | 125.7 | PRT | 5.6 | 0.7418 | 0.8637 | 16.4 | ZWE | 29.2 | 5.8564 | 0.1498 | -97.4 |
| DOM | 10.9 | 0.6297 | 1.2118 | 92.42 | KOR | 8.6 | 0.8326 | 0.9648 | 15.9 | PRY | 3.3 | 0.6747 | 1.1943 | 77.0 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.7. Persistent and Time-Varying Inefficiency in Educational Quality

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **ALB** | 29.4 | 2.3 | 0.6 | -75.5 | **GEO** | 28.4 | 2.1 | 0.6 | -71.0 | **MYS** | 27.2 | 0.7 | 0.6 | -15.3 |
| **ARE** | 27.5 | 1.4 | 1.1 | -18.9 | **GRC** | 18.5 | 1.3 | 1.7 | 30.7 | **NLD** | 16.6 | 0.7 | 1.5 | 105.2 |
| **ARG** | 31.7 | 2.0 | 0.4 | -81.7 | **HKG** | 8.9 | 1.3 | 1.6 | 29.1 | **NOR** | 14.2 | 1.3 | 0.8 | -40.5 |
| **AUS** | 8.5 | 0.6 | 2.0 | 232.3 | **HRV** | 13.2 | 0.8 | 1.0 | 19.2 | **NZL** | 7.2 | 0.6 | 2.0 | 210.3 |
| **AUT** | 13.4 | 0.6 | 1.1 | 101.4 | **HUN** | 8.0 | 0.9 | 2.5 | 162.9 | **PER** | 34.4 | 3.3 | 0.4 | -88.8 |
| **AZE** | 30.5 | 1.2 | 1.2 | -1.3 | **IDN** | 31.1 | 1.4 | 1.3 | -4.9 | **POL** | 9.3 | 0.9 | 1.3 | 48.4 |
| **BEL** | 16.0 | 0.8 | 1.6 | 84.8 | **IRL** | 8.3 | 0.5 | 1.0 | 84.1 | **PRT** | 16.0 | 1.4 | 0.7 | -47.6 |
| **BGR** | 22.5 | 2.4 | 0.8 | -65.8 | **ISL** | 9.8 | 0.8 | 2.0 | 160.8 | **QAT** | 41.9 | 2.1 | 0.6 | -69.2 |
| **BRA** | 31.2 | 1.6 | 1.1 | -29.9 | **ISR** | 21.8 | 3.3 | 0.6 | -81.3 | **ROM** | 25.3 | 2.9 | 0.6 | -78.1 |
| **CAN** | 6.9 | 0.7 | 1.3 | 96.2 | **ITA** | 21.1 | 1.5 | 1.0 | -33.8 | **RUS** | 15.5 | 2.6 | 0.4 | -84.9 |
| **CHE** | 9.4 | 0.9 | 1.6 | 78.2 | **JOR** | 26.3 | 0.8 | 1.2 | 60.2 | **SGP** | 10.8 | 1.6 | 1.1 | -29.8 |
| **CHL** | 19.7 | 1.2 | 0.9 | -27.1 | **JPN** | 16.0 | 2.4 | 1.0 | -60.2 | **SRB** | 15.9 | 3.3 | 0.5 | -83.6 |
| **CHN** | 0.0 | 0.7 | 4.5 | 532.2 | **KAZ** | 22.4 | 1.3 | 0.5 | -65.8 | **SVK** | 11.4 | 0.7 | 2.6 | 262.3 |
| **COL** | 28.7 | 2.8 | 0.6 | -79.2 | **KGZ** | 42.8 | 3.1 | 0.5 | -85.1 | **SVN** | 13.4 | 0.5 | 0.8 | 62.7 |
| **CRI** | 18.0 | 0.8 | 1.8 | 121.7 | **KOR** | 7.6 | 0.5 | 3.1 | 522.7 | **SWE** | 13.9 | 0.4 | 1.6 | 272.7 |
| **CYP** | 22.1 | 1.0 | 1.2 | 17.4 | **LTU** | 12.5 | 0.7 | 1.4 | 87.8 | **THA** | 24.7 | 1.3 | 1.9 | 46.4 |
