Two-Dimensional Analysis of Public Expenditure Efficiency applied to Education and Health

Summary of the methodology and applications

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Relative efficiency is assessed visually in two dimensions: results (approximated by standard indicators of health outcomes) and financial means (public expenditure on health). Instead of one summary efficiency score, as would be obtained with other methods, the analysis returns two numbers for each country: one number measures the difference between actual and expected outcomes, and the other measures the difference between actual and expected public spending. Expected outcomes and expected spending are statistically predicted values obtained independently of each other using data from a large sample of countries; they are estimated conditional on income levels and other selected structural country characteristics (so that the observed deviation cannot be explained by these characteristics).

Panel data random-effect regression analysis may be used to measure structural efficiency in terms of evaluating the long-term standing of a country on public expenditure performance, taking account of variations both across and within countries. The random-effects regression separates the residual variance into a part that applies to each observation independently (the classical error term) and a part that is country-specific (time-invariant). The country-specific residual variance or "random effect" is used to measure the structural advantage/disadvantage of the country in the output and expenditure dimensions. The interpretation of results depends on the period and number of years for which data is available in a given country but in general, with sufficient amount of data, the efficiency position obtained from this analysis is not one that may be changed by tweaking levels of expenditures but more likely require structural reforms.

The cross-sectional regression analysis is used to measure efficiency over a given period of time based on period averages; it is repeated for two distinct periods to evaluate how the country's relative performance has changed over time. Given the analysis uses cross sectional data, it is important to use output indicators that can vary with changes in expenditure in the period considered. Given the lag expected between expenditures and outcomes, the analysis cannot be carried out to compare efficiency across short periods of time..

The choice of outcome/output indicator depends on the type of analysis and scope as well as data availability (overall and for the country of interest). For the point-in-time analysis, it is important to use indicators that can vary contemporaneously with changes in expenditure. For structural efficiency, providing the time period considered is long enough, one may use broader outcome measures (such as Youth Literacy Rates for Education or Life expectancy for Health).

Results of the analysis are expressed in such a way that countries can be compared against each other on the "efficiency map". The efficiency map is a four-quadrant graph where (0,0) is the point at which

