

Measuring Spending Efficiency: An Alternative Performance Metric for Performance-Based Budgeting (PBB)?

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Abstract

Performance information is a crucial component of performance-based budgeting (PBB). Data Envelopment Analysis (DEA), a mathematical program originally developed to assess spending efficiency in public programs, aligns well with PBB for two primary reasons: (1) PBB aims to connect a government's budget level with its targeted service outcomes, and (2) DEA assesses spending efficiency based on input (or budget level) and output (or public service outcomes). The aims of this paper are to calculate the Data Envelopment Analysis (DEA) spending efficiency scores of the world's central governments and to determine whether the DEA results are conceptually related to the other types of performance information. For the first research purpose, we use 94 countries' central government spending and service outcome data to calculate their DEA spending efficiency in three service functions: education, health, and transportation infrastructure. For the second research purpose, we further find that spending efficiency results relate to the other two types of performance information, i.e., the citizen satisfaction survey and the country's budgeting practice evaluation results. As the countries achieve spending efficiency, their citizen satisfaction survey results increase. As the countries' budget transparency and public engagement indexes increase, their spending efficiency increases. These results suggest that spending efficiency can be effectively used alongside other types of performance information within PBB, particularly for making internal budgetary decisions and management.

Keywords: performance-based budget, data envelopment analysis, central government spending, performance metrics, spending efficiency, central government budget, performance information

1. Introduction

Since the New Public Management era, many governments across the world, not only the United States, have gradually adopted performance-based budgeting (PBB) (Mauro, Cinquini, & Grossi, 2017). PBB requires central budget offices and their service departments to mutually prepare departmental strategic plans. These plans include (a) departmental goals related to a community's master plan, (b) department and program missions, (c) targeted objectives for departmental service outcomes, and (d) strategic activities as well as projected outputs (U.S. Congressional Research Service, 2024). During the budget preparation phase, the central budget offices and service departments align strategic plans with an optimal budget level identified through targeted outcomes (U.S. Congressional Research Service, 2024). Thus, in theory, performance measurement information may influence budgetary resource allocation, especially among programs within the same public service functions, e.g., education, health, environment, and public infrastructure (Mikesell, 2017).

The concept of PBB is promising in aligning public resources with a government's goals since it integrates performance information into the budgeting process. In practice, Ho (2011) found that within a local government department, the use of performance measurement causes budgetary changes at the program levels (p. 391). This suggests that performance information and PBB processes may influence budget decisions. Empirical evidence suggests that PBB processes, especially those adopted through official laws, tend to reduce waste and budget slacks (Park & Jang, 2021; Srithongrung, 2009).

Based on the above theory and findings, performance measurement information may influence budget decisions, thereby improving spending efficiency. Because PBB aligns the budget with targeted service outcomes, it may influence budget decision-makers to either (1) eliminate budget slacks or (2) increase budget levels, depending on performance information and a government's targeted service outcomes. Unfortunately, governments often lack

quantifiable, reliable, and valid measurements for targeted outcomes (Rivlin, 1971; Kettl, 1997; Othman, Kholeif, & Jack, 2019) even though performance measurement information is required in PBB (Lu, 2007).

Mauro, et al. (2017) assert that focusing on the finding that performance information and PBB can change budget allocation is misleading (p. 923). Instead, future research should focus on the uses of performance information and their potential impacts (Mauro et al., 2017). We agree and would like to add the following concept. To choose appropriate kinds of performance information (which may unnecessarily be a single approach), we need to have insights into various performance information regarding their validity and capacity to triangulate with one another. The performance measurement approaches commonly used by governments include citizen satisfaction surveys (Swindell and Kelly, 2000, Van Ryzin, 2004) and program evaluation (e.g., Program Assessment Rating Tool (PART) used by the U.S. Office of Management and Budget during the G.W. Bush Administration in 2002-2009).

Data Envelopment Analysis (DEA) was originally developed by Charnes, Cooper, and Rhode (1978) to assess public programs to improve planning and control the use of public resources. Nowadays, this technique is used worldwide to evaluate public and private producers' performance (Emrouznejad, Banker, Miranda Lopes, & de Almeida, 2014; Mishra, Nayak, & Saraf, 2012). However, in the public administration field, especially for PBB, we have rarely seen DEA usage, except for the excellent work by Ruggiero, Duncombe, and Miner (1995) and Herrera and Pang (2005). This is interesting given that the method was first developed for public performance measurement and improving budgetary resources. This technique emerged around the same time as performance evaluation and public choice school of thought (Niskanen, 1971; De Alessi, 1974; Leibenstein, 1978; and Rivlin, 1971). Although not commonly used by governments, Data Envelopment Analysis (DEA) has begun to receive scholarly attention in the fields of public school finance (Jiang, Lee, & Rah, 2020; Agasisti, 2013) and public highway finance (Hermans, Brijs, Wets, & Vanhoof, 2009).

Given that DEA is a performance measurement tool originally developed for public program spending, this study aims to (1) demonstrate how DEA can be used to obtain insights into the link between world countries' resource allocation processes and public service outcomes, and (2) determine whether DEA measurement results are consistent with those of commonly used approaches including citizens satisfaction surveys and budgeting process evaluations (such as PART).

To effectively use performance information in the PBB process, scholars and practitioners need to better understand whether the selected performance approaches are valid, reliable, and compatible with the public budgeting process (Kettl, 1997). In this study, we used DEA to calculate spending efficiency scores for 94 central governments across the world during 2015-2017, using service outcome as the targeted service accomplishment. We then examined the links among the efficiency scores, central government budgeting practice evaluation scores, and citizen satisfaction survey results. All three types of performance information are from the same period (2015-2017). This is to understand whether DEA efficiency scores are conceptually related to the other two performance measurement metrics (i.e., citizen satisfaction survey and budgeting practice evaluation).

The results suggest that the DEA efficiency scores reveal similar trends and concepts as those of the two performance measurement metrics. As the country samples achieve higher efficiency scores in resource allocation based on service outcomes, both their citizen satisfaction survey results and their budgeting practice scores also increase. These findings contribute to the literature in the public budgeting field that DEA may be a potential PBB tool in improving budget decisions by tailoring budget levels to correspond with governments' targeted service outcomes. For practices, budget officers may consider DEA as an alternative or supplementary tool in deciding budget levels and improving managerial efficiency.

The paper is organized into five major sections. The following section provides literature related to PBB, performance measurement, and DEA backgrounds. The section ends with the paper's conceptual framework for the use of the DEA model as a measurement tool for PBB. The third section provides methodology and data. The fourth section presents results and discussions. The fifth section provides a conclusion.