| **CZE** | 9.9 | 0.8 | 1.1 | 37.7 | **LUX** | 13.3 | 0.7 | 1.2 | 62.7 | **TTO** | 28.5 | 1.2 | 1.0 | -18.6 |
| **DEU** | 18.0 | 1.2 | 0.8 | -32.2 | **LVA** | 8.7 | 0.7 | 1.4 | 84.0 | **TUN** | 29.2 | 1.9 | 3.8 | 100.5 |
| **DNK** | 16.9 | 0.9 | 1.1 | 27.7 | **MAC** | 16.7 | 1.0 | 0.9 | -12.2 | **TUR** | 19.7 | 1.7 | 3.0 | 75.4 |
| **ESP** | 19.3 | 1.4 | 0.6 | -55.7 | **MDA** | 18.9 | 2.1 | 0.6 | -71.6 | **URY** | 20.7 | 0.8 | 0.7 | -13.0 |
| **EST** | 6.1 | 0.9 | 0.9 | -1.0 | **MEX** | 28.4 | 1.7 | 1.1 | -39.4 | **USA** | 17.6 | 0.8 | 1.4 | 75.4 |
| **FIN** | 5.2 | 0.4 | 2.2 | 380.7 | **MKD** | 31.9 | 0.5 | 2.1 | 301.3 | **VNM** | 5.2 | 0.7 | 1.6 | 114.1 |
| **FRA** | 17.6 | 1.1 | 1.0 | -7.9 | **MLT** | 23.4 | 1.1 | 1.0 | -12.3 | | | | | |
| **GBR** | 18.4 | 0.7 | 1.3 | 86.5 | **MNE** | 24.0 | 2.4 | 0.6 | -76.2 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.8. Persistent and Time-Varying Inefficiency in Access to Finance

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AGO** | 28.9 | 5.7 | 26.3 | 359.7 | **ECU** | 37.4 | 13.0 | 13.1 | 0.3 | **KSV** | 25.0 | 9.4 | 15.2 | 63.0 | **RWA** | 14.7 | 8.6 | 12.6 | 46.3 |
| **ALB** | 40.4 | 14.3 | 12.4 | -13.4 | **EGY** | 112.0 | 22.2 | 14.4 | -35.2 | **KWT** | 64.7 | 6.6 | 30.6 | 363.6 | **SAU** | 51.7 | 19.1 | 10.3 | -46.2 |
| **ARE** | 73.9 | 19.8 | 12.0 | -39.5 | **ESP** | 45.8 | 10.5 | 17.8 | 69.9 | **LBN** | 49.6 | 15.3 | 12.7 | -16.8 | **SDN** | 86.7 | 35.3 | 6.4 | -81.9 |
| **ARG** | 50.1 | 20.2 | 9.5 | -52.8 | **EST** | 26.8 | 7.7 | 19.1 | 146.6 | **LKA** | 14.3 | 9.5 | 11.3 | 18.8 | **SEN** | 103.1 | 34.4 | 7.4 | -78.4 |
| **ARM** | 70.4 | 8.2 | 26.8 | 227.4 | **FIN** | 38.9 | 9.2 | 18.8 | 105.1 | **LTU** | 23.2 | 7.8 | 17.6 | 124.9 | **SGP** | 61.2 | 9.0 | 23.2 | 157.5 |
| **AUS** | 35.1 | 8.8 | 18.8 | 114.0 | **FRA** | 55.2 | 10.1 | 19.9 | 96.6 | **LUX** | 84.9 | 11.5 | 22.2 | 93.2 | **SLE** | 31.6 | 6.7 | 23.5 | 253.1 |
| **AUT** | 52.0 | 9.9 | 19.8 | 99.7 | **GAB** | 80.9 | 25.3 | 9.5 | -62.3 | **LVA** | 17.7 | 6.8 | 18.0 | 164.2 | **SLV** | 80.1 | 40.4 | 5.0 | -87.6 |
| **AZE** | 64.0 | 26.1 | 8.0 | -69.1 | **GBR** | 57.8 | 10.3 | 20.1 | 94.8 | **MDA** | 54.6 | 8.6 | 23.1 | 169.4 | **SRB** | 18.0 | 11.4 | 10.7 | -6.2 |
