Addendum to "Reaching education targets in low and lower middle-income countries: Costs and finance gaps to 2030 for pre-primary, primary, lower- and upper secondary"

by Wils, Annababette. 2015. Background paper for UNESCO, Global Education Monitoring Report. Paris. URL: https://en.unesco.org/gem-report/sites/gem-report/files/background%20paper%20-%20costing%20education.pdf

Revised section 3 "Description of the projection model" to reflect changes in the 2018 version of the UNESCO education costing model developed for ESCAP.

3 Description of the projection model (updated, 12/2018)

This section briefly describes the key aspects of the model used to make the education costing calculations, respectively students; expenditures; PTR and teacher salaries; costs, financing, and finance gap.

SDG 4 for education, focuses on early childhood development and basic education from primary through secondary. Out of these goals, the 2018 version of the UNESCO education costing model focuses on: access to preschool in the year or years before primary, and primary and secondary schooling. In addition, the costing model considers post-secondary education – although it is outside the SDG framework – for the following reasons: post-secondary education takes up a large portion of the education budgets in developing countries and can be a direct constraint on the financial envelope for the provision of the SDG education goals; post-secondary education is necessary to develop teachers to reach the SDG education goals; post-secondary education is important to reaching a number of other SDG goals including economic growth and poverty reduction and health targets. That said, the costing of the education SDG's includes only those levels which are included in SDG 4.

All of the projections and computations discussed in this section are done *by country* in the education costing model, using country-specific benchmark data for all variables.

3.1 Number of students, preschool, primary, secondary, and post-secondary

The projected costs are a function of the number of students and the costs per student. Three groups of students are projected separately in the model: preschool students: primary and secondary students; and post-secondary students.

3.1.1 Preschool students

Preschool students in the benchmark year are the product of "school access in the year before primary" by sex (SDG 4.1.1) as provided by UIS, and the population of children, by sex, aged one year younger than official primary school entry, separately, for each country. For future years, school access in the year before primary (*NER1P*) is projected linearly, by sex, from the most recent year of data to the target

level (*target*) by the target year. For SDG costing, the target level is 100 percent access and the target year is 2030. The equations are as follows:

$$\text{School access in year before primary: } NER1P_{s,t} = NER1P_{s,t-1} + \frac{(NER1P_{target} - NER1P_{s,t-1})}{(targetyear - t + 1)}$$

$$\text{Number of students in preschool by sex: } S_{pre,s,t} = NER1P_{s,t} * Pop1P_{s,t}$$

Where Pop1P is the population aged one year before official primary entry, s is sex, and t is the current projection year. For simplicity, the model computes one year of full-time preschool access; however, countries can consider this to be equivalent to two years of half-time access or three of one-third time preschool access without changes to the overall costs.

3.1.2 Students in primary through secondary

Students (S) are projected by grade using a common spreadsheet method that takes account of pupil progress through grades over time, based on promotion (*pr*) and repetition rates (*r*); with incoming first grade pupils determined by the gross intake rates (*GIR*) and the school entry-age population (*Pop1*). Specifically, the equations are:

$$\text{For grade 1: } S_{1,s,t} = GIR_{s,t} * Pop1_{s,t} + S_{1,s,t-1} r_{1,s,t-1}$$

$$\text{For grades beyond 1: } S_{g,s,t} = S_{g-1,s,t-1} pr_{g-1,s,t-1} + S_{g,s,t-1} r_{g,s,t-1}$$

Where the subscripts 1 and g designate grades. The model computes the intake, promotion, and repetition rates by grade over time such that the target level of completion of upper secondary is reached exactly by the target year, and the trend of upper secondary completion is linear from the benchmark year to the target year. The completion of upper secondary is the number of non-repeating entrants into the last grade of upper secondary divided by the population of the official age of completing upper secondary school. The transition rates from primary to lower secondary are treated in the same way as promotion rates. The transition rates into upper secondary and between grades in that level are assumed to be 100 percent by the target year. The projections include students in general secondary and vocational secondary school. They also include public and private students.