2. Literature

2.1 Performance-Based Budget (PBB) and Performance Measurement Concepts

In the U.S., PBB received attention during the 1990s at about the same time the concept of new public management was introduced. New Public Management (NPM) emphasizes service-delivery efficiency and effectiveness by government producers (National Performance Review, 1993; Feldman & Khademian, 2002). The main concept is as follows: given that public managers know their citizen clients and have technical knowledge about their programs, they should be able to use their discretion to decide optimal service levels and to allocate a good mix of public resources based on their targeted service outcomes (Osborne & Gabler, 1993). The National Performance

Review (1993) emphasizes eliminating administrative costs resulting from multiple layers of bureaucratic structures and creating an entrepreneurial organization in which workflow and managerial structures are streamlined. In this public management paradigm, public managers are held accountable through their service outcomes rather than service inputs (Osborne, 1993; Denhardt & Denhardt, 2000). In PBB, targeted service outcomes are used not only as a resource control device but also as a managerial improvement device (Mikesell, 2017). In the latter aspect, valid outcome accomplishment indicators are necessary to detect managerial problems and to find the improvement directions to reach programs' targeted goals (Kettl, 1997; Mikesell, 2017).

In the U.S., PBB originated from the 1993 Government Performance Results Act (GPRA) and received more attention when PART was later used by the U.S. Office of Management and Budget (OMB) (Mullen, 2006). The purpose of PBB is to influence budget recommendations and managerial decisions at the program levels (Mullen, 2006). GPRA required that the U.S. central government departments set their service goals, determine annual objectives, create an action plan based on service objectives, and later measure program performance against those goals as well as publicly reporting on progress made (Miller, Hildreth, & Rabin, 2001). PART is a set of questionnaires developed by the G.W. Bush administration to assess federal programs' effectiveness (outcomes/results) (Congressional Research Service, 2024). The PART questionnaires were comprised of four sections: purpose and design; strategic planning; program management; and program results/accountability. Related to GPRA and PART, the goal of the PBB process is to (1) increase governance through service delivery quality which includes both efficiency and effectiveness, (2) focus on targeted outcome and strategic management practices to decide an action plan, and (3) use internal performance data and information to improve the service production process (Mikesell, 2010).

PBB differs from the traditional performance budget in that it strategically connects departments' goals and missions with outcomes through action plans. The traditional performance budget, such as activity-based cost (ABC), connects the budget with activities, while PBB connects the budget with outcomes. As is common with NPM concepts, PBB allows managerial flexibility by permitting public managers to shift funds and determine input mixes (e.g., labor, machines, contracts, and raw material supplies) for the production process if they can achieve targeted service outcome (Osborne & Gaebler, 1993). The PBB and NPM hold public managers accountable for service results, focusing on ex-post service results rather than ex-ante service inputs (Thompson & Jones, 1986). In theory, PBB allows fund transfers among programs within the same department and from one fiscal year to another as incentives for public managers to save budgetary resources while accomplishing program service goals (Osborne & Gaebler, 1993).

In contrast to other budget reforms that can serve only one function at a time (i.e., financial controlling, managerial efficiency, planning and programming effectiveness) (Schick (1966), PBB focuses on both program effectiveness and spending/or managerial efficiency. The PBB can be thought of as a strategic budgeting approach which is adopted when organizations have limited resources but are still required to produce a given amount of output (Reed & Swain, 1997). Because PBB links strategic planning with budget allocation and uses targeted outcomes as a guide for budget allocation, we expect to see the efficiency in governments' spending.

2.2 Data Envelopment Analysis

Charnes et al. (1978) originally developed DEA to evaluate public organizations' performance through productivity benchmarking techniques. Management efficiency refers to a ratio of output to input; a greater ratio suggests greater productivity (Dario & Simar, 2007). DEA (1) uses mathematical programming techniques to calculate the ratio of multiple outputs to multiple inputs by a producer, (2) identifies the best performers in a group based on the samples' efficiency ratios, and (3) compares an inefficient unit's performance with those of the best performers (Sherman & Zhu, 2006). Being nonparametric, DEA can use outcomes as alternative output measures if they can be quantified. This is because the DEA mathematical program focuses on ratios of output (or outcome) units and input units rather than the causality linkage between the denominator (inputs) and nominator (outputs or outcomes) (Dario & Simar, 2007). Thus, in this study, we opt for government service outcomes rather than outputs, to be consistent with PBB concepts.

In an input-oriented model, the DEA efficiency score, ranging from 0 to 1.0, reflects the targeted level of input a producer should use to accomplish the same level of outcome (i.e., the outcome is fixed, but the input can be adjusted). The DEA scores are identified by using the production profiles of the best performers in the group as a reference for other producers in the group. For example, a DEA input-oriented score equal to 0.7 suggests that the producer could cut 30% of input to achieve the same outcomes, as compared to the best performers in the group. The best performers have an efficiency score equal to 1.0, while the worst performers have an efficiency score equal to zero. The DEA efficiency score of any producer in a group is relative to those of the samples or peers.

For this reason, we cannot assume that the best performers (whose DEA score equals 1.0) in a group are universally efficient unless all producers in the group have the same profiles in terms of production size, technological advancement, environmental settings, and input prices (Sherman & Zhu, 2006). Once the samples in the study group are changed, the best performers identified by DEA may change. However, among the samples or peers with different profiles, we can say that the best performers are the most efficient compared to other real performers in the group given the producers' unique profiles. This DEA characteristic is very suitable for the public sector for two reasons. First, the public service by governments is unique. Second, there are not many private sector organizations producing the same public service; performance benchmarks resulting from multiple producers who have identical profiles are almost impossible (Thompson & Jones, 1986).

In addition to the efficiency scores, DEA can identify the causes of inefficiency by calculating economic efficiency (EE), allocation efficiency (AE), and scale economy (SE) (Dario & Simar, 2007). This DEA characteristic is powerful in public budgeting and productivity management because it gives a clue to the evaluators about the causes of inefficiency. In theory, management efficiency results from several factors, including (1) technical advancement, (2) input price, (3) the mix of input used to produce outcomes, and (4) scale economy (Dario & Simar, 2007). Without understanding that these factors contribute to efficiency, public managers (and citizens) may incorrectly assume that government inefficiency is due to only input price. However, the inefficiency could be due to unattainable targeted outcomes (e.g., unreasonably high public service demands), the lack of technological advancement, or using the wrong mix of inputs given their prices. Practical examples of wrong input mix are (1) when a public school could contract a school lunch service instead of using in-house production, and (2) a city could use parking fee collection machines instead of hiring human personnel. Given their prices (or wrong input mix), these wrong resource allocations could also result in inefficiency.

