the Education Commission

Background Paper
The Learning Generation

The Learning Generation Costing Model:

Semi-technical overview of key assumptions driving the Learning Generation estimates

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Overview

The Education Commission has undertaken extensive work on a model that estimates the costs of providing quality learning for a generation of children. The model provides global and 3country-level information for nearly all low- and middle-income countries about the education landscape today and projections into the future. It couples the data currently available with advanced estimation methods to paint the most complete picture of global education currently available.

The Commission's model is the culmination of two decades of global modelling work, including work for UNESCO, UNICEF, the World Bank, and the Lancet.[1] The Commission's Learning Generation model expands the scope and depth of its predecessors by including preschool, primary, secondary and post-secondary education; learning outcomes; upper-middle income countries; and by integrating both target-based projection and projections based on historical trends. It not only projects access and completion, but also education quality and learning, using evidence on what countries have achieved in the past, and interventions and investments needed for the future.

In 2016, the Learning Generation model was developed as a foundation for the Education Commission's flagship report.[2] In 2018, the Commission updated the data in the model, reflecting the latest annual release of education indicators.[3] Although this paper primarily describes the model as developed for the Learning Generation report using the "Learning Generation Vision" scenario, the tool can also be adjusted to different parameters and scenarios. For example, the tool has already been adapted to model the scenario to achieve SDG 4 by 2030, as detailed in Section 8.

This paper provides a description of the methodology that underlies the Commission's modelling work. Section 1 includes a brief summary of the Learning Generation report's *call to action* on global education. Section 2 discusses the Learning Generation Trend and Vision scenarios, which project the business-as-usual case and also what is possible to achieve

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[1] Bruns, Barbara, Alain Mingat and Rakotamalala. 2003. "A Chance for Every Child." World Bank; Education Policy and Data Center (EPDC) and UNESCO. 2009. "Estimating the costs of achieving Education for All in low-income countries" Background paper prepared for the Education for All Global Monitoring Report 2010. http://unesdoc.unesco.org/images/0018/001885/188561e.pdf; UNESCO. Pricing the Right to Education. 2015. http://en.unesco.org/gem-report/node/819#sthash.mDBDiEVT.dpbs (accessed June 30, 2016); Wils, Annababette. 2015. Reaching education targets in low and lower-middle income countries: costs and finance gaps to 2030 for pre-primary, primary, lower- and upper secondary schooling. Background Paper for EFA Global Monitoring Report, 2015. Paris: UNESCO; Wils, Annababette and George Ingram. 2011. "Universal Basic Education: A Progress-based Path to 2025", FHI360: Washington, DC; UNICEF. 2012. Simulations for Equity in Education: Model background, methodology, results from first two years. http://www.unicef.org/education/bege_SEE.html; Sheehan P, Sweeny K, Rasmussen R, Wils A, et al. 2017. Building the foundations for sustainable development: a case for global investment in the capabilities of adolescents. Lancet. https://doi.org/10.1016/S0140-6736(17)30872-3; Wils A. Technical aspects of the VISES education and marriage model. Appendix to Sheehan P, Sweeny K, Rasmussen R, Wils A, et al. Building the foundations for sustainable development: a case for global investment in the capabilities of adolescents.

[2] International Commission on Financing Global Education Opportunity. 2016. The Learning Generation: Investing in Education for a Changing World. https://report.educationcommission.org/downloads/

[3] The difference between the original projections and 2018 updated projections falls well within a margin of uncertainty that comes with interpretation of scarce data, which generates confidence in the robustness of the original projections and statistical modelling.

based on the rate of progress of the fastest improving countries. Sections 3, 4 and 5 describe how the Commission computed the costs of achieving the Learning Generation, which is the product of the number of students (Section 3) and per student costs (Section 4). The increased cost efficiency of the Learning Generation Vision scenario is demonstrated by the number of students reaching minimum learning benchmarks as decribed in Section 5. Section 6 outlines efficiencies and smart spending applied in costing estimates. Section 7 describes the methodology for the financing proposal – a combination of domestic, private, and international funds. Detailed diagrams of the model are provided in the Annex.

1. Summary of the Commission's Learning Generation proposal

In 2016, the Education Commission issued a call for the world to turn towards the Learning Generation,[4] where every low- and middle-income country embarks on a path of education transformation with a dedication to performance, innovation, inclusion and sufficient financing.

The Commission found that if education progress accelerates to the rates demonstrated by the fastest 25 percent of improvers, low- and middle-income countries could attain near-universal levels of preschool through secondary participation by 2030 and learning levels would approach where high-income countries sit today. This is the Learning Generation Vision scenario.

The benefits would be manifold: improved health and security, reduced climate impact, and more rapid economic development. To finance the Learning Generation, the Commission presented an investment proposal, based on national commitment and global support. **The costing numbers are not a prediction; they are an investment plan and a call to action.**

Making this vision a reality will require significantly more financial resources as outlined in the cost estimates in this paper. It will also require governments to make reforms to ensure that new and existing resources are invested efficiently to deliver the greatest possible returns.

Alongside the estimates of progress and associated costs, the Commission identified four education transformations that national and international decision-makers need to undertake to build successful and sustainable education systems and achieve the Learning Generation. The Learning Generation projections in the Vision scenario are in alignment with these transformations. The four transformations are intended as a holistic approach – each depends on the other.

1. Education systems must focus on *performance* and results at every level, including through setting standards, tracking progress, and cutting waste through actions towards effective management and accountability.

2. Systems must harness *innovation*, fostering new and creative approaches to achieve results, capitalizing on opportunities for innovation in who delivers education, where and how.

3. Systems must prioritize *inclusion*, supporting those with the greatest risk of not learning – the poor, discriminated against, girls, refugees, the disabled, and those facing multiple disadvantages.

4. Successful education systems will also require *more and better finance*, based on the primary responsibility of national governments and supported by international partners. The Vision scenario emphasizes not only additional spending, but smart and efficient spending. Ensuring more effective and efficient spending will be critical for mobilizing more financing for education.

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[4] International Commission on Financing Global Education Opportunity. 2016. The Learning Generation: Investing in Education for a Changing World.

2. Learning Generation Vision and Trend pathways

The Learning Generation pathways encompass seven vital education objectives in line with the objectives of the Sustainable Development Goal 4:

1) Preschool access
2) Primary completion
3) Primary learning (reaching minimum primary level learning benchmarks)
4) Secondary completion
5) Secondary learning (reaching minimum secondary level learning benchmarks)
6) Post-secondary access
7) Equity at all levels

For each of these goals, the Commission analyzed historical trends to identify ambitious but achievable pathways of progress. This analysis shows that a global transformation to attain these seven education objectives for the coming generation of children and youth is necessary *and possible*. Many countries are far from one or more of the objectives, but one of the Commission's most important insights is that *many low- and middle-income countries – approximately 25 percent, in fact – already demonstrate the necessary education growth rates to attain one or more objective.* This set of fastest improvers are not the most well-off developed countries. They are diverse, spanning all income groups, regions and socio-political contexts.

First, using data from UNESCO Institute for Statistics (UIS) obtained via the World Bank EdStats online database and from international learning assessments, we observed how fast each of the seven education objectives had changed in the past 100 years, and particularly in the last decade, in countries around the world.

A basic observation emerged: *the potential for the fastest growth rates is when levels of access, completion or learning are low*. For example, among countries with preschool gross enrolment rates (GER) below 10 percent in 2010, there were three – Bhutan, Ethiopia, and Myanmar – where *growth in* preschool GER exceeded 23 percent annually from 2010 to 2015. Among all countries where less than 10 percent of children enrolled in preschool in 2010, growth rates averaged 11 percent annually. In contrast, among countries with preschool GER between 40 and 60 percent in 2010, the average annual growth rate was 4 percent and the fastest annual growth rates – in Brazil, Indonesia, and Colombia – were only 8 percent. Among countries with preschool GER above 80 percent, top annual growth rates were a mere 2 percent. In fact, across all seven education objectives, the very fastest growth rates are always among countries starting from a low level; and, in all cases, where levels were near universality, growth rates were close to zero. This pattern of growth produces the commonly observed logistic or S-shaped pathways of growth.

Based on our observations with regards to the pace of progress, the Commission model developed a Vision pathway based on the fastest improving countries. The selection of the fastest improvers was done separately for each of the seven objectives. The fastest improving countries for each of objective, we argued, show what is feasible and could be used as *attainable stretch targets* for all other countries that were moving more slowly. The group of countries with a "high" growth rate was identified after adjusting for the starting level. To illustrate using the preschool enrolment example above, Bhutan, Ethiopia and Myanmar are

fast movers in absolute terms, but also given their starting levels. Meanwhile Brazil, Indonesia, and Colombia are included because they were fast movers among *their* peers, even though growth rates were far below those of Bhutan, Ethiopia and Myanmar.