| **BDI** | 79.1 | 10.6 | 22.9 | 115.1 | **GEO** | 25.7 | 10.0 | 14.5 | 45.1 | **MDG** | 103.3 | 14.2 | 21.1 | 48.2 | **SVK** | 30.7 | 7.8 | 20.0 | 157.0 |
| **BEL** | 59.2 | 10.5 | 19.9 | 88.5 | **GHA** | 25.6 | 10.8 | 13.3 | 23.4 | **MEX** | 81.2 | 20.4 | 12.3 | -39.5 | **SVN** | 30.4 | 8.4 | 18.4 | 118.3 |
| **BEN** | 62.9 | 21.2 | 10.1 | -52.1 | **GIN** | 126.8 | 29.6 | 11.2 | -62.1 | **MKD** | 15.7 | 7.1 | 16.2 | 126.8 | **SWE** | 44.2 | 9.4 | 19.4 | 106.3 |
| **BFA** | 46.7 | 9.4 | 19.9 | 112.5 | **GRC** | 46.8 | 11.1 | 17.0 | 53.2 | **MLI** | 62.4 | 22.8 | 9.3 | -59.2 | **TCD** | 75.0 | 6.5 | 32.9 | 406.9 |
| **BGD** | 27.7 | 7.3 | 20.5 | 182.4 | **GTM** | 48.8 | 26.2 | 7.0 | -73.2 | **MLT** | 44.4 | 9.8 | 18.8 | 92.3 | **TGO** | 50.0 | 25.0 | 7.5 | -70.0 |
| **BGR** | 25.7 | 10.1 | 14.2 | 40.0 | **HKG** | 53.7 | 10.8 | 18.5 | 71.6 | **MNE** | 35.3 | 11.9 | 14.0 | 17.1 | **THA** | 19.5 | 8.2 | 15.5 | 89.1 |
| **BHR** | 73.1 | 17.1 | 14.0 | -18.1 | **HND** | 43.3 | 17.9 | 10.2 | -43.2 | **MNG** | 7.7 | 7.1 | 10.0 | 40.6 | **TJK** | 112.7 | 61.0 | 3.2 | -94.8 |
| **BIH** | 22.2 | 6.9 | 19.7 | 184.1 | **HRV** | 25.3 | 7.6 | 19.0 | 151.9 | **MRT** | 30.1 | 11.4 | 13.5 | 18.6 | **TKM** | 294.4 | 78.8 | 4.6 | -94.1 |
| **BLR** | 17.6 | 9.4 | 12.7 | 34.7 | **HTI** | 44.5 | 7.2 | 24.9 | 247.4 | **MUS** | 26.4 | 8.6 | 17.0 | 97.4 | **TUR** | 43.3 | 8.3 | 21.5 | 157.3 |
| **BOL** | 22.1 | 15.5 | 8.7 | -44.2 | **HUN** | 35.6 | 8.4 | 19.6 | 132.6 | **MWI** | 34.9 | 8.5 | 19.3 | 125.3 | **TZA** | 35.5 | 9.9 | 16.8 | 69.1 |
| **BRA** | 36.0 | 12.7 | 13.2 | 4.5 | **IDN** | 60.4 | 26.4 | 7.7 | -70.8 | **MYS** | 21.9 | 10.8 | 12.4 | 15.1 | **UGA** | 24.7 | 13.3 | 10.7 | -19.7 |
| **BWA** | 24.3 | 18.4 | 7.7 | -58.4 | **IND** | 22.0 | 15.2 | 8.9 | -41.5 | **NER** | 154.4 | 44.0 | 7.1 | -83.8 | **UKR** | 24.7 | 10.7 | 13.2 | 23.9 |
| **CAN** | 37.3 | 9.7 | 17.6 | 82.0 | **IRL** | 42.4 | 9.2 | 19.5 | 112.6 | **NGA** | 32.8 | 13.8 | 11.6 | -15.7 | **URY** | 52.2 | 29.4 | 6.3 | -78.5 |
| **CHL** | 43.5 | 18.1 | 10.0 | -44.6 | **IRN** | 18.3 | 10.4 | 11.8 | 13.7 | **NIC** | 60.9 | 16.8 | 12.8 | -23.3 | **USA** | 60.3 | 11.3 | 18.8 | 65.4 |