3.1.3 Students in post-secondary

The primary stream of post-secondary is considered to be tertiary education, with access to two other streams of post-secondary - post-secondary non-tertiary and online certification – also included. Access to tertiary, or the *tertiary entry rate* (GIRT) in the benchmark year is approximated by the tertiary gross enrollment rate (GERT). For future years, GIRT is assumed to increase linearly from the benchmark level to a target level *set by the user*[1]. There is currently no internationally agreed-upon target for this level.

$$\text{Tertiary entry rate: } GIRT_t = GIRT_{t-1} + \frac{(GIRT_{target} - GIRT_{t-1})}{(targetyear - t + 1)}$$

The projected number of students in tertiary, is equal to the new entrants plus continuing tertiary students in the following way:

$$\text{Tertiary students in benchmark year: } S_{T,t=b} = GERT_{t=b} * Pop_{T,t}$$

$$\text{Tertiary students: } S_{T,t} = GIRT_t * PopT1_t + S_{T,t-1} * \frac{dT-1}{dT}$$

[1] In cases where the projected tertiary access exceeds the projected upper secondary completion rates, the lower of the two is used.

Where PopT1 is the population of tertiary entry age, just one year older than the official age of upper secondary completion, and official dT is the duration of tertiary[2].

The post-secondary non-tertiary entry rate (GIRPSNT) is computed as a ratio of tertiary entry, where that portion is projected linearly from the observed benchmark value to a target ratio *set by the user*, and the number of students is computed in the same way as for tertiary.

$$\text{PSNT entry as a portion of tertiary entry: } r(\tfrac{P}{T})_t = r(\tfrac{P}{T})_{t-1} + \frac{(r(\frac{P}{T})_{target} - r(\frac{P}{T})_{t-1})}{(targetyear - t + 1)}$$

$$\text{PSNT entry rate: } GIRPSNT_t = r(\tfrac{P}{T})_t * GIRT_t$$

$$\text{Students in PSNT: } S_{PSNT,t} = GIRPSNT_t * PopT1_t + S_{PSNT,t-1} * \frac{dPSNT-1}{dPSNT}$$

Finally, a third stream of post-secondary students are those who pursue online, or new delivery (ND) education. Entry into online education is projected to start from zero in the benchmark year to a target ratio of tertiary entry and the duration is assumed to be one year. Other than the parameter differences, the equations are the same as for PSNT.

3.2 Costs

The *basic costs function* for basic education -- preschool, primary and secondary -- are the sum of two types of expenditure, namely recurrent and infrastructure:

$$C_{BE} = C_r + C_i$$

Recurrent costs, C_r are calculated for preschool, primary and lower and upper secondary education separately. The biggest component of recurrent costs is teacher salaries. These are: the product of the number of teachers (the number of students divided by the pupil teacher ratio) and the average teacher salary. In the 2015 version of the model only public-school students are include in the calculation of costs; in the 2018 update, costs for both public and private students are included – the financing plan in turn, includes the household contributions for private schooling[3]. The PTR and teacher salaries themselves follow the trajectory described in section 3.3. The salary costs are multiplied by: one plus material and administrative cost as a percent of salary costs. The target percentage for non-salary costs is set externally in the scenarios (the target value is 35 percent of teacher salary costs in the SDG scenarios). These recurrent costs, in turn are multiplied by: one plus costs for marginalized as a percent of other recurrent costs. The percentage of marginalized students are assumed to be children from households below the poverty line; only these receive subsidies. The subsidy per poor student is set by the user in the scenario settings, as a portion of the unit recurrent costs. For the very last-to-be reached marginalized children, the last 10 and 5 percent, the base subsidies are increased by 20 and 50 percent respectively. Together, the entire equation for recurrent costs *in each school level* is:

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[2] UIS does not provide the official duration of tertiary; it is computed by matching the total population of tertiary age (provide by UIS) to the corresponding population age-groups.