2.3 How can DEA be used in PBB Process?

Because of its capacity to measure the overall efficiency (i.e., technical efficiency [TE]) of a producer relative to its peers and identify the causes of inefficiency, DEA appears to be appropriate for PBB's processes. In addition, DEA was originally designed to assess public program performance, as mentioned above. In particular, the DEA scores, derived from calculating the ratio of multiple public inputs to multiple public outcomes, can be used as a supplementary (or an alternative) tool to decide whether the proposed budget should be cut or augmented. This performance information helps governments to obtain insights into their budget spending level and production process. Thus, we consider that DEA unlocks the managerial black box, connecting service inputs (i.e., budget) with service outcomes. Figure 1 below presents a conceptual framework for DEA in the context of PBB used as an outcome measurement tool by central governments.

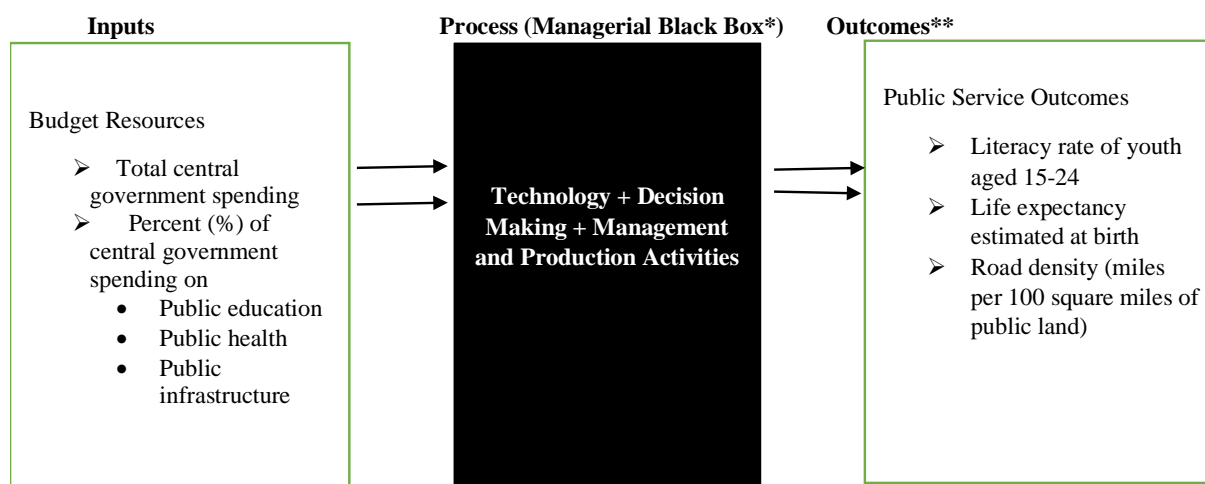


Figure 1. DEA Conceptual Framework in Context of Performance-Base Budget (PBB)

Note. The DEA unlocks the managerial black box by identifying efficiency level and types of inefficiency, including technical efficiency (TE), scale efficiency (SE), economic efficiency (EE), and allocative efficiency (AE). **Performance efficiency (or productivity) = outcomes/inputs.

2.4 Conceptual Framework for the DEA Model

Figure 1 illustrates that central governments are basically responsible for main service functions such as education, health, and public infrastructure. These functions are core government service productions due to one of the following reasons: uneven resource redistribution (education), market failure (health), and requiring a very large cost in starting the public service production process (public infrastructure). In the PBB context, as presented in Figure 1, total public spending is considered the main input of the public production process. The percentages of central government spending on the three core public service programs (i.e., education, health, and infrastructure) are incorporated to examine the efficiency of the input mix by each central government. The two categories (i.e., total public spending and percentages of core service spending) are not necessarily the same because other public spending (e.g., welfare service, debt services, public pension and retirement systems, economic development, and intergovernmental spending) are excluded in this study. Spending levels in the three core public service programs are considered input levels and input mixes (as shown in the left-side box in Figure 1). Publicly desirable goals (i.e., literacy, life expectancy, and transportation network availability) are considered the outcome of government production processes (as shown in the right box of Figure 1).

As shown by the middle box of Figure 1, DEA opens the managerial black box of public management by linking inputs with outcomes, identifying the production efficiency of each government as compared to its peers facing the same sets of public goals and challenges. DEA efficiency scores including technical efficiency (TE), scale efficiency (SE), economic efficiency (EE), and allocation efficiency (AE) identify not only the overall efficiency levels of the country samples but also the causes of inefficiency.

3. Methodology and Data

In this study, we implemented two stages of analysis. In the first stage, we estimated the 94 countries' central government spending efficiency during 2015-2017 through DEA techniques. The DEA model has three inputs, three prices, and three outcomes. The first stage yields 94 countries' efficiency scores including TE input-oriented, TE output-oriented, EE, and AE. The SE is noted at the end of the DEA process. In the second stage, we examined the correlations between DEA efficiency scores and the other performance measurement information including:

- (1) citizen satisfaction survey results for core public service functions including education, health, and transportation, and
- (2) central governments' budgeting practice evaluation scores

Statistically significant correlation coefficients between DEA efficiency scores and each of the two types of performance information suggest the following patterns: (a) efficiency measurements linking budgeting level with service outcomes are conceptually related to citizen satisfaction toward public service and (b) budgeting practices may positively relate to managerial efficiency, especially when the targeted outcome is a factor in the budget decision.

3.1 Stage 1 Analysis

Table 1 below presents concepts, measurements, and data sources for the variables used in the DEA model. As seen in Table 1, three inputs, including percentages of government spending on education, health, and infrastructure were used. The public service production prices include the percentage of tax burden to Gross Domestic Product (GDP), the percentage of total government spending to GDP, and the Production Price Index (PPP). The three public service outcomes include the percentage of literacy among the youth citizens aged 15 to 24 years old, the life expectancy at birth, and the road length per square kilometer. All data sources are present in the last column of Table 1. Note that in the DEA model, the countries' budget input data lags two years behind their service outcome data. We intentionally selected the two-year lag between budget input and service outcome data to allow government programs to manifest their short- to intermediate-term outcomes. Therefore, all input and price variable data are in the year 2015 while outcome variables are in the year 2017.