The selection of these countries was a two-step process. First, we created an "average" growth path using a regression with growth rate as the dependent variable and starting level as the independent variable.[5] The average path was used to create predicted growth rates for each country, given their starting values. Second, we created ratios of the observed growth rate, and the predicted growth rate for each country. Top improvers, controlling for their base levels, are those with high ratios. We selected different groups of fastest improvers (top 10, 20, 25, 40 percent), then created fastest improver "growth paths" and applied those growth paths in projections for all countries. We observed that if we selected the top 25 percent of improvers for each of the education objectives, most countries would be able to come close to reaching the SDG targets within a generation.[6] The Learning Generation pathway was thus formulated to follow those top 25 percent groups of countries. See *Model Diagram 2* in the annex.

Figure 1a visualizes the top 25 percent improver analysis for primary completion, illustrating a cross-tabulation of primary completion starting levels in 2010 (x-axis) and growth rates from 2010 to 2015 (y-axis). The entire set of dots (green and gray) includes all the countries with positive growth rates. Countries with negative growth rates are not shown. The green dots are the selected top 25 percent fastest improving countries. Note that the collection of green dots slopes down, just as the entire collection of observations does, and some of the top 25 percent countries with high starting levels had lower rates of absolute growth than some countries not in the top 25 percent. This highlights the *selection of fastest improvers based on a country's relation to its peers*.

The figure shows a green line through the green dots, which represents the line used to project the Learning Generation Vision pathway for primary completion growth rates. For example, Country C, marked in red in the figure, is performing below the Learning Generation pathway. In the Learning Generation projection path for Country C, shown by the dotted green arrow, we assume that this country's growth rate jumps up and follow the green pathway in the projected years.

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[5] For the updated 2018 version of the model, the growth interval for this analysis was 2011-2016; the starting values used were for 2011. For those countries where 2016 was not available, 2015, 2014, 2013 was used in that order; and if 2011 values were not available, 2010, 2012, 2009 were used instead, and the growth rate was adjusted for the length of the observation interval.

[6] This analysis was as follows: We generalize to say that each countries' growth path can be characterized by a logistic growth equation $G=c-c*L$ (where G is growth rate and L is starting level). For those countries with data, given each countries' observed level (L) and observed growth rate (G), we can compute c for each country as $c = G / (1-L)$. The Top 25 percent improvers are the quarter with the highest values for c.

Figure 1a. Visual example of the analysis to determine top 25 percent improvers
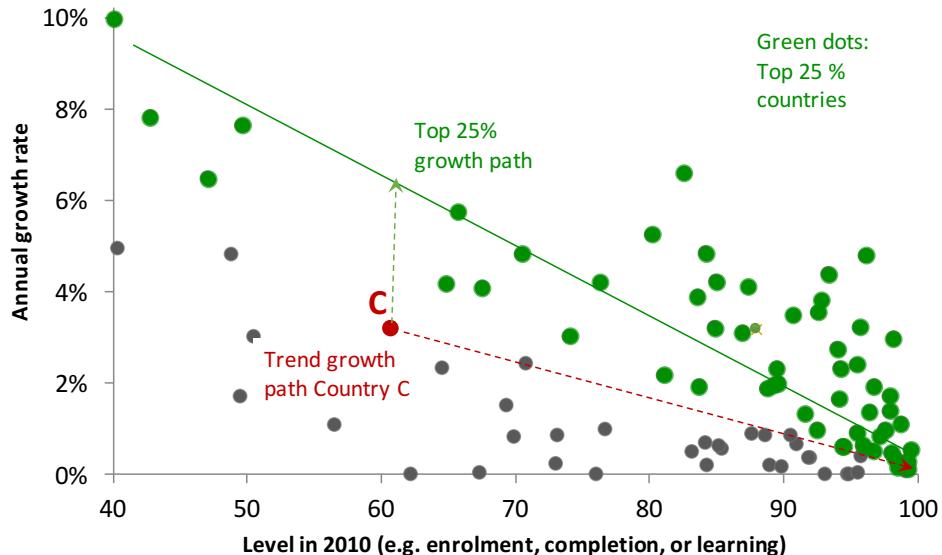
Note: Figure 1a shows all the selected top 25 percent improvers (in green dots); the top 25 percent (i.e., Vision) growth pathway (green regression line); and the Trend growth pathway (red dotted line) for an actual country C.

The Commission also created an alternative Trend pathway for each country, to show what would happen in the case of business as usual. For the Trend pathways, we assume that the countries move forward along a growth path that simply continues from their starting point, with growth rates adjusting towards zero as universal levels are reached. In the figure, this is the red dotted line.

Figure 1b shows the two alternative projections for Country C (Democratic Republic of Congo): the Learning Generation Vision for completion rates in the green line, and the Trend completion rates in the black line.

Country-by-country projections based on the Trend and Vision scenarios were made for all low- and middle-income countries for the seven objectives – preschool access, primary completion, primary learning, secondary completion, secondary learning, post-secondary access, and equity.

Figure 1b. Projected pathways for Country C

Primary Completion Rate in DRC
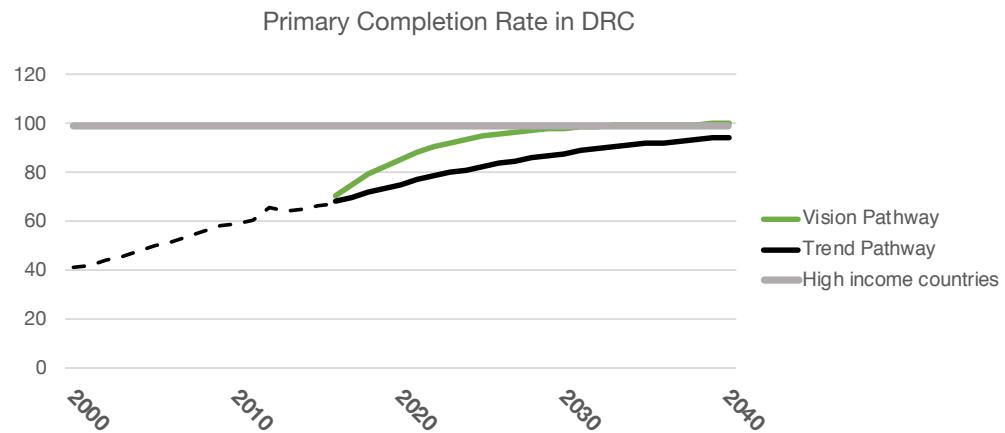
Note: Figure 1b shows two projected pathways for country C: the Learning Generation Vision pathway in green, and the Trend pathway in black.

3. Projected number of students from preschool to post-secondary

The model projects total cost of providing education along the pathway specified (be it Trend or Vision). Total costs are equal to the number of students multiplied by the cost per student, by school level and by country. This section discusses how the number of students is projected.

The Learning Generation Vision and Trend pathways project the share of children and youth who will reach each of the seven education markers. The model uses a detailed bottom-up approach and estimates the education progress of students by grade over time from preschool through secondary. Student progression is determined by rates of entry, promotion, repetition, and dropout. The number of students then determines how many teachers, classrooms, materials, etc. are needed, and the costs are the sum of teacher salaries, other recurrent costs, capital investments, and support for marginalized students or specific interventions, depending on the scenario.

The trends for students combine attendance pathways with demographic projections and data regarding the starting patterns of entry, repetition, and promotion by grade. Attendance pathways are for preschool access, primary completion, secondary completion and post-secondary access. The starting number of students by level from preschool through post-secondary, as well as information on the duration of primary and secondary school, and repetition, are obtained from UIS via the World Bank Edstats online database. The demographic projections are from the United Nations World Population projections (medium

variant) for absolute numbers of children and youth obtained via the World Bank Health Nutrition and Population Statistics online database.

3.1   Projected number of preschool students

Countries differ in their official designation of preschool. Some countries designate only the last year before the official start of primary school as official preschool; while others, such as Afghanistan, officially have four years of preschool prior to primary. In our global estimate of the number of preschool students, the Commission used the Sustainable Development Goal indicator, namely that all children should participate in *one year of organized learning prior to beginning primary school.*[7]

The calculation of preschool students in each country is straightforward: it is the product of the projected preschool gross enrollment rate (GER), according to the Learning Generation or the Trend pathway, and the projected number of children aged one year younger than the official starting age for primary according to the UN World Population Projections. See *Model Diagram 3* in the Annex.