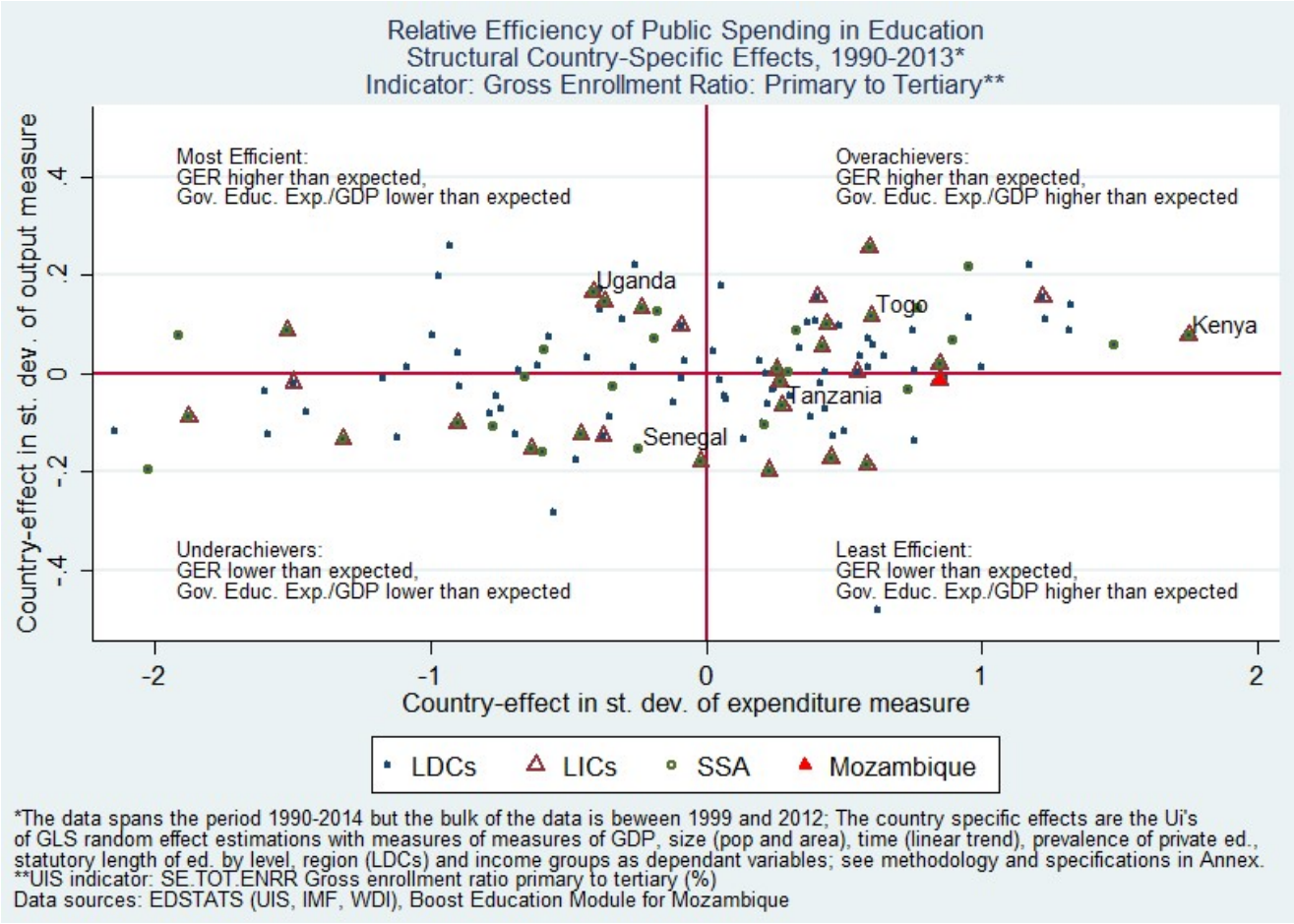
health outputs and expenditures are at levels predicted by the model; percentage deviations from expected health outcomes are represented vertically (along the y axis) and deviations from expected expenditure horizontally (the x axis). Results are also presented so the efficiency map can be directly compared across indicators and across time. Across indicators, direct comparison implies that percentage deviations are expressed as positive for a better performance and negative for a worse performance (e.g. a 50% higher mortality rate will show on the map as -50%). Countries can be categorized into relative efficiency groups depending on the quadrant of the map where they appear. Most efficient countries are in the northwest quadrant, least efficient countries are in the southeast quadrant. The southwest quadrant groups "underachievers", countries where outcomes are worse than expected but expenditure are also relatively low. In the northeast quadrant, the "overachievers" achieve better outcomes but also spend relatively more. When looking at changes over time, movements to the northwest indicate efficiency gains and movements to the southeast indicate efficiency losses. Movements in the other directions reveal important trade-offs between expenditure and output performance.

The analysis focuses on public health/education expenditure but all health expenditures are expected to have some effect on outcome—so why exclude private expenditure on the resource side? Although data quality and availability are an important constraint in measuring private expenditure, they are not the main reasons to focus on government expenditure; indeed, the goal is to evaluate public expenditure needs on efficiency grounds: if a country can obtain better health outcomes with less public expenditure because the private sector can take on a larger part of the burden (and do better than the public sector), it is indeed considered an efficiency improvement in terms of public expenditure. Nevertheless, if countries A and B obtain similar results given the same level of government expenditure, but B relies more on private healthcare than A, one would consider public expenditure to be more efficient in A. So, while it is inappropriate to include private expenditure as an input in the efficiency analysis, it is important to capture structural differences in public sector participation across countries. To this effect, a variable recording the private share in total current health expenditure is used as an explanatory variable in the expenditure regression (so expected public expenditure take account of these differences).