Table 1. Variables used in DEA analysis (stage 1 analysis)

DEA Variable	Concept	Measurement	Data Sources
Input 1	Government spending on education	% of public spending on education to total government expenditure)	National Account Table, World Development Data, the World Bank
Input 2	Government spending on health	% of health expenditure, public to total government expenditure	National Account Table, World Development Data, the World Bank,
Input 3	Government spending on public infrastructure	% of public infrastructure outlays to total government spending	Government Finance Statistics, Other Government Expense including public capital spending for non-financial assets, International Monetary Fund
Price 1	Public service price paid by citizens	Tax Burden % GDP	Index of Economic Freedom, Heritage Foundation
Price 2	Public service price faced by central government unit	Gov't Exp % GDP	Index of Economic Freedom, Heritage Foundation
Price 3	Local production price index faced by each central government	2015 price level of government consumption	2015 Production Price Index (PPP). Penn World Data Base
Outcome 1	Citizens' formal education opportunity	literature rate, youth total (% of people aged 15-24)	World Development Data, the World Bank
Outcome 2	Citizens' access to basic health including prevention care, risk factors for serious disease, and standard health care accessibility	life expectancy at birth (years)	World Development Data, the World Bank
Outcome 3	Public transportation networks, especially through roads and ground transportation	Road density (km of road per 100 sq. km of land area)	World Development Data, the World Bank

The study departs from those of Herrera and Pang (2005) and Ruggiero, Duncombe, and Miner (1995), in that it incorporates price data into the DEA model. Propher (2015) argues that, in efficiency measurement, the cost of public service should be incorporated to control the different costs of living, varying across countries. We used three types of public service costs. First, the total tax burden imposed by the central government is an indicator of

public service costs in education, health, and transportation networks. Second, total public expenditure is the overall costs of service faced by the central government; these costs include labor, equipment, research, and development expenditures. Third, the government consumption price is the local price faced by each individual government. Table 2 below presents summary statistics for the data used in our DEA model. As shown in Table 2, in 2015, the average effective tax rate (or total tax burden) for the 94 countries was 20%. The average government expenditure to GDP (or total public expenditure) is 32%. The average production price index faced by 94 country samples is 71.

For input variables, as shown in Table 2, the 94 country samples, on average, spend about 16%, 11%, and 9% of the total spending on education, health, and public transportation programs, respectively. For outcome variables, we used youth literacy rate to reflect governments' service outcomes in providing accessibility to formal education. In 2017, the average literacy rate of the youth sample (age 15-24 years old) was about 91%. We used the life expectancy rate to reflect governments' service outcome in providing basic health services. In 2017, the average life expectancy at birth was 69 years old. We used the road density rate to reflect the capacity of governments to provide public transportation networks corresponding to citizen demands. On average, in 2017, the country samples processed 58 kilometers of road per 100 square miles of land area.

Table 2. Summary statistics for the variables in the DEA model

Variables	Mean	Standard Deviation	Minimum	Maximum	Total Observation
Input 1: Government spending on education (INP1) (%)	15.89	5.16	7.08	31.11	94
Input 2: Government spending on health (INP2) (%)	11.19	4.17	3.58	28.03	94
Input 3: Government spending on public transportation (INP3) (%)	8.56	7.98	-0.01	39.91	94
Price 1: Public service price paid by citizens or tax burden (INPRICE1) (%)	19.91	9.74	2	57.7	94
Price 2: Public service price faced by central government – % of government expenditure to GDP (INPRICE2) (%)	32.11	10.14	13.459	62.103	94
Price 3: Production price faced by central government – Penn World price level of government consumption (INPRICE3)	70.61	41.13	8.55	168.55	94
Outcome 1: Formal education opportunity – youth (15-24 years old) literacy rate (%) (OUT1)	90.59	14.48	36.55	99.97	94
Outcome 2: Citizens' access to basic health service – life expectancy at birth (OUT2) (years)	69.41	8.77	47.98	82.33	94
Outcome 3: Public transportation network – Road density (OUT3) (km of road per 100 square km of land area)	57.66	118.20	0.72	968	94

Following Herrera and Pang's (2005) conceptual framework and approaches, we estimated the government efficiency index in education, healthcare, and public transportation through Data Envelopment Analysis (DEA). The productivity index is calculated by the DEA model (by Charnes et al., 1978), which is mathematical linear programming based on the number of inputs and outputs used by decision-making units (DMU). Kim, Kim, and Shin (2014, p. 57-58) and Lee and Brower (2006, p. 164-165) provide a good review for standard DEA mathematical models according to Fair, Grosskopf, and Lovell (1994). These standard models yield a technical efficiency (TE) score based on two assumptions: input-oriented and output-oriented models. As mentioned above, TE refers to the overall efficiency including technological advancement, price, and input mix. The input-oriented

model focuses on the input usage, while the output-oriented model focuses on outcome achievement level. To achieve efficiency, a country may either reduce input levels or increase outcome achievement levels, depending on specific units and models.

3.2 State 2 Analysis

In Stage 2 Analysis, we derived the central government budget practice evaluation data from the year 2015 from the 94 countries from the International Budget Partnership (IBP). We also retrieved the citizens' satisfaction survey results regarding the quality of public services in education, health, and infrastructure in the year 2017 from Gallup World's Poll Survey. The Gallup World Poll Survey's Community Basic Index measures peoples' perceptions about their everyday life in a community including environment, health service, and infrastructure. According to Gallup Analytics (2017), the index is the measurement of "overall satisfaction" with life in a community as a place to live. Four questionnaires that are relevant to the three public service functions in this study include: (1) *In the city or area where you live, are you satisfied or dissatisfied with the public transportation systems?* (2) *In the city or area where you live, are you satisfied or dissatisfied with the roads and highways?* (3) *In the city or area where you live, are you satisfied or dissatisfied with the availability of the quality of healthcare?* and (4) *In the city or area where you live, are you satisfied or dissatisfied with the educational system or the schools?* We are aware that the index is constructed based not only on these four questions but also on other questions asking about the respondent's satisfaction with the quality of air, quality of water, housing availability, and quality. As our objective is to analyze the correlation between DEA scores and citizen satisfaction survey results regarding public service, rather than investigating the causality between these variables, the overall satisfaction survey is deemed appropriate. This survey includes content related to citizens' satisfaction with the three public services.

We used four main indicators to gauge a country's budgeting practices based on IBP's documental analysis and evaluation. All indicators range from 0 to 100 points. The first IBP indicator is the *Open Budget Index*, which evaluates whether a country's budget documents, and planning are transparent, available for public scrutiny prior to legislative decision processes, and publicly available on government websites. The second IBP indicator is the *Public Engagement Index*, which indicates how a country incorporates citizens' inputs and encourages its citizens to engage in the central government budgeting process. The third IBP indicator is the *Legislative Strength Index*, which measures whether the country's elected officials have enough knowledge and information to decide on a budget based on policy priority and outcomes. One of the several factors that IBP used to evaluate is whether a country's legislative office has legislative researchers who can provide technical information and analyses to the decision-makers, especially in terms of spending, program output, and program outcomes. The last IBP indicator is the *Audit Strength Index*, which measures how well the country's auditing system functions, including but not limited to having an official comprehensive annual financial report publicly available, having a third party (outside of the central government) audit financial statements, and having a comptroller office report financial and performance audit both in the current and previous years. All four indicators were evaluated by IBP researchers and are assigned to a composite index ranging from 0 to 100 (0 suggests that a country's budget system is the weakest and 100 is the strongest).