[3] We opted for this change because in practice the public-private organizational distinction is not clearly aligned with the public-private cost distribution – in many countries, parents contribute to public school costs; while in others, governments pay for private schools. It therefore makes more sense to project the costs for all students and schools regardless of ownership, and then assume a distribution of costs over government and private sources.

$$C_{r,t} = \frac{S_t * Sal_t}{PTR_t * (1 - mt_t)} * (1 + mg_t)$$

where: *Sal* is the average salary; *S* is the number of students; *PTR* is the pupil teacher ratio; *mt* is the percent of non-salary recurrent costs; *mg* is the percent of expenditure for marginalized children[4]. The projected trends for the components of the model – pupils, salary, PTR, etc. – are assumed as per the targets and assumptions described in the previous section.

Infrastructure costs, C_i (for the construction of new classrooms, furniture and durable materials such as blackboards, and the maintenance of existing classrooms) are calculated as follows. Total desired number of classrooms is assumed to be equal to the number of teachers ($K_{d,t} = T_t$); new classrooms *needed* for next year ($K_{n,t+1}$) is equal to the desired number of classrooms minus actual classrooms, (($K_{n,t+1} = K_{d,t} - K_{a,t}$), where actual classrooms is the number of classrooms in the previous year depreciated according to the lifetime of classrooms plus new classrooms which are built in that year ($K_{a,t} = K_{a,t-1} * \frac{lf-1}{lf} + K_{c,t}$) It is assumed that there is continually a delay in the construction of new classrooms, so that the actual new construction is not equal to need, and instead equal to: $K_{c,t} = K_{n,t}/d$, where d is a user set delay time.

The cost for each classroom is equal to: the base construction cost, (c_K), enhanced by a multiple for durable furnishings and materials, f. The base costs are a percentage of GDP per capita, where the percentage is set based on values obtained from the literature and maintained constant throughout the projection period. Maintenance costs are equal to the number of existing classrooms times assumed maintenance costs, Mt. Like recurrent costs, infrastructure costs are calculated for preschool, primary, lower, and upper secondary schooling separately:

$$C_{i,t} = c_K * K_{c,t} * (1 + f) + K_{a,t} * Mt$$

The unit costs for post-secondary streams are computed in a simpler manner. The benchmark unit costs are computed from two UIS variables, "Government funding per tertiary student as a percent of GDP per capita" plus "Household funding per tertiary student as a percent of GDP per capita". The unit costs of tertiary and PSNT are assumed equal in the benchmark year. For countries without data, regional averages are used. The projected unit costs are projected to change linearly from the benchmark value to target unit cost as percent of GDP per capita *set by the user*. The unit costs for online education as a percent of GDP per capita are *set by the user* and the percent is constant for all projection years. The following are the three equations used for post-secondary costs.

Unit costs of post-secondary stream: $c_{PS,t} = c_{PS,t-1} + \frac{(c_{PS,target} - c_{PS,t-1})}{(targetyear - t + 1)}$

Total costs per post-secondary stream: $C_{PS,t} = c_{PS,t} * S_{PS,t}$

Total cost of post-secondary: $C^*_{PS,t} = C_{T,t} + C_{PSNT,t} + C_{ND,t}$

3.3 Calculation of PTR and teacher salaries

PTR and teacher salaries vary considerably within poorer countries. In the set of 82 countries projected in 2015, the PTR in primary ranges from 6.3 in Georgia to 80.1 in Central African Republic. In countries