In interpreting results of any efficiency analysis, it is important to remember that they do not take into consideration the distribution of outcomes. Some countries with higher spending may be less efficient in producing health care but better at reaching the poor so the poor are less disadvantaged in health. Lower efficiency results may be justified if they are accompanied by equity improvements.

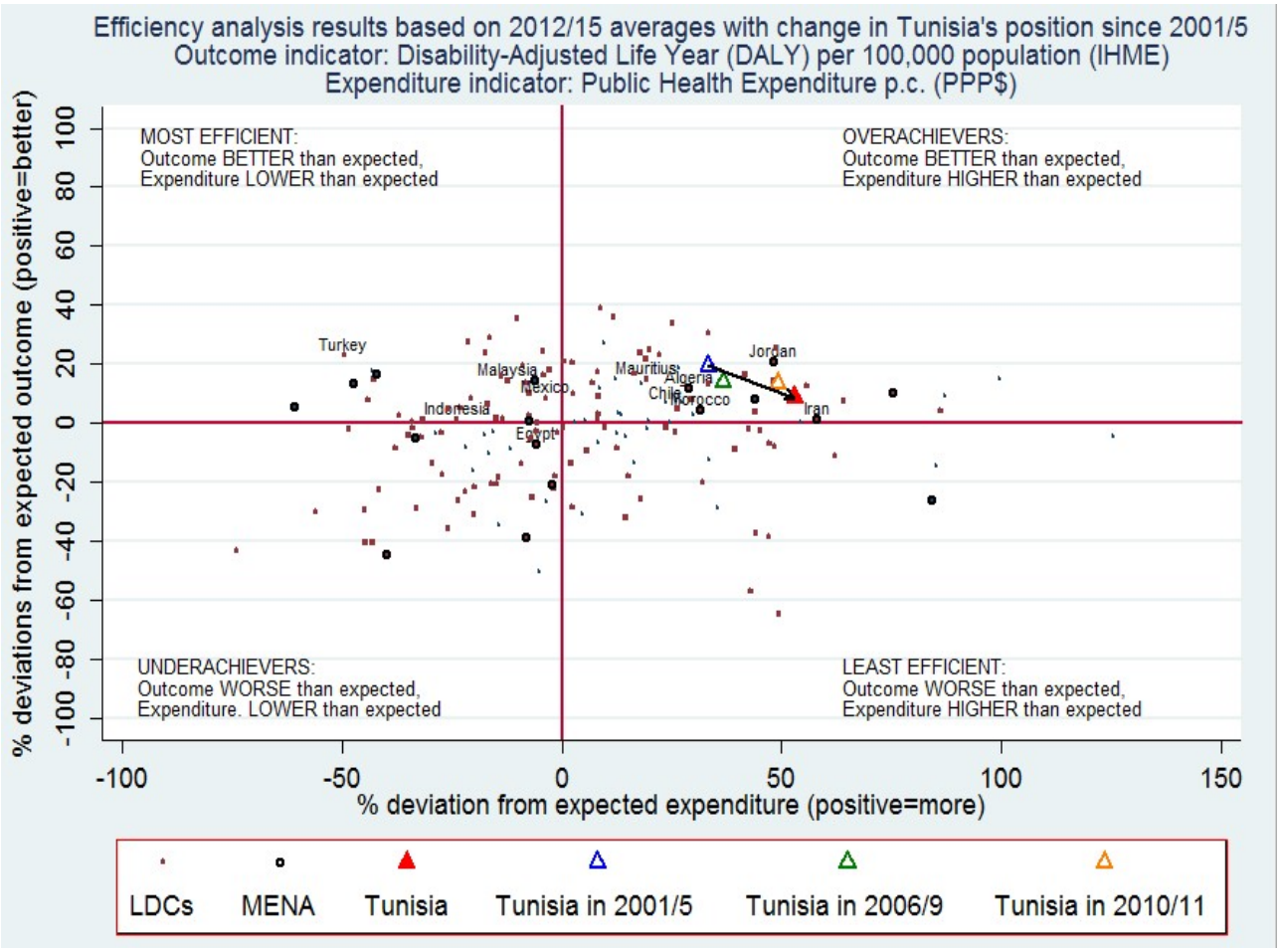
Below are examples of output in figures and graph. The examples are taken from analyses performed by the author for World Bank Public Expenditure Reviews (PERs). Figure 1 gives results of a random-effect analysis (structural efficiency results) carried out for the Mozambique Education PER (2015, published 2017) and figure 2 is the most recent output from a cross sectional analysis with comparison over time done for the Tunisia Health sector PER (2018)