Table 3 below presents the summary statistics for the five variables used in Stage 2 Analysis. Note that the IBP budget practice composite index is in the same years as those of input and price variables in the DEA model, i.e., year 2015. This is because the budgeting practices and spending levels on the service programs occur approximately in the same year. Meanwhile, the citizen satisfaction survey results are from the same years as those outcomes in the DEA model, i.e., year 2017. This is because we believe that service outcomes need sometimes to be realized after government spending and implementation. As shown in Table 3, the countries achieved 42, 20, 52, and 69 points, on average, for the levels of openness, public engagement, legislative strength, and audit strength in the budgeting process, respectively. As also shown in the last column of Table 3, citizen satisfaction with their government service index was 60 on average.

Table 3. Summary statistics for IBP's central government budget practice and Gallup's citizen satisfaction survey for core public service indexes

	IBP's 2015 Open Budget Index (1- 100)	IBP's 2015 Public Engagement Index (1- 100)	IBP's 2015 Legislative Strength Index (1- 100)	IBP's 2015 Audit Strength Index (1- 100)	Gallup's 2017 Community Index (as an Indicator for Citizen satisfaction)
Mean	42.3	19.5	51.9	68.8	60.0
Standard Deviation	24.3	17.0	21.5	27.8	12.4
Minimum	0	0	0	0	29.4
Maximum	93	92	91	100	82.0
Count	94	94	94	94	94

In Stage 2 Analysis, we used DEA results and the data in Table 3 to examine:

- (1) Pearson's correlation between the DEA efficiency scores and Gallup's citizen satisfaction survey on core government service, and
- (2) Pearson's correlation between the DEA efficiency scores and IBP's Central Government Budget Practice Indexes.

The first analysis determines whether the DEA efficiency score is relevant to the citizen satisfaction survey (i.e., construct validity). If the correlation coefficient is significant, then it is likely that the DEA approach yields result consistent with those of the citizen satisfaction survey. This suggests that DEA can be an alternative or supplemental measurement tool for PBB. The latter analysis determines if the DEA scores can reveal similar trends to those of IBP budgeting practices (i.e., criterion-related validity). If DEA can do so, the correlation coefficients between DEA scores and IBP budgeting practices will be significant. In brief, we use Gallup's citizen satisfaction survey and the IBP budget practice evaluation results as an anchor to see if DEA scores convey similar or relevant concepts to the first and second types of performance information, respectively.

4. Results and Discussion

In Stage 1 Analysis, we executed DEA calculations to derive the countries' public service spending efficiency scores, using data discussed in the last section. Table 4 below presents a summary of the DEA results. The full results of each country sample are presented in the Appendix.

Table 4. DEA calculation results

Data Envelopment Analysis (DEA) Results				
Input Variables: Government Spending on (1) Education, (2) Health, and (3) Transportation Network				
Outcome Variables: % youth literacy rate, life expectancy at birth, road network density				
Price Variables: % tax burden, % government consumption on GDP, Penn World's local price level				
Sample Size: 94 Decision-making Unit (DMU); 92 Complete DMU				
Technology Assumption: Variable Returns to Scale (VRS)				
Estimated Efficiencies:	Mean	Std. Deviation	Minimum	Maximum
Technical Efficiency (TE)				
– Input-Oriented	0.7527	0.1972	0.3703	1.0000
– Outcome-Oriented	0.9388	0.094	0.6268	1.0000
Economic Efficiency (EE)	0.5948	0.2192	0.1498	1.0000
Allocative Efficiency (AE)	0.7883	0.178	0.1602	1.0000

The DEA efficiency scores were mathematically calculated for three different efficiency types, namely technical efficiency (TE), economic efficiency (EE), and allocative efficiency (AE). TE refers to the overall technical efficiency of a country in using public budgets to produce public service. TE includes TE input-oriented and TE outcome-oriented scores. A TE-input-oriented score suggests the percentage of input a country should use to achieve the current outcome level, as compared to those of the best country performers in the group. For example, a country's TE input-oriented score equal to 0.40 suggests that the country needs to cut 60% of its budget level to achieve the same level of service outcomes it currently produces. Note that this is a relative concept; the DEA compares the country's production profile with the rest of its peers. A TE outcome-oriented score suggests a percentage of outcome a country should produce more, as compared to those of the best country performers in the group. For example, a country's TE outcome-oriented score equal to 0.40 suggests that the country should produce 60% more of the current level of its outcome achievement.

As seen in Table 4, the average TE input-oriented score is 0.7527, suggesting that, on average, the countries could use approximately 25% (1-0.75) less than their current budget levels to achieve the current service outcome levels. As shown in Table 4, the average TE outcome-oriented score is 0.9388, suggesting that, on average, the countries could achieve 6% (1-0.94) more than the current outcome using the same amount as their current budget level. Based on the average TE input-oriented and TE outcome-oriented scores shown in Table 4, our interpretation is as follows:

(1) In 2015-2017, most countries performed well when it came to producing public service since they achieved 94% of the public service level they were supposed to achieve as compared to the best country performers in the group.

(2) However, for the same period, most countries were struggling with input usage since they could cut about 25% of the budget given the existing outcome and price, as compared to the best-performing countries. This problem could result from the countries' high input cost, the wrong mix of input usage, or the diseconomy of scales, which were further analyzed.

EE refers to economic efficiency given the countries' input price and amount. Table 4 shows that the average EE score is 0.5948, suggesting that, on average, the cost of public service can be cut by about 40% given the input price, usage, and country's outcome achievement. AE refers to allocative efficiency resulting from using the appropriate input mix in the production process given input price. For example, if the labor cost is expensive, the public producer may consider reallocating labor costs to machine usage or contracting out. Table 4 shows that the average AE score is 0.7883. This suggests that, on average, 79% of input usage is allocated appropriately given input prices. Combining the EE and AE results, we interpret that, on average, the country samples perform better in terms of choosing the right mix of inputs; the main cost of inefficiency in the input-oriented model is likely to come from input cost. In other words, the cause of inefficiency (judged by TE input-oriented) is likely to be too high of a cost instead of the wrong mix of input usage.