3.2   Projected number of primary and secondary students

The calculation for the number of primary and secondary school students starts with the observed number of students, by sex, in each grade from primary to the last grade of upper secondary.[8] Student numbers are projected by grade, based on new entrants to primary school (gross intake rate), and grade-wise promotion, repetition, and dropout rates. Promotion, repetition, and dropout rates – what are called *student flow*s – for the initial year can be computed from students and repeaters by grade in two consecutive years.

To compute the projected number of students for the Learning Generation Vision and Trend scenarios, we work backwards from the projected *completion rates* in each scenario (the proportion of children who will reach the end of primary and upper secondary) to compute the *student flows* that lead to those completion rates. There are different promotion and repetition rates for each grade and there is no unique mathematical solution. The model simplifies by taking the most recent actual intake, grade-wise promotion and repetition rates for each country by sex and by grade, and shifts these up or down proportionally, year by projected year, to the levels that lead to the Learning Generation Vision or Trend completion rates.[9]

Once these flows for the Trend and Vision scenarios are established, the number of students for each of these is projected forward starting from the most recent observation of students by sex and grade, applying the grade-wise student flows for intake, promotion, and repetition rates. The number of first graders is equal to the projected population of primary grade 1 multiplied by the gross intake rate, plus repeaters from the previous year. Aside from grade 1, the number of students in each subsequent grade is the number of students in the previous

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[7] https://sustainabledevelopment.un.org/sdg4.
[8] Many countries differentiate general and vocational upper secondary; in the Commission's projections these two streams are treated as one.
[9] Promotion rates are generally shifted upwards; repetition rates are shifted downwards if repetition starts at greater than 5 percent but maintained constant if starting below 5 percent. Intake rates are shifted upwards if intake is less than universal, and downwards to reach 100 if starting values are greater than universal.

grade in the previous year times the promotion rate plus the number of repeaters based on repetition rates. Finally, primary school, lower secondary, and upper secondary school students are aggregated based on the country-specific number of grades in each level. See *Model Diagram 4* in the Annex.

3.3   Projected number of post-secondary students

Post-secondary access is increasing by leaps and bounds in many countries, and it is difficult to predict how long such expansion can continue. The Learning Generation Vision is based on the *top 50 percent* of improvers because using the growth rate of the top 25 percent leads to near-universal post-secondary access by 2040, an implausible outcome.

The post-secondary access rate is defined as the *proportion of youth who enter post-secondary.* The number of post-secondary entrants is computed as post-secondary access rate multiplied by the projected population aged one year beyond the official age to complete upper secondary, capped by the number of upper secondary school completers.

These post-secondary entrants are distributed over three post-secondary streams of training – tertiary education, post-secondary non-tertiary (professional) training, and virtual forms of post-secondary education.[10] Across each stream, the duration of post-secondary in each stream varies from very short professional degree training to very long post-graduate training. To account for this variation, the Commission's model projects a distribution of entrants across the three streams, with a specific average duration of study in each stream. UIS does not provide the official duration of post-secondary streams by country, only the population of the official tertiary age. For traditional tertiary, the population of official tertiary age is divided by the population of tertiary entry age (one year older than the official age to complete secondary) to get an approximation of the official duration of tertiary according to UIS; or as equal to 4 years if data is not available. The duration of post-secondary non-tertiary is estimated in the same way; or as equal to 2 years if data is not available. Based on existing examples, virtual education tends to be short and focused, and an average duration of one year was assumed. To estimate the *number of post-secondary students*, the costing model multiplies post-secondary entrants by the average number of years that students are within each of the three streams. The total number of post-secondary students is the sum of these three streams. See *Model Diagram 5* in the Annex.

The Commission made two assumptions on future shifts between the three post-secondary streams, based on expert consultation:

- First, it assumed that there would be a shift towards non-tertiary training and away from traditional tertiary among "brick and mortar" students that physically go to classes at tertiary or post-secondary non-tertiary (often, professional post-secondary) institutions. The model projects that by 2030 the distribution would be 6:4 for tertiary vs. post-secondary non-tertiary. For the sake of simplicity, the Commission estimated that the average years each student stays in their study is equal to the official duration in either stream.

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[10] This new stream "leapfrogs" traditional modes, and uses, for example, online learning, skills-based credits, immersive programming, and other innovations.

- Second, although most post-secondary students attend "brick and mortar" institutions today, in the next generation there may be a deep shift toward online education. Experts consulted by the Commission[11] believe that a rapid disruption by virtual, online training programs is necessary, inevitable and accelerating. They estimated that by 2030, as much as 50 percent of the world's post-secondary aged youth could use such virtual channels. This estimate is highly provisional as there are no existing historical trends, but enrolment data from a few online-based learning organizations supports this trend. For example, Udemy, an online course marketplace founded in 2007, has 10 million learners today. Topica, serving Vietnamese, Philippine, and other Southeast Asian learners had 23,000 enrolled in 2016 and has been doubling enrolments every year. UNICAF, an online provider focused on Africa, predicts it will have 100,000 learners on the continent by 2020. Moreover, there is no global compilation of virtual education data today, and researchers must rely on anecdotal evidence, which indicates that this sector is gaining ground rapidly.

4. A basic quality education service package: Unit cost estimates

Costs per student make up the second half of the cost equation (Total costs = number of students multiplied by unit costs). Because the unit of analysis is the student in this 'bottom-up' model, these costs are based on the environment or context that each student needs to remain in school and learning. The basic unit cost is recurrent plus capital cost. The recurrent cost equation is teacher salary plus the costs of materials per teacher divided by the pupil teacher ratio; and unit capital costs are equal to the cost of building a classroom (including long-term materials and maintenance for the lifetime of the classroom divided by the product of the pupil classroom ratio and average classroom lifetime.

Costs are projected separately for each country and at each school level. Total projected costs are the aggregate of the country-specific costs. For the Learning Generation Vision scenario, the Commission estimates that all countries will provide a *basic quality education service package* for the provision of preschool through secondary education by 2030, including teachers; material and personnel support for teachers and students; and classrooms.

Cost categories are based on analyses of programs and policies using multiple resources: the Systems Approach for Better Education Results (SABER) database, meta-analyses, an integrated intervention-based projection module, and background research papers commissioned for this purpose. These costs are not meant to be prescriptive, but rather provide a reasonable budget benchmark toward raising learning outcomes and access to the Vision pathway. Costs are divided into four components: pupil teacher ratio, teachers' salaries, the aggregate of non-salary recurrent supporting expenditures, and construction of

new buildings.[12] Country context, which is approximated by GDP per capita and the poverty rate, influences unit costs.

The costs here represent *conservative unit cost estimates* that assume that *resources are being used efficiently* (e.g. not lost to corruption). A central insight from this analysis is that to improve quality, most countries will need to add inputs, but those inputs are synergistic with existing resources (like teachers) and the additional costs are often far less than the improvements they leverage.

4.1   Pupil teacher ratios

Pupil teacher ratios (PTR) vary widely in low- and middle-income countries – from over 70 primary students per teacher in some poorer countries, to fewer than 10 in some middle-income countries. As shown in

Figure *2*, there is a clear trend of wealthier countries having smaller class sizes. Low-income countries having class sizes ranging from 20 to 80 students per teacher while all high-income countries have class sizes below 20.[13] If this trend continues to hold true, then as countries' incomes rise, they will tend to invest in smaller classes.

At the same time, research suggests that there are diminishing returns to reducing class sizes once a certain threshold has been reached.[14] We further substantiated this research by comparing the PTR of high-performing countries – defined as those with the highest test scores within four international assessments (Programme for International Student Assessment (PISA), Latin-American Laboratory for Assessment of the Quality of Education (LLECE), Programme for the Analysis of Education Systems (PASEC), and Southern Africa Consortium for Monitoring Educational Quality (SACMEQ)) – relative to GDP per capita.[15] This group of countries is shown in red dots in

Figure *2*. If anything, the PTR relative to GDP per capita is slightly *higher* in the high-performing countries.

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[12] The unit costs per pupil can be broadly expressed in some simple equations. The per pupil cost (PPC) is equal to the annual per class cost (PCC) divided by the average pupil teacher ratio (PTR): $PPC = PCC/PTR$. The annual cost per class is equal to the product of average teacher salary, *sal*, and the non-salary supportive expenditure multiplier, *mult,* plus the average cost to provide the classroom, *const*, distributed over the classroom's life time, *l,* and possible double shifting effects, *ds*: $PCC = sal * mult + constr/(l * ds)$. To obtain the per pupil cost as a percentage of GDP per capita, salary, classrooms construction and per pupil cost are divided by total population.