Figure 1: Relative efficiency of Government Spending in Education in Mozambique



*The data spans the period 1990-2014 but the bulk of the data is beween 1999 and 2012; The country specific effects are the Ui's of GLS random effect estimations with measures of measures of GDP, size (pop and area), time (linear trend), prevalence of private ed., statutory length of ed. by level, region (LDCs) and income groups as dependant variables; see methodology and specifications in Annex.
**UIS indicator: SE.TOT.ENRR Gross enrollment ratio primary to tertiary (%)
Data sources: EDSTATS (UIS, IMF, WDI), Boost Education Module for Mozambique

Figure 2: Graphical results using DALYs as an outcome variable (Tunisia)



*Predicted values are based on log on log OLS regressions with measures of GDP (in PPP), population, size, and region as dependant variables; the expenditure prediction also controls for the weight of the private sector in current health expenditure. All countries with data are used to calculate expectations (including HICs and some outliers not shown on the graph). **Public Health expenditure are based on revised SHA 2011 data and calculated to include current and capital, domestic and foreign expenditure. For details on methodology and specifications, see Gaudin (2017).

Source: Authors using Stata program and World Bank's HNP/HF database, Dec 2017 update (compiled using data from WDI, WHO, IHME, IMF)

Results may also be presented in table form, allowing comparisons across indicators and across time within a country (table 1), and across indicators and across countries at a given point in time (table 2). The table form can also be used to highlight differences in evolution across countries (table 3)

Table 1: Relative Efficiency Analysis Results and Robustness Analysis: Tunisia, 2001-5 and 2012-15

		Indicator value[a/]		Expected value[a/]		% deviation[b/]		Change
	Indicator (Y)	2001-05	2012-15	2001/5	2012/5	2001/5	2012/5	(% point)
Bro	Overall Disease Burden (DALY per 100,000, IHME)	24607	24185	30438	26468	19.2	8.6	-10.5

	SDG achievement index[a/] (0-100, IHME)	60.4	63.0	40.1	45.3	50.5	39.1	*-11.4*
	Health-Adj. Life Expectancy (years, IHME)	66.2	67.0	61.5	63.1	7.6	6.2	*-1.4*
MCE outcomes	Infant Mortality[c/] (per 1000 live births, WHO)	22.0	12.6	29.3	18.6	24.7	30.8	6.0
	Child under-5 Mortality [c/] (per 1000 live births, WHO)	26.2	14.6	35.6	22.1	26.5	32.7	6.2
	Maternal Mortality[d/] (per 100,000 live births)	78.4	63.3	68.8	48.1	-13.9	-31.6	-17.6
Health Expenditure	**Public - domestic and foreign (GHED – SHA2011)**							
	In per capita PPP$ of 2011	227	421	170	275	*33.3*	*53.2*	*19.9*
	In per capital USD of 2010	90	167	67	107	*33.9*	*56.1*	*22.2*
	In percent of GDP	2.76	3.96	2.04	2.58	*35.1*	*53.7*	*18.6*
	Government - Domestic (GHED – SHA2011)							
	In % of GDP	2.76	3.89	2.02	2.28	*36.2*	*71.1*	*34.9*
	Total Health Expenditure (HIME series)							
	In % of GDP	5.40	7.02	4.77	5.57	*13.1*	*25.9*	*12.8*

[a/] All values averaged over the period indicated except for the SDG index (2005 used for period 1 and 2016 for period 2).