SE refers to the stages of the production process including steady, cost recovery, and maturity stages. In the steady stage, the ratio of outcome achievement to input usage is about one-to-one, meaning that a country producer has recovered the relatively large, fixed cost of public service that tends to occur in the beginning stage of production. This stage is referred to as constant return to scale (CRS). In the cost recovery stage, the ratio of outcome achievement to input usage is greater than one-to-one, meaning that a country producer must produce more outcomes to recover the fixed cost. This stage is called increasing return to scale (IRS). In the maturity stage, the ratio of outcome achievement to input usage is smaller than one-to-one. This means that a country producer must consider creating new programs since the existing programs become cumbersome, possibly due to bureaucracy. This stage is called decreasing return to scale (DRS).

The DEA reveals the production stage of every country producer in the group by comparing a country's DEA scores derived from the CRS assumption with those derived from the variable return to scale assumption (VRS). The VRS can be either IRS or DRS depending on the difference between the CRS and IRS scores. Table 5 below presents the list of the countries and their production stages, segregated into three groups based on the Scale Economy (SE) analysis results. As seen in Table 5, 14 countries are in the steady stage of production (CRS). Fifty-four countries are at the cost recovery stage of their public service production (IRS). Twenty-six countries are at the maturity stage of public service production (DRS). The countries in the cost recovery stage should keep producing more outcome levels so that they can recover the relatively high fixed cost of public service invested in earlier periods. The countries in the maturity stage should consider replacing the old service programs with the new ones that are more streamlined in terms of management layers and bureaucratic processes. The SE results are consistent with those of other DEA scores, especially for EE: on average, the causes of inefficiency faced by the

countries could be either (a) expensive input cost (b) stages of production, or both. Possible solutions include either (a) cost cutting or (b) keeping production toward more service outcomes to distribute fixed costs.

Table 5. Scale economy (SE) results (input-oriented)

Scale Economy (SE) Based on TE Input-Oriented Grouping.	
(Countries listed according to DEA SE Input-Oriented and in Descending Value)	
Steady Stage of Production (CRS = VRS, TE Input-Oriented); SE Score = 1.000	Azerbaijan, Bahrain, Brazil, Cyprus, Kazakhstan, Kenya, Lebanon, Macedonia, Malaysia, Malta, Oman, Pakistan, Panama, Serbia
Cost Recovery Stage of Production (IRS as defined by DEA)	Algeria, Bangladesh, Belize, Benin, Bhutan, Botswana, Bulgaria, Burkina Faso, Burundi, Cambodia, Cape Verde, Central African Republic, Colombia, Costa Rica, Dominican Republic, Egypt, El Salvador, Ethiopia, Ghana, Guatemala, Guinea, India, Iran, Israel, Jamaica, Kuwait, Lao PDR, Lesotho, Madagascar, Mali, Mauritius, Mongolia, Morocco, Namibia, Nepal, Niger, Philippines, Romania, Swaziland, Thailand, The Gambia, Togo, Tunisia, Turkey, Uganda, Venezuela, Zambia, Nicaragua, Paraguay, Peru, South Africa, Trinidad and Tobago
Maturity Stage of Production (DRS as defined by DEA)	Argentina, Armenia, Belarus, Bolivia, Chile, China, Croatia, Estonia, Georgia, Greece, Hungary, Indonesia, Italy, Jordan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Poland, Portugal, Russia, Slovenia, Spain, Tajikistan, Ukraine, Uruguay

Note. SE = VRS TE input-oriented/CRS TE input-oriented

In Stage 2 Analysis, we examined the correlation coefficients between DEA scores and the Gallup’s citizens’ public service satisfaction survey index, and the DEA scores and IBP budgeting practice scores. As aforementioned, we examined Pearson’s correlations of the two pairs of performance information to understand:

- (1) whether DEA efficiency scores linking budgeting level with service outcomes reveal the same trend as those of Gallup’s citizen satisfaction survey results, and
- (2) whether DEA efficiency scores relate to IBP’s budgeting practice score

Table 6 below presents Pearson’s correlation matrix among a country’s DEA scores (i.e., TE input-oriented, TE output-oriented, EE, and AE) and IBP budget practices (i.e., open budget index, public engagement index, legislative strength index, and audit strength index), as well as Gallup’s Community Basic Index. Table 6 presents the correlation analyses among the three types of performance information (i.e., DEA efficiency scores, IBP budget practice indexes, and Gallup’s citizen satisfaction for core public service index).

Table 6. Pearson’s correlation coefficients among the three types of performance information: Author’s DEA efficiency scores, IBP’s Budget Practice scores, and Gallup’s Survey Results for Citizen Satisfaction toward core public service.

Gallup’s Citizen Satisfaction Survey	TE Input Oriented Score	TE Output Oriented Score	EE Score	AE Score	IBP Open Budget Practice Score	IBP Public Engagement Practice Score	IBP Legislative Strength Score	IBP Audit Strength Score

Gallup's Citizen Satisfaction Survey Results	1.000								
TE Input- Oriented Score	0.067	1.000							
TE Output-Oriented Score	0.245**	0.502**	1.000						
EE Score	0.101	0.738**	0.417**	1.000					
AE Score	0.085	0.041	0.118	0.682**	1.000				
IBP Open Budget Practice Score	0.092	0.217	0.378**	0.125	-0.031	1.000			
IBP Public Engagement Practice Score	0.103	0.2	0.275**	0.290**	0.211	0.576**	1.000		
IBP Legislative Strength Score	-0.038	-0.012	-0.054	-0.002	-0.033	0.504**	0.410**	1.000	
IBP Audit Strength Score	0.260*	0.0485	0.173	0.046	0.002	0.496**	0.414**	0.412*	1.000

Note. **Indicates statistical significance at .05 level, *** Indicates statistical significance at .01 level

As shown in Table 6, the TE output-oriented score statistically and positively correlates with Gallup's citizen satisfaction survey for Core Public Service at a .01 level (coefficient 0.245). Although the magnitude of the correlation is not relatively large, it is statistically significant, and hence, we can conclude that DEA performance information, especially for TE output-oriented, shares the same concept as those of citizens' perception toward core public service. The more the countries achieve overall efficiency, the greater satisfaction the citizens feel toward core public service. It is important to note that the measurements are from different approaches and evaluators. Furthermore, Gallup's survey contains more types of citizen satisfaction toward their community other than education, health, and infrastructure. The fact that the two types of performance information (i.e., DEA and Gallup's citizen satisfaction survey) are statistically and strongly correlated (at .01 level), suggests that they may share the same concepts for government performance.