[13] Used threshold for low-income countries from the World Bank as of 2017, which defines a low-income country as one that is below $1,005 GNI per capita in 2016.

[14] These estimates are based on a variety of studies which include: Lockheed, Marlaine E., Adriaan M. Verspoor, and associates. 1991. "Improving Primary Education in Developing Countries." Oxford University Press for the World Bank: Oxford; Bruns, Barbara, Alain Mingat, and Ramahatra Rakotomalala. 2003. "Achieving Universal Primary Education by 2015: A Chance for Every Child." World Bank: Washington, DC; EQUIP 1. 2007. "Large class sizes in the developing world: What do we know and what can we do?" USAID: Washington, DC; and UNESCO. 2006. Global Monitoring Report: Education for All – Strong Foundations. Early childhood care and education. UNESCO: Paris.

[15] For "high performers" we selected the top 15 scoring countries from PISA; and the top 2-5 from the LLECE, SACMEQ, and PASEC regional assessments. For PISA these countries are: Singapore, Japan, Estonia, Finland, Canada, Vietnam, Korea, New Zealand, Slovenia, Australia.   For LLECE, the countries are: Ecuador, Colombia, Peru, Brazil, Costa Rica. For PASEC (low income), these countries are: Burkina Faso, Cote d'Ivoire. For SACMEQ (LMIC countries) these are: Kenya, Swaziland, and Tanzania.

Figure 2. Pupil teacher ratios, primary relative to average income in 2015.
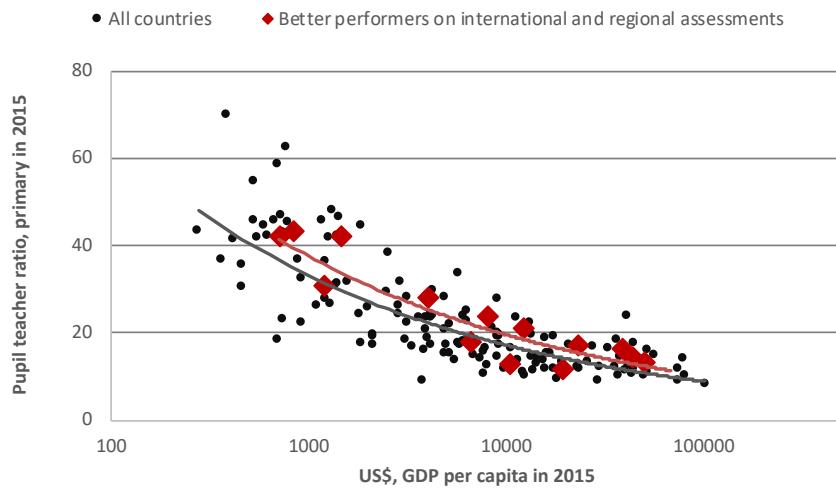
Note: Graph includes all low- and middle-income countries with data.

Following this evidence, the Commission developed two tiers of assumptions for pupil teacher ratio projections.

- First, we assume that countries *prefer* lower pupil teacher ratios as incomes rise and that the *preferred path* is for countries to reach the international PTR-GDP per capita trend by 2030 (the black trend-line shown in

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- Figure *2*). As long as countries have sufficient domestic resources – from government and households – and do not rely on external resources, the projections follow this preferred route.

- Second, for those countries that will rely to some extent on external resources the Commission assumes that class sizes converge to levels similar to those used by World Bank and UNESCO in previous global education costing estimates.[16] Specifically, in resource-constrained countries, the PTR is assumed to converge to 20 for preschool, 40 for primary school, and 35 for secondary school by 2030. This results in a leveling-off or an increase of PTR in some countries.

The Commission recognizes that it is not always politically simple to maintain larger classes, let alone to increase class size; but has included the above assumptions because **there are significant cost-savings in allowing classes to be somewhat larger** – savings that can be more effectively invested in proven reforms to improve quality (see below for discussion of salaries, non-salary recurrent expenditures, and support for marginalized children). In terms of

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[16] Bruns et.al. "A Chance for Every Child"; UNESCO, 2009 (2010?) Global Monitoring Report costing; UNESCO 2015 Costing the Right to Education.

costs, a reduction of PTR is accompanied by a roughly proportional increase in recurrent costs. See *Model Diagram 7* in the Annex.

4.2   Teacher salaries

Teacher salaries are the largest component of unit costs, and good teachers are the most important component of quality education. To attract good teachers, the overall package for teachers, including salaries, should be competitive. At the same time, salaries cannot over-burden the budget. The Commission analyzed teacher salaries around the world to understand general trends and identify a pattern of teacher salaries in high-performing countries. The data used is from three online databases compiled by UIS, Pole de Dakar, and the International Labor Organization (ILO).[17]

The ILO data comprises salary information by occupation for over 100 low- to high-income countries. These data show one remarkable consistency, namely, that teacher salaries are similar to salaries of other mid-level professionals, regardless of overall income levels. This suggests that in most contexts, schools compete with the rest of the labor market for teachers as skilled workers.[18] Second, earlier research had already shown that the ratio of teacher salaries to income per capita declines as incomes rise; in very poor countries with many low-skilled workers, the skills of teachers command a higher premium.[19] This is still the case, as shown in Figure 3. In low-income countries, teacher salaries average 3.7 times GDP per capita; 2.9 times GDP in lower-middle income countries 2.9; and 1.8 times GDP in upper-middle income countries. Within this pattern, the range of salaries is considerable. For example, teacher salaries are 1.9 times GDP per capita in low-income DRC, but 7.1 times GDP per capita in low-income Burundi.

We checked evidence for the relationship between learning outcomes and teacher salaries. For salaries, we used teacher salaries as a multiple of GDP per capita from World Bank, Pole de Dakar, and OECD datasets. For learning outcomes, we looked at the percentage of students who reach the "low" learning outcome in the TIMMS or PISA tests, and split those observations into counties that were "high performers" in the Top 25 percent (selected as discussed in section **Error! Reference source not found.**) and all others. Figure 3 shows the correlation of salaries and GDP per capita for the "higher performing" group (red dots) and all others (black dots). Among the group of better performers on learning assessments, *teacher salaries are all clustered in the top half of the overall teacher salary-income distribution*), It is possible that there are unmeasured outliers, where there is high learning and low teacher salaries; however, a reading of the existing evidence suggests, albeit not conclusively, that teacher salaries that are somewhat above the current international average are a *necessary*

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[17] UIS database accessed "Annual statutory teacher salaries in public institutions in USD, 15 years of experience" by school level divided by GDP per capita of the same year; Pole de Dakar database accessed 9/1/16 "Rémunération brute annuelle moyenne d'un enseignant du primaire sur le budget de l'Etat (en unités de PIB/habitant)"; ILOSTAT "Mean nominal monthly earnings of employees by sex and occupation - selected ISCO level 2" by major occupation group, including "Teaching professionals".

[18] The Commission analyzed teacher salaries relative to other occupations and found that there is a strong nearly one-to-one correlation of teacher salaries with administrative professionals, and that teacher salaries are overall, somewhat below those of health professionals. This holds true over a range of countries from relatively poor Ethiopia to the wealth OECD countries. Data source: ILOSTAT "Mean nominal monthly earnings of employees by sex and occupation - selected ISCO level 2" by major occupation group, including "Teaching professionals".

[19] For example, Wils, Annababette and George Ingram. 2011. "Universal Basic Education: A Progress-based Path to 2025". FHI360, Washington, DC.

condition to better learning outcomes (even while they are not *sufficient*). **Based on this, we assume that teacher salaries need to be on par with the "high performance" group, reaching the high-performance trend line by 2030, to reach the learning outcome levels projected in the Learning Generation Vision.**

Specifically, the salary projections use an income-dependent target path based on the salaries in the upper half of the income-salary distribution. As countries get wealthier over time, their target moves; all countries are assumed to reach the target for their respective income level by 2030. In some countries, that implies a dampening of salary growth (not a decrease in absolute terms),[20] but in many, especially those with low teacher salaries, these assumptions imply a strong salary increase over the next decade. See *Model Diagram 6* in Annex.