| **CHN** | 17.7 | 9.4 | 12.8 | 35.5 | **IRQ** | 137.1 | 16.8 | 23.0 | 36.7 | **NLD** | 65.1 | 10.9 | 20.2 | 84.5 | **UZB** | 24.0 | 21.3 | 6.6 | -69.0 |
| **CMR** | 77.6 | 6.9 | 31.9 | 362.9 | **ISR** | 50.5 | 10.0 | 19.4 | 93.7 | **NPL** | 19.9 | 13.1 | 9.7 | -25.8 | **VEN** | 52.4 | 16.6 | 12.0 | -27.8 |
| **COG** | 86.7 | 26.4 | 9.5 | -64.1 | **ITA** | 71.0 | 15.9 | 14.8 | -6.6 | **NZL** | 31.9 | 8.7 | 18.3 | 111.5 | **VNM** | 37.6 | 15.7 | 10.9 | -30.6 |
| **COL** | 54.8 | 14.6 | 14.0 | -4.6 | **JAM** | 20.9 | 9.5 | 13.7 | 44.4 | **PAK** | 107.7 | 8.9 | 31.1 | 247.4 | **YEM** | 150.7 | 33.4 | 11.3 | -66.2 |
| **CRI** | 26.2 | 12.7 | 11.4 | -10.4 | **JOR** | 60.4 | 9.0 | 23.0 | 154.4 | **PAN** | 45.8 | 23.4 | 7.8 | -66.8 | **ZAF** | 29.2 | 13.0 | 11.7 | -9.9 |
| **CYP** | 50.3 | 10.6 | 18.3 | 72.5 | **JPN** | 66.9 | 10.8 | 20.7 | 92.3 | **PER** | 62.0 | 17.9 | 12.1 | -32.6 | **ZAR** | 80.5 | 45.7 | 4.2 | -90.8 |
| **CZE** | 38.1 | 9.2 | 18.7 | 104.3 | **KAZ** | 29.0 | 11.1 | 13.7 | 22.6 | **PHL** | 52.3 | 10.5 | 18.9 | 80.2 | **ZMB** | 26.4 | 15.5 | 9.4 | -39.3 |
| **DEU** | 58.2 | 10.7 | 19.5 | 81.9 | **KEN** | 13.7 | 11.6 | 9.0 | -22.1 | **POL** | 32.2 | 10.2 | 15.7 | 54.5 | **ZWE** | 28.9 | 3.6 | 40.1 | 1019.0 |
| **DNK** | 58.7 | 10.4 | 20.0 | 92.2 | **KGZ** | 85.9 | 64.1 | 2.6 | -95.9 | **PRT** | 42.7 | 11.2 | 16.2 | 45.4 | | | | | |
| **DOM** | 37.6 | 16.9 | 10.1 | -40.6 | **KHM** | 99.3 | 50.8 | 4.0 | -92.2 | **ROM** | 36.6 | 13.8 | 12.3 | -11.0 | | | | | |
| **DZA** | 32.3 | 17.0 | 9.4 | -44.5 | **KOR** | 41.4 | 9.0 | 19.7 | 118.2 | **RUS** | 30.9 | 14.0 | 11.2 | -20.1 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.9. Persistent and Time-Varying Inefficiency in Old-Age Pension

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|
| AGO | 291.4 | 0.1687 | 0.1677 | -0.61 | KOR | 48.7 | 0.1683 | 0.1685 | 0.13 |
| ALB | 19.8 | 0.1679 | 0.1688 | 0.52 | LAO | 218.6 | 0.1689 | 0.1684 | -0.29 |
| ARG | 93.4 | 0.1687 | 0.1682 | -0.28 | LVA | 18.8 | 0.1683 | 0.1686 | 0.19 |
| ARM | 39.0 | 0.1686 | 0.1683 | -0.16 | MAR | 62.8 | 0.1685 | 0.1683 | -0.12 |
| BDI | 95.0 | 0.1686 | 0.1684 | -0.15 | MDA | 15.2 | 0.1684 | 0.1687 | 0.17 |