As shown in Table 6, Pearson's correlation coefficient between IBP's open budget practice and TE output-oriented scores is 0.378. Pearson's correlation coefficient between IBP's public engagement and TE output-oriented scores is 0.275. Pearson's correlation coefficient between IBP's public engagement and EE scores is 0.290. All three coefficients are statistically significant at the conventional level (.05 level). These results suggest that transparency in public budgeting conceptually relates to budget efficiency. Likewise, public engagement conceptually relates to economic efficiency in public budgeting. These results are understandable given that citizen inputs and public scrutiny can shape public performance through management and budgeting levels. Once again, although these correlation coefficients are not relatively large, they are statistically significant at the conventional level (i.e., .05 level). Thus, we interpret that the performance information measured by IBP's and DEA's approaches share the same concepts in terms of public performance and budgeting quality. This is because the two types of performance information come from different sources and are measured by different evaluators, but they appear to be statistically correlated.

We further note that TE output-oriented scores significantly correlate with both IBP budgeting practice (coefficients 0.378 and 0.275) and Gallup's citizen survey (coefficient 0.245). These results, combined, suggest that the TE output-oriented measurement is relevant to the citizens' perceptions. This is reasonable since citizens can perceive government performance through service outcome levels. Meanwhile, the internal management process identified through input mix (AE) and budget level (TE input-oriented) are less observable by the public's eyes.

5. Conclusion

As Lu (2007) maintains, performance measurement is a prerequisite for PBB. The PBB shares the NPM's, GPRA's, and PART's concepts in that governments are held accountable toward outcomes and budgeting levels should be allocated based on targeted outcomes. Public budgeting literature suggests that researchers should sort through the types of performance information and its impact on government spending. We agree and would like to add that prior to this, researchers might want to obtain some insights into the quality and concepts of each type of performance information so that they can correctly match the type of performance information with budget impacts. For this reason, we executed two tasks in this study. First, we introduced the DEA approach and demonstrated its usage and benefits in evaluating 94 countries' spending efficiency based on their service outcome. Second, we compared DEA efficiency measurement scores with the other two different types of performance information, derived from different approaches and evaluated by different institutions. The first performance result used to compare with the DEA results is IBP's country budgeting practices. The latter is Gallup's Community Basic Index as a proxy for the overall citizen satisfaction toward public service.

For the first purpose, the DEA analytical results from Stage 1 Analysis suggest that, in the DEA output-oriented model, most countries perform well in terms of producing outcomes, compared to the best-performing countries in the group (see the Appendix for the best performers). On average, they achieve public service outcomes at about 94% given that their budget level is fixed. However, in the DEA input-oriented model, most countries suffer from being inefficient due to input usage. On average, they need to cut about 25% of the budget used to achieve the same outcome level as those in the studying period. DEA results further reveal that this inefficiency may result from the relatively high cost of public service production input (as revealed through the economic efficiency score), rather than the wrong mix of input usage such as labor and capital (as revealed through the allocative efficiency score). On average, the countries could cut input costs by about 40%. Meanwhile, on average, only 21% of the input used by the country samples is the wrong type. Finally, scale economy scores suggest that a majority of the country samples (54 countries) are at the cost recovery stage. To achieve efficiency, they need to keep producing public service at a level greater than what they achieved in the studying period.

For the second purpose, Pearson's correlation matrix reveals that budget efficiency measurement results derived from the DEA approach share the same concepts as those of the citizen satisfaction survey approach. This is especially true for the TE output-oriented model. Budget efficiency measurement results derived from the DEA approach share the same concepts as those of budgeting practice indexes. This is especially true for the relationship between (1) budget transparency practice and TE output-oriented scores, (2) public engagement in budgeting practice and TE output-oriented scores, and (3) public engagement in budgeting practice and EE scores. All three types of performance information are from the same period, but they are measured by different approaches and evaluators. The fact that the three types of performance information are correlated suggests that they share similar concepts in government performance, and thus, DEA can be a potential tool to be used as a supplementary approach in the PBB process. This is especially through obtaining insight into managerial efficiency at the program level.

The results of this study contribute to both theory and practice. The findings add into the public budgeting field that the DEA approach can yield results that are consistent with the other types of performance information, and hence, it may be a potential PBB tool in improving budget decisions by tailoring budget levels to correspond with governments' targeted service outcomes. In fact, triangulation of multiple performance information may help budget officers and program managers become more confident in making budget recommendations. Furthermore, since both citizen satisfaction surveys and budgeting practices are correlated with DEA results, scholars in the field may choose citizen satisfaction survey results for budget recommendations since the public is most familiar with this approach. At the same time, the budgeting officers can use the DEA tool to detect causes of inefficiency and adjust the amount of input and price as suggested by the government peers. Furthermore, the top management can redesign budget procedures, informed on how transparency and citizen engagement are related to spending efficiency.

This study is not without limitations. The first limitation is that the data used in this study is not from the current period and is only in a single period. Gallup Analytics survey results are not publicly available free of charge, and hence, we are limited to only a year of data from when we could access them at one point in the past. Future studies should replicate this study using more updated and longitudinal data. Second, although the DEA approach is forgiving in the sense that it does not require causality between inputs and outcomes of the model, its nonparametric method cannot guarantee that the results are generalizable to different sample groups. Thus, further studies should validate the DEA results with other efficiency measurement methods such as Stochastic Frontier Analysis (STA), which is a parametric method to generalize DEA results. Last, the correlation analysis results in

this study do not necessarily indicate causality among all three types of performance information, and hence, we cannot conclude that government spending efficiency results in citizen satisfaction. Likewise, we cannot conclude that good budgeting practices result in government spending efficiency. Future studies should also try to investigate the causality among these variables.