Figure 3. Teacher salaries relative to average income and Learning Generation teacher salary path for Learning Generation report 2016.
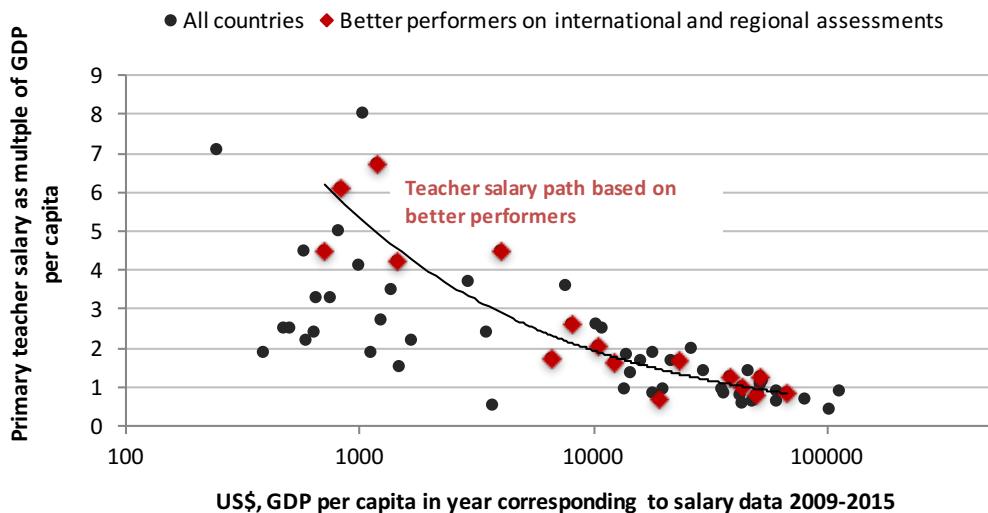
4.3   Non-salary recurrent costs

Another important component of quality is the provision of teaching materials and additional support for teachers and pupils. On average, low- and middle-income countries allocate only about 15 percent of education spending to such non-salary recurrent costs at the primary level.[21] In contrast, in OECD countries, non-salary recurrent costs are almost 30 percent of total spending.[22] Moreover, when non-teacher salaries are excluded, high-performance OECD countries spend approximately 42 percent.[23] In another high-performing country, Vietnam, this

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[20] We assume that it would not be politically feasible to reduce teacher salaries in absolute terms. Therefore, in countries with salaries far above the Learning Generation salary path, we assume that absolute salaries remain constant, even while GDP per capita grows over time, until the salaries are in line with the Learning Generation salary path.

[21] Estimate based on UIS data for percentage of public education expenditures on non-salary recurrent spending.

[22] UIS data extraction from World Bank Edstats for the indicator "All staff compensation as % of total expenditure in primary public institutions (%)" using the most recent data in the time range 2012-2015, and filtering only for OECD countries.

[23] OEDC. 2016. "Education at a Glance", OECD, Paris. Reference found on page 256.

category of spending is almost 50 percent of the total recurrent expenditure.[24] These costs include everything from classroom materials, in-service training, monitoring, data collection, assessments, making classrooms inclusive, and giving vulnerable children material support.

In addition to the evidence from non-salary recurrent spending in high-performance systems, the Commission conducted a meta-meta-analysis of field research on interventions that improve learning and the impact of risk-factors on school outcomes.[25] These findings were input to computations of how much a selection of the most effective interventions would be able to improve learning outcomes..[26] **These calculations suggest that a selection of highly effective interventions could, in combination, raise learning outcomes in low- and middle-income countries to the Learning Generation Vision levels** and that these changes would require an increase in the non-teacher-salary component to approximately 30 percent of recurrent costs. This assumes that the effect sizes found in research carry over to other contexts, although we tried to account for varying contexts in the meta-analysis. This finding is corroborated by the 30 percent that the high-performing OECD countries spend on non-salary recurrent costs as a portion of all recurrent costs, but it is lower than what the high-performance outlier Vietnam spends. The Commission thus set a target of 30 percent of recurrent costs to be used for non-teacher salary costs for the Learning Generation Vision scenario. See

Model Diagram 9 in the Annex.

In general, children from a marginalized background – poverty, ethnic minority, rural regions, girls – are disadvantaged in education. It is possible to reduce these disadvantages with focused programs. In addition to the additional non-salary recurrent costs spending of 30 percent of teacher salaries, the Learning Generation projections also include additional subsidies for reaching marginalized children (using children living in extreme poverty as a proxy). The Commission's Learning Generation Vision model assumes that these marginalized children require an additional 20 percent of investment at the primary level, 30 percent at the lower secondary level, and 40 percent at the upper secondary level.

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[24] Commission calculations based on data from Vietnam Education Sector report – National Education Account document for Vietnam for salaries and online Government statistics for teacher numbers.

[25] For a review of the interventions, see Conn, Katherine. 2016. "The Effectiveness of Education Programs Worldwide: Evidence from a Meta-Analytic Dataset." Background Paper for the Education Commission. https://report.educationcommission.org/resources/

For a review of risk groups, see Kan, Sophia and Annababette Wils. 2016. Analysis of Risk Factors in Education in Developing Countries: Technical report." Background Paper for the Education Commission.

[26] The Commission developed an intervention simulation model based on earlier work published by UNICEF and the Lancet (UNICEF. 2013. Simulations for Equity in Education. Model background, methodology, and results from the first two years. UNICEF. New York. Available on: https://www.unicef.org/education/bege_SEE.html ; Sheehan, Sweeny, Rasmussen, and Wils et.al. 2017 "Building the foundations for sustainable development: a case for global investment in the capabilities of adolescents." Lancet doi: 10.1016/S0140-6736(17)30872-3). In the intervention-led model, education improvement is driven from the bottom up: participation and learning improvements respond to impacts from assumed changes in programs and interventions, rather than from exogenous target or trend settings. The model takes into account dynamics such as diminishing returns to effective interventions as the context improves, as well as improved cost-effectiveness through targeting of specific risk groups. This intervention-led model is currently being finalized but when complete, the model will easily allow a user to test a variety of intervention baskets for different countries. The Commission tested many different baskets to come to its estimate for non-salary costs.

4.4 Capital costs

The number of classrooms needed is assumed as equal to the number of teachers (one classroom per teacher). **The model assumes that new schools need to be added in tandem with teachers, and old schools replaced based on a 30-year lifetime of classrooms.** The costs of constructing classrooms were obtained from country and regional studies, as was the estimated lifespan of 30 years.[27] Total capital costs are the number of classrooms to be constructed multiplied by the unit costs. See *Model Diagram 8* in Annex.

4.5 Shifts in the level of spending per student

The above assumptions make up the basic quality package, which countries are assumed to reach by 2030. For the Learning Generation report projections, the cost dynamics underlying the changes in pupil teacher ratios, teacher salaries, non-salary recurrent costs and capital investments are as follows:

1. **Pupil teacher ratios.** As incomes rise, PTR declines if a country has no financial constraints; but, as is the case for many countries, if a country has cost constraints, assumptions are triggered that lead to rises in PTR.
2. **Teacher salaries.** As incomes rise, teacher salaries also rise, but *more slowly* than average incomes, in particular as countries transition from low-income to middle-income. At the same time, salaries are assumed to converge at the trend-line defined by countries with better learning outcomes. In most countries, the balance of these two dynamics is for teacher salaries to rise in absolute terms. In low-income countries, on average, salaries for primary school teachers rise in absolute terms *and* relative to GDP per capita (but this is not true for all countries). On average, the balance of salary dynamics is a substantial growth of payment for teachers. In middle-income countries, on average, primary school teacher salaries to rise almost proportionally to GDP per capita. At the secondary school level, on average, teacher salaries to rise proportionally to GDP per capita for all income groups.
3. **Non-salary recurrent costs** to support teachers and pupils will rise in the large majority of countries as a portion of total costs.
4. **Capital investments.** Classroom costs rise proportionally to average income (from country-specific starting levels) as countries provide one classroom for one teacher; construction and maintenance is projected accordingly. In low-income countries, the growth in population, rising school access, and declining pupil teacher ratios generate a substantial rise in capital investments; while in middle-income countries, capital investments make up a smaller share of total costs than previously, amounting to noticeable savings in per pupil expenditures.

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[27] A brief and clear discussion of classroom construction and estimates of costs in developing countries can be found in: Theyndyck , Serge. 2003. "Education for All: Building Schools" Policy Notes. World Bank. All of the dollar values found in this report as well as other sources were converted to multiples of GDP per capita to be used in the projections, so construction costs rise with general incomes as one would expect. These classroom construction costs were used for the UNESCO 2015 and Learning Generation Investment models.
This brief also provides a discussion of different costs of constructing classrooms depending on procurement, and estimates for furniture and maintenance: Leathes, Bill, Roger Bonner, P K Das, Ripin Kalra and Nigel Wakeham. 2004. "Delivering Cost Effective and Sustainable School Infrastructure" The TI-UP Resource Centre and DFID, UK.