| BEN | 111.5 | 0.1686 | 0.1685 | -0.08 | MEX | 108.7 | 0.1685 | 0.1685 | 0.03 |
| BFA | 131.2 | 0.1683 | 0.1686 | 0.14 | MNG | 37.1 | 0.1688 | 0.1680 | -0.48 |
| BGD | 209.7 | 0.1688 | 0.1689 | 0.05 | MUS | 49.8 | 0.1685 | 0.1683 | -0.12 |
| BGR | 22.2 | 0.1685 | 0.1684 | -0.06 | NIC | 46.5 | 0.1687 | 0.1682 | -0.30 |
| BLZ | 19.7 | 0.1692 | 0.1693 | 0.03 | OMN | 215.9 | 0.1696 | 0.1696 | 0.01 |
| BOL | 44.8 | 0.1684 | 0.1687 | 0.21 | PAK | 138.4 | 0.1695 | 0.1677 | -1.06 |
| BRA | 86.6 | 0.1687 | 0.1682 | -0.33 | PER | 40.1 | 0.1686 | 0.1683 | -0.16 |
| BTN | 110.3 | 0.1685 | 0.1682 | -0.14 | POL | 27.8 | 0.1684 | 0.1685 | 0.07 |
| CHL | 78.9 | 0.1685 | 0.1685 | 0.00 | PRY | 100.1 | 0.1688 | 0.1682 | -0.37 |
| CHN | 19.3 | 0.1687 | 0.1674 | -0.75 | RUS | 31.1 | 0.1685 | 0.1685 | 0.02 |
| CMR | 112.3 | 0.1692 | 0.1686 | -0.31 | SAU | 149.9 | 0.1689 | 0.1681 | -0.42 |
| COG | 158.0 | 0.1697 | 0.1678 | -1.12 | SGP | 112.0 | 0.1686 | 0.1685 | -0.01 |
| COL | 91.3 | 0.1688 | 0.1685 | -0.14 | SLV | 193.5 | 0.1659 | 0.1712 | 3.23 |
| CRI | 60.1 | 0.1688 | 0.1683 | -0.29 | SVN | 55.6 | 0.1684 | 0.1686 | 0.09 |
| CYP | 99.5 | 0.1686 | 0.1685 | -0.04 | TGO | 135.4 | 0.1686 | 0.1696 | 0.58 |
| CZE | 65.1 | 0.1684 | 0.1686 | 0.07 | THA | 67.3 | 0.1687 | 0.1681 | -0.35 |
| DZA | 31.3 | 0.1684 | 0.1683 | -0.06 | TTO | 37.7 | 0.1686 | 0.1686 | -0.03 |
| ECU | 63.0 | 0.1682 | 0.1689 | 0.42 | TUN | 26.4 | 0.1684 | 0.1685 | 0.09 |
| HND | 72.0 | 0.1685 | 0.1686 | 0.07 | TUR | 93.4 | 0.1681 | 0.1687 | 0.39 |
| HRV | 44.5 | 0.1684 | 0.1685 | 0.09 | TZA | 107.9 | 0.1686 | 0.1686 | -0.03 |
| IDN | 148.0 | 0.1691 | 0.1691 | 0.03 | UKR | 14.0 | 0.1684 | 0.1683 | -0.04 |
| IND | 62.6 | 0.1685 | 0.1685 | 0.06 | URY | 49.8 | 0.1686 | 0.1681 | -0.35 |
| ISR | 62.5 | 0.1685 | 0.1684 | -0.05 | VNM | 24.5 | 0.1687 | 0.1683 | -0.23 |
| JOR | 51.6 | 0.1688 | 0.1683 | -0.27 | ZMB | 102.4 | 0.1686 | 0.1684 | -0.12 |
| JPN | 90.7 | 0.1680 | 0.1697 | 1.01 | ZWE | 38.5 | 0.1680 | 0.1690 | 0.59 |
| KEN | 27.6 | 0.1691 | 0.1677 | -0.82 | | | | | |

Source: Based on authors' calculation of inefficiency estimates.
Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.