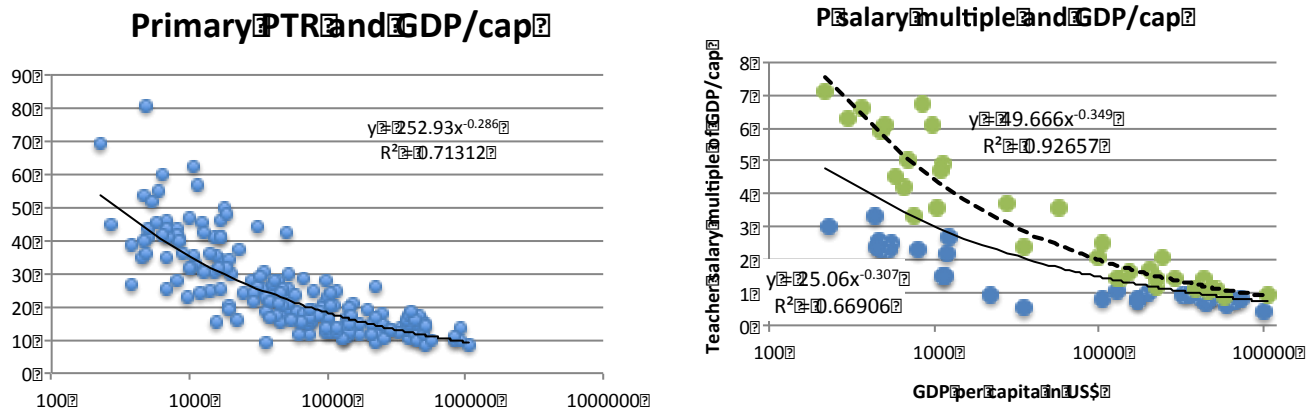
[4] It is possible to set the subsidy rate for preschool/primary vs. lower secondary separately. In the base scenario it is 20 percent for primary and 30 percent for lower secondary, and 40 percent for upper secondary.

with lower average incomes, PTR tends to be higher, probably reflecting a scarcity of human and financial resources. Primary teacher salaries, standardized as a multiple of GDP per capita, range from a multiple of 7.4 in Somalia, to 0.5 in Myanmar. Similar ranges exist for the salaries of lower and upper secondary school teachers. Poorer countries tend to have higher multiples – probably because the skills required for teaching are scarcer and command higher premiums. Wils and Ingram (2011) noted the association of PTR and teacher salaries with GDP per capita in their EFA projections based on historical trends.

Figure 1 shows the correlation of GDP with PTR (left-hand figure) and teacher salaries (right-hand figure) using data from Pole de Dakar and the World Bank Development Indicators database most recent years. The solid lines in each figure show the overall trend within the data using an exponential function[5]. The second, dotted line in the right-hand salary graph shows a higher trend for *only those countries that lie above the average salary-income trend.*

In the scenarios, it is assumed that in each country, as GDP per capita grows over the projection period, the PTR will approach the international trend line by the target year; and the teacher salaries will approach the "better half" international trend line by the target year. Filtering the salary trend to include only the better-paying countries allows us to improve overall average teacher quality by shifting many of the salaries upwards, in particular for countries where teachers are presently under-paid. This results in primary teacher salaries averaging 3.4 times the GDP per capita 2030 in the base scenario with a range from 2.1 to 8.0.

Figure 1. Pupil teacher ratios and teacher salaries correlated with GDP per capita in 2012 or most recent year, all countries for which data is available.



3.4 Financing education

[5] The exponential function results in the best fit to the data as compared to linear, power, logistic or polynomial functions. The specification of the function for PTR is $PTR = 510 * Y^{-.346}$. The function for teacher salary, all countries, is $S = 60 * Y^{-.378}$. The function of teacher salary, only including the countries above the average trend, is $S = 332 * Y^{-.43}$. Y in all three equations is GDP per capita PPP.

The model assumes two domestic sources of education finance – the government and households. If the balance of contribution from these two sources is not sufficient to cover the costs, then there is a finance gap, for which other, external funding is needed. In the 2018 model, government expenditures are not divided over education levels because of with inclusion of household there is considerable fungibility of finance streams over different education levels depending on government and household priorities. The model subtracts the total domestic finance envelope from the total costs to obtain a total finance gap.