[b/] For outcome indicators, all positive deviations indicate a "better" result (a lower than expected value for mortality rates). Figures in blue are desirable and figures in red italics are not desirable. Deviation changes in red indicate a relative worsening of the position in a given dimension. Changes in efficiency need to take account of both outcome and expenditure deviation changes. If both are red, the loss of efficiency is unambiguous; if both are blue, the gain is unambiguous, if one is red and one is blue, relative magnitudes of change need to be appreciated.

[c/] Other estimates of Infant and Child Mortality Rates were used with very similar results for Tunisia.

[d/] Maternal Mortality Ratio is the modeled estimate (HNP), it matches the 2 observed values from WHO in 2000 and 2015

Source: Author using STATA and World Bank HNP/HF database (incl. data from IMF, IHME, WHO)

Table 2. Comparisons of Efficiency Positions in Select Countries Based on 2012/15 Averages

	Expenditure Deviations	Outcome Deviations			
Indicator	**Public HE/c**	**DALY**	**SDG**	**CMR**	**MMR**
Memo: Tunisia	53	8.6	39	33	-32
Regional peers (from lowest relative spending)					
Turkey	-50	23	-3.2	-131	-60
Egypt	-6	-7.4	13	-6.0	37
Algeria	29	12	31	-9.2	-179
Morocco	32	4.4	39	-2.8	-90
Jordan	49	21	48	21	-10
Iran	57	1.2	30	16	37
Other select countries					
Indonesia	-24	1.1	-15	-76	-167
Malaysia	-12	14	12	25	-69
Mexico	-4	8	5	13	33
Mauritius	19	15	45	19	19
Chile	24	7	-4	42	53
Brazil	43	-2	6	17	33

Public HE include domestic and foreign health expenditure, excluding capital investment (based on GHED's gschcontr variable). Clearly efficient positions are highlighted in bright green and inefficient ones in bright orange. Lighter shades are used for positions as over- or under-achievers or when deviation are less than 5.

Source: Authors using STATA and World Bank's HNP/HF database, Dec 2017 update (data from WDI, WHO, IHME, IMF)

Table 3. Efficiency Analysis Results: International Comparisons of 10-year Movements in Expenditure and Outcome Positions

2001/5 to 2012/5	Change in Expenditure Deviations	Change in Outcomes Deviations			
Indicator:	**Public HE/c**	**DALY**	**SDG**	**CMR**	**MMR**
Memo: Tunisia	+20	-10.5	-11.4	6.2	-17.6
Regional peers (from lowest relative increase in spending)					
Jordan	-73	1.5	-5.4	-6.0	-11.7
Egypt	-22	-22	-4.5	-20	-7.7
Turkey*	-18	3.1	8.0	38.1	252.5
Morocco	+29	-5.3	-6.2	-14.6	8.8
Iran	+36	0.8	32.2	11.1	11.7
Algeria	+55	-3.1	11.6	-11.7	-52.2
Other select countries					
Chile	-2.6	-7.8	-18.1	-11.3	-0.9
Mexico*	-1.8	-3.3	-2.0	16.6	29.0
Brazil	+0.2	-4.4	-5.6	9.8	9.1
Malaysia	+0.7	-8.2	-4.9	-8.3	-13.9
Indonesia	+12	5.7	9.3	10.5	42.7
Mauritius	+35	-23.9	-32.5	-18.8	-44.5

Public HE include domestic and foreign health expenditure, excluding capital investment (based on GHED's gschcontr variable). Bright orange color indicate clear loss of efficiency. Bright greens are clear gains in efficiency. Lighter shades are used when the efficiency gain/loss is ambiguous. The number is red if the changed made the country move below the line of expected outcomes (based on results reported in table above).

Source: Authors using STATA and World Bank's HNP/HF database, Dec 2017 update (data from WDI, WHO, IHME, IMF)