## Appendix A.10. Persistent and Time-Varying Inefficiency in Income Inequality

| Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ | Ctry | $\eta_{i0}$ | $\tau_{i0}$ | $\tau_{iT}$ | $\Delta\%\tau_i$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALB | 8.7 | 14.2 | 14.9 | 4.9 | GBR | 20.3 | 12.2 | 17.5 | 43.9 | MYS | 24.3 | 14.7 | 16.9 | 15.0 |
| ARG | 25.5 | 20.3 | 11.7 | -42.2 | GEO | 18.6 | 7.9 | 15.6 | 98.0 | NER | 12.4 | 30.9 | 11.4 | -63.1 |
| ARM | 11.6 | 27.3 | 21.9 | -20.0 | GHA | 23.6 | 13.3 | 18.2 | 36.7 | NIC | 29.3 | 17.3 | 18.2 | 4.8 |
| AUS | 12.2 | 15.8 | 14.5 | -8.6 | GIN | 12.6 | 21.5 | 8.8 | -58.9 | NLD | 13.2 | 12.8 | 17.4 | 36.0 |
| AUT | 16.8 | 5.7 | 17.8 | 209.4 | GRC | 18.6 | 10.8 | 20.4 | 89.8 | NOR | 6.9 | 24.7 | 17.7 | -28.3 |
| BDI | 19.0 | 6.9 | 24.2 | 250.5 | GTM | 42.5 | 20.7 | 12.2 | -41.1 | PAK | 9.0 | 16.5 | 15.6 | -5.5 |
| BEL | 12.2 | 14.7 | 16.5 | 12.7 | HND | 44.6 | 20.0 | 9.4 | -53.2 | PAN | 32.6 | 14.2 | 14.3 | 0.6 |
| BFA | 18.7 | 20.8 | 10.3 | -50.5 | HRV | 13.8 | 15.8 | 15.5 | -1.4 | PER | 30.1 | 19.5 | 9.9 | -49.5 |
| BGD | 12.2 | 14.5 | 15.8 | 9.6 | HUN | 13.2 | 27.1 | 21.7 | -19.9 | PHL | 28.3 | 15.4 | 16.7 | 8.2 |
| BGR | 16.0 | 14.2 | 22.5 | 58.2 | IRL | 9.5 | 13.8 | 15.7 | 14.2 | POL | 14.3 | 14.9 | 14.2 | -4.8 |
| BIH | 12.3 | 13.4 | 16.9 | 25.8 | IRN | 23.0 | 17.2 | 12.0 | -30.2 | PRT | 22.3 | 16.9 | 14.8 | -12.3 |
| BLR | 6.3 | 10.3 | 16.1 | 56.7 | IRQ | 7.6 | 10.9 | 18.6 | 70.8 | PRY | 41.1 | 13.5 | 17.4 | 28.9 |
| BOL | 37.4 | 25.9 | 11.7 | -54.7 | ISL | 6.6 | 14.6 | 8.7 | -40.5 | ROM | 8.0 | 15.6 | 12.5 | -19.5 |
| BRA | 42.3 | 16.4 | 13.2 | -19.3 | ISR | 36.0 | 12.7 | 17.5 | 37.5 | RUS | 17.9 | 13.1 | 16.0 | 22.4 |
| BTN | 20.7 | 13.0 | 18.2 | 39.2 | ITA | 20.2 | 10.2 | 18.5 | 82.1 | RWA | 46.1 | 13.9 | 17.1 | 23.3 |
| CAN | 11.0 | 13.7 | 16.9 | 23.9 | JOR | 12.0 | 15.5 | 17.1 | 10.0 | SEN | 18.0 | 11.0 | 20.0 | 81.3 |
| CHE | 16.1 | 16.5 | 15.7 | -4.4 | KAZ | 7.4 | 41.4 | 10.0 | -75.8 | SLB | 20.0 | 24.6 | 6.6 | -73.3 |
| CHL | 35.3 | 13.9 | 15.1 | 8.8 | KGZ | 8.5 | 17.6 | 4.8 | -72.5 | SLV | 35.3 | 20.4 | 10.8 | -46.8 |
| CHN | 25.1 | 15.5 | 16.1 | 4.3 | KOR | 16.5 | 13.0 | 16.1 | 23.9 | SRB | 10.9 | 32.8 | 15.0 | -54.2 |