Domestic government financing for education (*G*) is equal to government expenditure as a percentage of GDP (itself the product of the expenditure rate and GDP, $Y * E$) and the proportion of public budget for education, ED.

$$G_{ED,t} = Y * R * ED$$

The initial values are taken from the World Bank WDI database. The components of government expenditure are assumed to change linearly to the user set target levels; and GDP is projected to grow as per the most recent IMF Economic Outlook projections[6] or the UN DESA projections (the user can select to use one or the other in the ESCAP model).

For household financing for education, there are two targets, *set by the user*: the maximum percent of post-secondary costs covered by households, and the maximum percent of basic education (preschool-secondary) costs covered by households. The maximum household spending for post-secondary by 2030 set in the default ESCAP scenarios, was 50 percent of costs for middle-income countries, and 25 percent of costs for low-income countries; while maximum contribution for basic education was set at 10 percent of costs for all countries.

The benchmark levels of household contribution for basic education are based on the percent of students in private schools (in many countries a poor proxy for household contributions) and for post-secondary education using the contributions from households provided by UIS. Household education expenditures are computed in multiple steps as explained below.

The maximum household contributions as a percent of costs, for post-secondary as well as for basic education, is projected linearly from the benchmark values

Max household contributions (% of costs): $h^x_{l,t} = h^x_{l,t-1} + \frac{(h^x_{l,target} - h^x_{l,t-1})}{(targetyear - t + 1)}$

For post-secondary, the household contributions are simply the maximum contribution percentage times the total costs of post-secondary:

Post-secondary household expenditures: $H_{PS,t} = h^x_{PS,t-1} * C^*_{PS,t}$

The government is assumed to finance the remainder of post-secondary costs:

Post-secondary government expenditures: $G_{PS,t} = C^*_{PS,t} - H_{PS,t}$

The finance envelope for basic education is computed after considering cost constraints imposed by financing post-secondary education. This is not because post-secondary *should* be prioritized, but because the costs are real and act as a real constraint on public education finance, and because using

[6] IMF projections are for 3 years from the current one. For years beyond, up to 2030, the average of the last two observed years + projected three years is used.

this order allows the model to take the maximum of household contributions to post-secondary. With this is mind:

Basic education government expenditure: $G_{BE,t} = \min(C_{BE,t}, G_{ED,t} - G_{PS,t})$

Household contributions are added to finance a portion of the remaining gap (if any):

Basic education household expenditure: $H_{BE,t} = \min(0, C_{BE,t} - G_{BE,t}, h^{x}_{BE,t-1} * C_{BE,t})$

Finally, the *scenario finance gap* is equal to the difference between the total costs of education and domestic financing:

$$Gap_t = \left(C_{PS,t} + C_{BE,t}\right) - (G_{ED,t} + H_{PS,t} + H_{BE,t}).$$

The *scenario finance gap* shows how much additional funding is needed to achieve the SDG trajectory of education growth for all (in quantity and/or quality).

3.5 Data

The data used for the projections are from many international and national sources. International data are used where available; national sources where they are not; and if no national sources could be found, estimates were made based on other countries in the region or computations based on other national data, in that order of preference.

The international sources consulted are as follows:

- Enrolments, repeaters, preschool gross enrolment rates: UIS online database
- Expenditure, pupil teacher ratios, percent private enrolment: UIS online database
- GDP, GPD per capita, poverty headcount (percent living on <$2 a day): World Bank Development Indicators database, and IMF and DESA databases for GDP growth projections
- Official development assistance: Global Monitoring Report data tables.
- Construction costs – international literature.
- Teacher salaries: benchmark values estimated based on: number of students, PTR, and education expenditure data.
- Population: World Bank Health Nutrition and Population Statistics database.
- Post-secondary unit costs: UIS online database.

The international data provided the majority of the information used in the model. *All of the data sources are documented in comments in the excel model.*