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Appendix A

Table B1. Detailed efficiency scores by country and type

Country	TE, Input-Oriented		TE, Output-Oriented		Economic (EE)		Allocative (TE/EE)	
	Rank	Value	Rank	Value	Rank	Value	Rank	Value
Algeria	61	0.67515	69	0.91871	39	0.63166	19	0.93558
Argentina	73	0.56466	37	0.9923	65	0.45361	53	0.80333
Armenia	25	0.95009	28	0.99838	72	0.41076	88	0.43234
Azerbaijan	1	1	1	1	78	0.37518	90	0.37518
Bahrain	1	1	1	1	1	1	1	1
Bangladesh	69	0.59496	78	0.86082	69	0.41643	68	0.69993
Belarus	59	0.67916	26	0.9985	41	0.63019	23	0.9279
Belize	54	0.70901	65	0.94944	43	0.59549	47	0.83989
Benin	72	0.57429	88	0.69912	56	0.5157	29	0.89798
Bhutan	62	0.67157	77	0.86875	52	0.544	52	0.81004
Bolivia	43	0.76905	36	0.99439	33	0.66996	36	0.87115
Botswana	35	0.83223	64	0.95356	19	0.75794	27	0.91073
Brazil	1	1	1	1	11	0.92455	24	0.92455
Bulgaria	41	0.79966	51	0.97964	28	0.69518	37	0.86935
Burkina Faso	90	0.40122	89	0.67494	90	0.22483	81	0.56038
Burundi	68	0.61205	84	0.77596	64	0.45773	60	0.74788
Cambodia	30	0.87658	74	0.87592	20	0.74533	43	0.85028
Cape Verde	49	0.74448	47	0.98364	29	0.69089	22	0.92801
Central African Republic	71	0.58804	91	0.6519	71	0.41156	69	0.69988
Chile	66	0.6345	39	0.9894	91	0.21544	91	0.33955
China	48	0.74782	35	0.99449	26	0.70578	16	0.94379
Colombia	81	0.4888	49	0.98129	87	0.2555	82	0.52272
Costa Rica	89	0.40648	48	0.98307	86	0.26231	77	0.64532
Croatia	31	0.87575	32	0.99719	53	0.54379	78	0.62094
Cyprus	1	1	1	1	1	1	1	1
Dominican Republic	55	0.69451	58	0.96854	48	0.5795	48	0.83441
Egypt	37	0.82029	63	0.95589	35	0.65407	55	0.79737
El Salvador	77	0.53963	62	0.96059	76	0.38017	67	0.70449
Estonia	34	0.83224	27	0.99842	22	0.73679	33	0.8853
Ethiopia	33	0.86207	83	0.80344	59	0.50088	79	0.58102
Georgia	1	1	1	1	16	0.85694	41	0.85694
Ghana	83	0.45764	82	0.80858	83	0.34264	59	0.7487
Greece	21	0.99461	23	0.99876	30	0.68473	73	0.68844

Guatemala	91	0.38986	76	0.87045	77	0.37803	12	0.96965
Guinea	22	0.98966	85	0.77012	31	0.67492	74	0.68197
Hungary	36	0.82568	38	0.98981	49	0.5755	70	0.69701
India	47	0.74817	79	0.85152	34	0.65804	34	0.87953
Indonesia	1	1	1	1	50	0.57478	80	0.57478
Iran	74	0.55111	44	0.9869	70	0.4146	58	0.7523
Israel	1	1	1	1	17	0.82071	49	0.82071
Italy	1	1	1	1	1	1	1	1
Jamaica	32	0.86266	57	0.9686	74	0.40103	85	0.46487
Jordan	64	0.63986	40	0.98889	54	0.54171	44	0.84661
Kazakhstan	1	1	1	1	1	1	1	1
Kenya	1	1	1	1	12	0.92416	25	0.92416
Kuwait	26	0.93508	41	0.98864	92	0.14976	92	0.16016
Kyrgyz Republic	46	0.74962	25	0.99853	25	0.71268	15	0.95072
Lao PDR	29	0.87668	72	0.89804	21	0.7371	46	0.84079
Latvia	23	0.97794	21	0.99918	14	0.87247	31	0.89215
Lebanon	1	1	1	1	1	1	1	1
Lesotho	87	0.43016	68	0.91948	75	0.38286	32	0.89005
Lithuania	45	0.75705	31	0.998	51	0.54931	64	0.72559
Macedonia	57	0.68302	43	0.98742	36	0.63498	20	0.92966
Madagascar	92	0.37026	81	0.8103	88	0.25134	76	0.67883
Malaysia	1	1	1	1	8	0.96713	13	0.96713
Mali	84	0.44581	92	0.62683	84	0.34109	57	0.76511
Malta	1	1	1	1	1	1	1	1
Mauritius	67	0.61826	60	0.96694	58	0.50463	51	0.81621
Moldova	78	0.52737	34	0.9951	61	0.48951	21	0.9282
Mongolia	39	0.81681	61	0.96121	27	0.69521	42	0.85113
Morocco	44	0.76155	70	0.91749	82	0.34645	86	0.45493
Namibia	50	0.74304	67	0.93155	85	0.3248	87	0.43712
Nepal	40	0.80413	73	0.89238	45	0.59307	62	0.73752
Nicaragua	88	0.41764	71	0.90028	80	0.35195	45	0.84272
Niger	85	0.43823	90	0.6685	89	0.22885	83	0.52222
Oman	1	1	1	1	15	0.86325	40	0.86325
Pakistan	1	1	1	1	73	0.4076	89	0.4076
Panama	1	1	1	1	24	0.71296	65	0.71296
Paraguay	63	0.66729	45	0.98663	62	0.47109	66	0.70597
Peru	79	0.50147	55	0.97396	63	0.47053	17	0.93832
Philippines	24	0.95842	52	0.97885	10	0.94328	10	0.9842
Poland	28	0.87935	24	0.99875	23	0.71897	50	0.81762
Portugal	27	0.91199	30	0.99811	38	0.63259	71	0.69363
Romania	53	0.72533	56	0.97347	60	0.5003	72	0.68976

Russia	51	0.73068	33	0.9971	55	0.53854	63	0.73704
Serbia	1	1	1	1	18	0.79171	56	0.79171
Slovenia	1	1	1	1	13	0.90439	28	0.90439
South Africa	70	0.58921	54	0.97625	47	0.58508	8	0.99299
Spain	1	1	1	1	1	1	1	1
Swaziland	65	0.63858	66	0.93696	46	0.58972	26	0.92349
Tajikistan	38	0.81706	22	0.99911	42	0.61028	61	0.74692
Thailand	86	0.43778	50	0.98083	68	0.42965	11	0.98143
The Gambia	80	0.49519	87	0.71461	66	0.43338	35	0.87517
Togo	52	0.73041	80	0.81833	37	0.63478	38	0.86907
Trinidad and Tobago	1	1	1	1	9	0.95726	14	0.95726
Tunisia	76	0.5433	59	0.96836	79	0.37027	75	0.68152
Turkey	75	0.54725	53	0.97843	57	0.51321	18	0.93779
Uganda	56	0.68857	75	0.87462	44	0.59493	39	0.86402
Ukraine	60	0.67652	29	0.99826	32	0.6708	9	0.99154
Uruguay	58	0.67981	42	0.98828	81	0.34793	84	0.51181
Venezuela	42	0.79152	46	0.98624	40	0.63151	54	0.79785
Zambia	82	0.48184	86	0.74432	67	0.43057	30	0.8936

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