| CMR | 26.0 | 9.8 | 21.9 | 124.2 | KSV | 11.3 | 28.9 | 11.3 | -60.8 | SVK | 9.4 | 20.4 | 15.3 | -25.2 |
| COG | 28.8 | 11.4 | 20.5 | 80.2 | LAO | 14.9 | 12.4 | 18.3 | 47.9 | SVN | 6.4 | 9.7 | 20.5 | 112.0 |
| COL | 43.8 | 11.3 | 15.3 | 35.4 | LBR | 10.0 | 17.8 | 12.2 | -31.7 | SWE | 7.0 | 10.6 | 22.7 | 115.0 |
| CRI | 29.7 | 8.5 | 17.0 | 99.5 | LKA | 22.9 | 18.0 | 18.4 | 2.3 | TGO | 26.4 | 9.9 | 21.8 | 119.3 |
| CYP | 10.8 | 3.6 | 26.1 | 615.4 | LTU | 15.9 | 11.5 | 24.9 | 116.0 | THA | 22.9 | 19.9 | 12.4 | -38.0 |
| CZE | 9.5 | 13.3 | 15.6 | 17.0 | LUX | 16.1 | 8.2 | 16.3 | 98.8 | TJK | 9.8 | 16.1 | 13.9 | -13.7 |
| DEU | 14.5 | 15.2 | 17.0 | 12.2 | LVA | 16.7 | 18.5 | 15.0 | -19.2 | TUN | 15.8 | 15.5 | 15.3 | -1.1 |
| DJI | 28.2 | 17.1 | 14.7 | -13.8 | MDA | 13.5 | 24.7 | 0.0 | -100.0 | TUR | 24.5 | 17.9 | 20.9 | 16.4 |
| DNK | 9.2 | 5.1 | 22.9 | 350.0 | MDG | 17.5 | 8.0 | 19.6 | 145.0 | TZA | 15.4 | 16.9 | 13.8 | -18.1 |
| DOM | 40.0 | 15.6 | 9.8 | -37.3 | MEX | 33.6 | 17.3 | 17.0 | -1.9 | UGA | 28.8 | 12.4 | 14.1 | 14.2 |
| ECU | 37.4 | 20.0 | 9.4 | -53.0 | MKD | 27.1 | 20.0 | 9.1 | -54.5 | UKR | 5.3 | 22.6 | 9.9 | -56.4 |
| EGY | 8.7 | 15.3 | 12.6 | -17.5 | MLI | 12.3 | 21.9 | 8.4 | -61.9 | URY | 17.8 | 19.5 | 8.8 | -54.6 |
| ESP | 18.4 | 4.1 | 21.2 | 412.7 | MLT | 10.3 | 9.3 | 16.6 | 78.3 | USA | 26.4 | 14.9 | 17.2 | 15.3 |
| EST | 13.0 | 12.4 | 23.1 | 86.3 | MNE | 11.0 | 14.5 | 18.9 | 30.1 | VEN | 36.7 | 20.6 | 11.9 | -42.5 |
| FIN | 7.3 | 11.1 | 14.6 | 31.6 | MNG | 9.2 | 19.0 | 11.6 | -38.9 | VNM | 16.1 | 11.8 | 13.6 | 14.8 |
| FJI | 20.9 | 20.2 | 11.0 | -45.3 | MOZ | 29.2 | 6.0 | 25.9 | 328.0 | YEM | 12.0 | 9.1 | 21.2 | 133.4 |
| FRA | 15.2 | 3.6 | 17.5 | 390.1 | MRT | 7.9 | 18.3 | 11.2 | -38.7 | ZAF | 56.4 | 14.5 | 17.8 | 22.7 |
| FSM | 29.1 | 16.4 | 15.5 | -6.0 | MUS | 15.4 | 13.6 | 17.1 | 25.6 | ZMB | 43.6 | 14.5 | 18.5 | 27.4 |

Source: Based on authors' calculation of inefficiency estimates.

Note: $\eta_i$ is the time-invariant inefficiency in log difference in percentage, $\tau_{i0}$ and $\tau_{iT}$ are the time-varying inefficiency components for the first and last year respectively. $\triangle\%\ \tau_i$ the percentage change in inefficiency between the final and the initial year.