In the Learning Generation Vision, the effect of these four shifts is that per student expenditure in primary education in low-income countries needs to increase substantially. [28] In middle-income countries, primary pupil expenditure should rise roughly proportionally to GDP per capita growth. Within unit costs, there would also be a marked shift towards expenditures other than teacher salaries. Capital costs are expected to rise from today's level only in low-income countries due to the large education expansion necessary there.

Countries can, of course, opt for expenditures higher than the basic quality package if there is political and private will to invest domestic resources in that way. For example, middle-income countries could opt to maintain small class-sizes in secondary school without compromising non-salary spending, accept higher unit costs, and allocate domestic resources to education in line with this preference. The projections are not a prescription for countries, but an attempt to compute baseline costs for reaching the Learning Generation goals.

4.6   Unit costs for post-secondary education

The costs for post-secondary are calculated differently than described above. Due to data scarcity as well as the focus on primary education within the Sustainable Development Goals, the two streams of "brick and mortar" post-secondary education were estimated as a lump sum rather than by components. Post-secondary unit costs are assumed to be the same for both tertiary and post-secondary non-tertiary education.[29] As with many other cost indicators, we used a regression analysis to find the correlation of costs with GDP per capita and found that that post-secondary costs as a percent of GDP per capita decline as GDP per capita rises. In the Learning Generation Vision projection, the unit costs for each country are assumed to reach this average regression line by 2030. For costing virtual education, we consulted experts in this area. One year of virtual post-secondary is assumed to cost 25 percent of GDP per capita.[30] See

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[28] Some readers may argue there are education models that deliver basic education in poorer countries at cost levels below those of the Commission. For example, the annual costs of a student in a Bridge International in Kenya cost are about $140 (figure on Bridge Academies website), or 10 percent of GDP per capita. The Economist cites $71-$122 for tuition annually, but elsewhere the full costs, excluding lunches, are estimated to be higher. Moreover, as of 2017, Bridge had yet to break even with this cost structure. While this project and other low-cost alternatives deserve to be followed closely, they are not, at this point, proven methods to run an entire country's school system and have yet to be implemented in a low-income country. Sources: http://www.economist.com/news/business/21715695-its-biggest-challenge-may-well-be-financial-bridge-international-academies-gets-high-marks, and http://www.bridgeinternationalacademies.com/wp-content/uploads/2016/09/Brookings-Millions-Learning-case-study.pdf.

[29] Unit costs are taken from the UIS post-secondary expenditure indicator, "government spending per student as a percentage of GDP per capita", or computations based on aggregate government spending on post-secondary divided by the number of students. For countries with missing data, regional averages were used.

[30] Salmi, Jamil. 2016. Tertiary Education and the Sustainable Development Goals In Search of a Viable Funding Model. Background paper prepared for the Education Commission. Global Tertiary Education Expert, and Staton, Michael. 2016. Leapfrogging College: Moving beyond the incumbent model to achieve access, affordability, and quality in postsecondary education. Background paper prepared for the Education Commission. Learn Capital

5. Projected learning levels

Learning is the purpose of education, and many thought up until recently, perhaps naively, that if children attended school, they would be learning. Unfortunately, mounting evidence – emerging particularly in the past 10 years – shows learning levels in developing countries that are far below what they should be, with many students not able to read simple sentences or do basic addition and subtraction even after years of schooling.[31]

Even as this general insight has emerged, it has also become clear that there are many gaps in this knowledge of how well children are learning in low- and middle-income countries. While many countries measure their students' learning outcomes annually through high-stakes entrance or certification exams and assessments,[32] these are not internationally comparable and sometimes not even comparable from one year to the next within the same country.[33] To date, there is still a significant group of countries for which no public assessment of learning exists. About 50 low- and middle-income countries participate in *regional and international sample-based assessments* at the primary level. At the secondary level, 32 middle-income countries participate in these assessments, but no low-income countries.

The Commission's work to estimate learning in low- and middle-income countries is an effort to compile the available comparable data and estimate the proportion of students learning in primary and secondary school in all low- and middle-income countries. Benchmarks used in the model are due to data availability and we recognize that actual learning is a much more broad and complex process. Our efforts expand on existing work, and we believe that they are likely to become superseded in the next few years as more countries join international and regional assessment series and as methodologies to align assessments mature.[34]

5.1   Primary learning data

The learning benchmark for primary students is reaching at least Level 1 on a PIRLS grade four reading assessment or equivalent. Data is taken from a cross-section of regional and international learning assessments.

From the international assessments (e.g. PIRLS), the "low" level of achievement was taken as the minimum benchmark. For the regional assessments, we used countries that had participated in both the regional and an international assessment, taking the percentage of students who reached the "low" international level and matching that to a regional learning level reached by the same percentage of students. For LLECE, this was the level 2 in reading, based on data from Colombia; for SACMEQ this was level 6 reading, using Botswana and South Africa. There were no countries that participated in both PASEC and an international

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[31] See, for example, Global Education Monitoring Report. 2016. "Education for people and planet: Creating sustainable futures for all."

[32] The UIS Catalogue of Learning Assessments includes over 70 countries to date.

[33] See, for example, EPDC 2008 for an analysis of national learning assessments. Education Policy and Data Center. 2008. Sub-national Disparities in Learning: An Analysis of Differentials in Learning Scores in 25 Countries, and the Correlations with School Entry and Retention Rates and Pupil-Teacher Ratios . EPDC Working Paper No. EPDC-08-10. FHI360. Washington DC.

[34] The UNESCO Institute for Statistics (UIS) is currently leading in the development of these methodologies.

assessment; reading level 4 was used as the minimum benchmark based on a comparison of the descriptions of reading capabilities from the PASEC 2014 reports and PIRLS. International and regional assessments provide learning data for about half of low- and middle-income countries.

For countries with no data after combining international and regional assessments, estimates were made for primary learning based on the country income group, as there is a clear relationship between learning outcomes and income levels of countries. Variation within income groups suggest that we cannot use the income-estimated learning levels as a stand-in for specific countries, but, combined with observed data on learning for about half of countries, these estimates are reasonable for calculating global and regional averages.

5.2   Secondary learning data

For secondary school learning benchmarks, the equivalents are set at PISA or TIMSS (grade 8) level 1 or higher in the mathematics assessments. For countries that had participated in either assessment, actual scores were used. In cases where countries had not participated in either assessment, the Commission used a statistical predictive model that builds on earlier models for identifying factors correlating with learning outcomes.[35] It should be clear that we do not assume that we have identified a causal model of learning; this is simply a prediction based on correlation.

We tested a range of variables suggested by this earlier research to be correlated with learning outcomes, and the primary level learning dataset. These were compiled into a hierarchical set of predictive learning production models using multivariate regression in Stata.[36] Models 1-2 in Table 1 show regressions with two dependent variables of economic indicators – the log of GDP per capita, and extraction rent as a percent of GDP. A model with just these variables fits reasonably well with the secondary math learning outcomes, with an R-squared of 0.56. The third model includes of the primary learning scores as described in Section 4.1. Here, not surprisingly, the fit of the model is dramatically improved, as the R-squared value rises to 0.76 with all three variables highly significant. Model 4 includes average years of adult education, with an R-square of 0.62 and all three variables significant at the 1 percent level. Model 5 includes a dummy for socialist or communist countries, as well as a dummy for Vietnam to account for this country's extreme outlier position (performing as well as OECD countries in PISA). The fit of model 5 is almost as good as the model with the primary-level learning assessments, at an R-squared of 0.79 with all five independent variables significant at the 1

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[35] Some of this literature was summarized in the UNESCO 2008 Global Monitoring Report on learning. In 2011, the Education Policy and Data Center (EPDC) proposed a production function to predict learning outcomes using a multi-stage regression analysis (Education Policy and Data Center. 2011. "Estimating Education output in Developing Countries". EPDC Working paper 2011-1. FHI-360, Washington, DC.). Hanushek and Krueger also analyzed school-level inputs as determinants of learning outcomes in various publications (Hanushek, Eric A. 1995, "Interpreting Recent Research on Schooling in Developing Countries." World Bank Research Observer, 10(2):227-246; Hanushek, Eric A. 1997, "Assessing the Effects of School Resources on Student Performance: An Update", Educational Evaluation and Policy Analysis 19(2), Summer 1997, pp. 141-164.; Hanushek, Eric A. and J.A. Luque, 2003. "Efficiency and equity in schools around the world." Economics of Education Review 22 (2003) 481–502; Krueger 2003.)

[36] The predicted learning outcome for each country is: $L = c + \sum_f \beta_f * F_f$. In the equation, F denotes the factors of learning, β_f the regression coefficient, and c the constant.

percent level or below. Model 6, for countries for which the average adult years of schooling are not available, includes only the economic and political dependent variables and performs slightly worse than model 5, with an R-squared of 0.75 and all independent variables significant at <0.1 percent.

Table 1. Step-wise regression results for the learning production function.

Specifications	(1)	(2)	(3)	(4)	(5)	(6)
Ln GDP per capita	9.13***	8.20***	3.13**	4.80**	8.64***	11.34***
Extraction rent as a percent of GDP		-0.74***	-.41***	-0.66***	-.63***	-.68***
Percent reaching primary learning benchmark[+]			.60***			
Average years of schooling adults 25-34				3.41**	2.50**	
Socialist/communist state dummy					13.53***	14.39***
Vietnam dummy					38.49***	37.22***
Constant	-5.16	8.58	2.59	4.12	-26.49**	-26.00*
N	74	74	54	68	68	74
R squared	0.36	.56	.76	0.62	.79	.75

*** significant <.1 percent; ** at <1 percent; * at <5 percent level

Overall, the model predicts the observed values well. For two-thirds of the distribution, there are a fairly large number of observations and with a mean error of 7.4, the predicted values of the model are likely to be reasonably close to actual values.

5.3   Projections of learning

The projections of learning outcomes are included only for those two high-level outcomes – primary learning as measured by the low benchmark in reading and secondary learning as measured by the low benchmark in math. Like access and completion goals, the progression of learning over time is based either on either the Trend scenario, historical trends consisting of country-specific progress, or on the Vision scenario, which uses the growth rates of the top 25 percent fastest improvers in learning. No earlier global costing models include learning explicitly. *This remains a very simplified representation of learning outcomes, and we would like to see it as the first starting point for learning projections that may later have more differentiation.*

6. Smart spending: getting more learning out of education investments

An important takeaway from the Vision scenario cost calculations is that despite increases in costs overall, the Learning Generation Vision would result in substantial cost-savings by cutting waste and increasing effectiveness. To summarize the previous section, the projected costs are the product of the number of students – determined by country context, Learning Generation trajectories, and population growth – and unit costs. Unit costs are based on quality assumptions regarding class size, teacher pay, capital investments, and other costs. All calculations are rooted in country-specific data and contextual differences regarding levels of development or poverty, as well as data analysis of global trends.

The Learning Generation Vision scenario results in a marked increase in effectiveness: *the increases in the number of children and youth learning far outstrips the rise in cost*. Very roughly, one can measure the increased efficiency as the ratio of growth of number of children learning versus growth of expenditure on education as percent of GDP. The more the former growth exceeds the latter, the greater the efficiency. For example, in the Learning Generation report projections, the Commission's Vision scenario projects that the number of children and youth on track to meet minimum learning benchmarks in low-income countries would quadruple by 2030. In lower-middle income countries, the number of children and youth learning would nearly double by 2030.[37] In contrast, the increase in spending as a share of GDP does not come close to doubling for either income group.

Another way to measure the efficiency of the Learning Generation scenario is to compare it to an alternative "Access and Completion Only" scenario, where we assume that access and completion rise as in the Learning Generation scenario[38] but, due to the lack of investment in quality, *learning outcomes remain at today's levels* and there is no additional investment for equity. In this alternative scenario, we assume that class size converges to 40 students per teacher in primary and 35 students per teacher in secondary; projected teacher salaries follow the average salary curve; non-salary recurrent expenditures remain at today's (low) levels; and there is no additional subsidy for marginalized students. Compared to the Learning Generation Vision scenario, this "Access and Completion Only" scenario results in a 15 percent cost savings, but a 70 percent loss in the number of children and youth on track to reach secondary school learning benchmarks. In fact, the average annual costs *per learning student*[39] in the alternative scenario are *40 percent higher* than in the Vision scenario, due to the reduction of students who spend 'lost years in school' with little or no learning.

7. Financing the Learning Generation

The Learning Generation Vision requires large increases in finance for education. Providing a knowledge-filled future for our children and youth cannot be done without more resources than

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[37] There are no low-income countries with such high learning outcomes today and only one lower-middle income country (Vietnam). These learning outcome improvements were projected using the simulation model that incorporates interventions and learning improvements. They are consistent with standard deviation improvements for different interventions found in this meta-analysis: Conn, Katherine. 2016. "The Effectiveness of Education Programs Worldwide: Evidence from a Meta-Analytic Dataset." Background Paper for the Education Commission. https://report.educationcommission.org/resources/

[38] This assumption is actually optimistic because it assumes that access and retention can rise without the supportive measures for marginalized students that are included in the Learning Generation scenario.

[39] Costs per learning student are computed as total costs divided by the number of learning students, that is, students who do not reach the minimum learning benchmarks are not counted.

are currently being allocated. This section describes the modeling behind the Commission's proposal to finance the Learning Generation.

The Commission's finance plan is based on three distinct finance streams: 1) government finance raised from domestic sources; 2) private contributions from households; and 3) government financing from external flows such as official development assistance (grants and loans), emerging donors, philanthropists, NGO's and other private organizations. The sections below provide a general overview of how each finance stream is calculated.

The Commission's finance plan requires a major effort from all domestic and international partners. The largest share of the financing effort will be borne by domestic governments, but international players will also need to significantly increase their contributions by 2030. Households are expected to continue to provide substantial contributions, albeit that for some low-income countries, the Commission's finance plan lowers household education payments from comparatively high levels.

7.1 Projection of government expenditures from domestic sources

The Commission divided government expenditure from domestic sources into two components – total government expenditure as a percentage of GDP, and the allocation of government expenditure to education. Each was analyzed and projected independently. As with other parts of the costing model, the projections reflect the patterns found in historical trends.

An observational analysis of past total government expenditures and allocations to education shows that governments overall expenditures as a portion of GDP increased from 2000-2015 but that the allocation to education remained more or less constant, even declining slightly.[40]

A multivariate OLS regression of government spending provides more insight into factors that correlate with these trends (no causation is assumed). The analysis shows that, on average, government expenditure as a portion of GDP rises with per capita incomes; fragile states on average spend a somewhat higher share of GDP on government expenditure; and that there are regional effects. With regards to allocations to education, the analysis found that fragility sharply reduces allocation to education and that some of the income and region effects seen in government expenditure are offset (see Table 2).

The coefficients from this regression analysis are used to create predicted *average expenditure pathways* of government expenditure for each country based on the projected population, GDP per capita, region, and fragility status.[41] No country is exactly on this average path in the start

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[40] Similar results were found in: Steer, L. and K. Smith. 2015. "Financing Education: Opportunities for Global Action." Brookings Institution: Center for Universal Education; and Mustapha, S. and P. Krause. 2016. "The capabilities of finance ministries. Overseas Development Institute. The Commission updated those analyses and found that the trends had not changed.

[41] The predicted average path for government expenditures (as a percentage of GDP) is a function of the log of GDP per capita, and population, which change over time, as well as constant factors for region and fragility: $Gav_t = c + c_y y_t + c_p P_t + c_f f + c_r R$. The allocation of government expenditure to education (in percent of total expenditures) have the same equation, with different coefficients, and is also dependent on total government expenditure levels: $Aav_t = a + a_y y_t + a_p P_t + a_f f + a_r R + a_p Gav_t$.

year; the projection model assumes countries will converge to their average paths gradually, by 2030.[42]

In addition to the average government expenditure and allocation paths, the Commission considered ambitious spending targets for countries according to the Learning Generation Vision scenario, based on the top 25 percent countries for government expenditure and the top 25 percent for allocation to education. This is based on cross-sectional correlations and is different from the list of top 25 percent improvers used to estimate progress toward education objectives. The top 25 percent of countries for government spending are those that spend the most *relative to the predicted level of spending*, given their development context.[43] A second, simpler multivariate correlation model was run with only the top 25 percent countries and including only the variables GDP per capita and population size. These models provide the coefficients to project *ambitious expenditure pathways* for countries that converge with their projected "top 25 percent" pathway by 2030.

In the Learning Generation Vision projections, the Commission assumes that total government expenditure expands according to the "average" predicted pathways, but that public allocation to education within the total budget expands to the "ambitious" pathways. See

Model Diagram 11 in the Annex.

Table 2. Regression results for correlates of total government expenditure as a percent of GDP and for allocation to education as a percent of government expenditure

Predictor variables	Coefficients for government expenditure as percent of GDP		Coefficients for allocation to education as a percent of government expenditure	
	Average	Top 25 percent	Average	Top 25 percent
Log GDP per capita	4.3*** (0.667)	2.7** (1.120)	-1.6*** (0.411)	.25 (0.274)
Fragile	2.9* (1.520)		-5.2*** (0.942)	
South Asia	-4.9* (2.811)		0.7 (1.859)	
Central Asia	2.8 (2.304)		-0.3 (1.589)	
Sub-Saharan Africa	-2.6 (2.277)		4.9*** (1.594)	
Latin America	-4.1* (2.361)		4.7*** (1.629)	
East Asia / Pacific	-3.9 (2.482)		3.6** (1.791)	
Population (billions)	1.4 (3.033)	-9.1** (3.898)	-2.1 (1.867)	-6.7***(2.232)
Gov exp. excluding grants			0.1** (0.044)	
_cons	-4.5 (5.979)	19.1**(8.702)	23.0*** (3.749)	20.5*** (1.997)

[42] Specifically, the model computes the initial ratios of actual spending $G_{t=0}$ or $A_{t=0}$ to predicted average spending, as $r_{t=0} = \frac{G_{t=0}}{Gav_{t=0}}$, and similarly for allocation to education. The model assumes that this ratio converges to 1 (one) linearly from the last year (t=0) of data to 2030. In any given projection year, government expenditure is projected as $G_t = r_t Gav_t$, and similarly for allocation to education.

[43] Specifically, to identify the top 25 percent fastest improvers we calculated the *ratios* of the actual values of expenditure and allocation to the predicted values based on the models from the previous section, and then selected the 25 percent of countries with the *highest ratios* i.e. those that were *relatively* the furthest above the predicted values. Twelve countries were excluded from the analysis due to having greater than 30 percent of GDP come from extraction rent because extraction skews domestic revenue upwards. These countries include Congo Rep., Mauritania, Angola, Azerbaijan, Solomon Islands, Congo Dem. Rep., Turkmenistan, Kazakhstan, Papua New Guinea, Liberia, Algeria, and Suriname. The 35 countries with fragile state status were also excluded.

N		355	88		214	199
R2		0.25	.12		0.32	.04

*=p<0.10; **p<0.05; ***p<.0.01
Source: Education Commission Analysis. 2016.

7.2   Private household spending for education

In many countries, households bear a large portion of education costs, but how much is often uncertain due to the paucity of data. This area merits further research. The Commission's estimates of household expenditures today are based on a triangulation of data on cost components and data on expenditures. We assume that these household contributions can come from domestic resources as well as international transfers from migrants. Although it is not possible to pinpoint household expenditures on education precisely, it is clear that households contribute large sums to the education of the next generation. Household expenditures are particularly large in the poorest countries where families have the least resources. The uncertainty of household contributions is greatest in the first years of the Commission's financing projections, and fades over the projection period as household expenditures converge to assumed targets.

The projection of household expenditures is one of the few topics where the costing model relies on external settings for targets. The user sets target levels for 2030 for the percent of education costs contributed by households in three income groups: low income, lower-middle income, and upper-middle income, and separately for basic (preschool-secondary) and post-secondary education. The model assumes there is a linear progression from the starting levels of household education expenditures to the target levels. As an example, Table 3 shows the target levels used for the finance plan of the International Financing Facility for Education (IFFEd).

Table 3. Target levels for IFFEd for private household contributions to total education costs by 2030, by country, income group, and education level.

	Low-income	Lower-middle income	Upper-middle income
Preschool-secondary	5%	10%	15%
Post-secondary	25%	50%	50%

In the model, three finance sources are considered and are implemented in hierarchical order: government, households, and external finance. If government can finance education according to the projected government expenditures (above) than neither household nor external finance are considered. When the domestic government education spending trajectory falls short of the costs (as is the case in most countries), household spending is the next considered source. Household expenditures are the smaller of two numbers: a) the gap between total costs and domestic government spending or b) the household expenditures computed in the linear path from the starting levels to the target levels (described in previous paragraph). See *Model Diagram 12* in Annex for more details.

7.3   Government expenditure from external finance

As the third and last source of education finance, external finance is simply the gap between costs and the domestic resources from government and households. The Commission's estimates for external funding for education in low- and middle-income countries include aid and official development assistance (ODA) through grants and loans as well as estimates of concessional loans and funding from philanthropists, NGO's and other private organizations. Of these funds, the model used only those that were directly allocated to countries. Some portion of this third stream may flow outside of government (e.g. in philanthropy-funded private schools), but due to the paucity of data, we do not delve into this distinction.

8. Adjusting the model for new parameters

The Learning Generation Vision parameters illustrate an attainable but ambitious pathway for all countries as they embark on a path of education transformation. The design of the modeling instrument, however, allows for flexibility for the user in defining and applying their chosen parameters. For instance, an earlier version of the tool[44] was used to model a scenario to achieve the Sustainable Development Goal of inclusive, quality education for all by 2030 (SDG4) and an updated projection of this scenario was made with the Learning Generation model.

The Learning Generation Vision pathway already takes into account many of the stated goals of SDG4. The model calculates additional costs to support targeted interventions for marginalized populations – 20 percent in primary school, 30 percent in lower secondary, and 40 percent in upper secondary (see section 5.3) – in observation of the goal to eliminate gender disparity and ensure equal access to education for persons with disabilities, indigenous peoples and children in vulnerable situations. In addition, capital costs for school facilities assume one teacher per classroom and include adequate furnishing and utilities, annual maintenance, and recurrent utility costs (see section 5.4). Furthermore, the supply of qualified teachers is set to expand as salaries converge in the model to the level of high-performing countries (the top 50 percent), controlling for GDP per capita (see section 5.2).

The primary difference in the presentation of the SDG model scenario is that all countries in the SDG model adhere to a linear path toward the externally defined target of universal enrolment in pre-primary, primary and secondary by 2030 rather than following a pathway based on the trajectories of the top improvers. Parameters were also set for countries to reach universal primary and secondary completion, although secondary completion rates do not reach 100 percent for all countries until after 2030 due to the way the model calculates progression of students through the grade levels.. The SDG model also captures an additional focus on learning outcomes than what is already found in the Vision pathway by introducing higher levels of non-salary recurrent costs in support of spending on targeted interventions to promote learning.

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[44] UNESCO, 2015. "Pricing the right to education. The cost of reaching new targets by 2030." Policy Paper 18.
https://unesdoc.unesco.org/ark:/48223/pf0000232197

9. Conclusion

Projected cost estimates are always uncertain, particularly when they involve complex decisions and planning. However, they are also critical. *Without financial plans, the education sector cannot advocate for allocations of funding*. Knowing this uncertainty, the Commission endeavored to make estimates that were based on extensive empirical analysis and that tended toward being more conservative. The costing estimates are based on decades of previous work, add a considerable amount of new research and evidence, and follow the principle that costs should be kept as low as possible in resource-poor countries, while still attaining the desired quality and inclusion levels.

There are some who advocate that countries should first achieve all possible efficiency levels before making any new investments. The Commission tested possible efficiencies and concludes it is unwise to follow this route. For example, we showed an "Access and Completion Only" scenario in section that resulted in a stagnation in learning outcomes and, on balance, *cost more per learning student*. This would put another generation of children at risk of a life of curtailed opportunity. We need to *simultaneously* pursue efficiency where it is possible and make the additional quality and equity investments where they are necessary to improve classrooms and help all children succeed in school.

This model creates projections using more than a decade of historical data on the full range of education indicators from international databases. Where data is not available, the model uses evidence-based estimation methods to paint the most complete picture of global education possible. Still, lack of complete and coherent data for planning and decision-making can lead to inefficient coordination among donors, wasted resources, and makes it more likely that efforts overlook those who need resources most. The more complete data we have about the education crises today, the better equipped we are to address today's issues and plan for the future.

# Annex: Flow diagrams of Education Commission Costing Model

Model Diagram 1: High Level Diagram, all projections by country, by education level

Legend:

External data (yellow)

User assumptions (orange)

Projections (green)

* **Education objectives**

1. Preschool GER
2. Primary completion
3. Primary learning
4. Secondary completion
5. Secondary learning
6. Post-secondary access
7. Equity
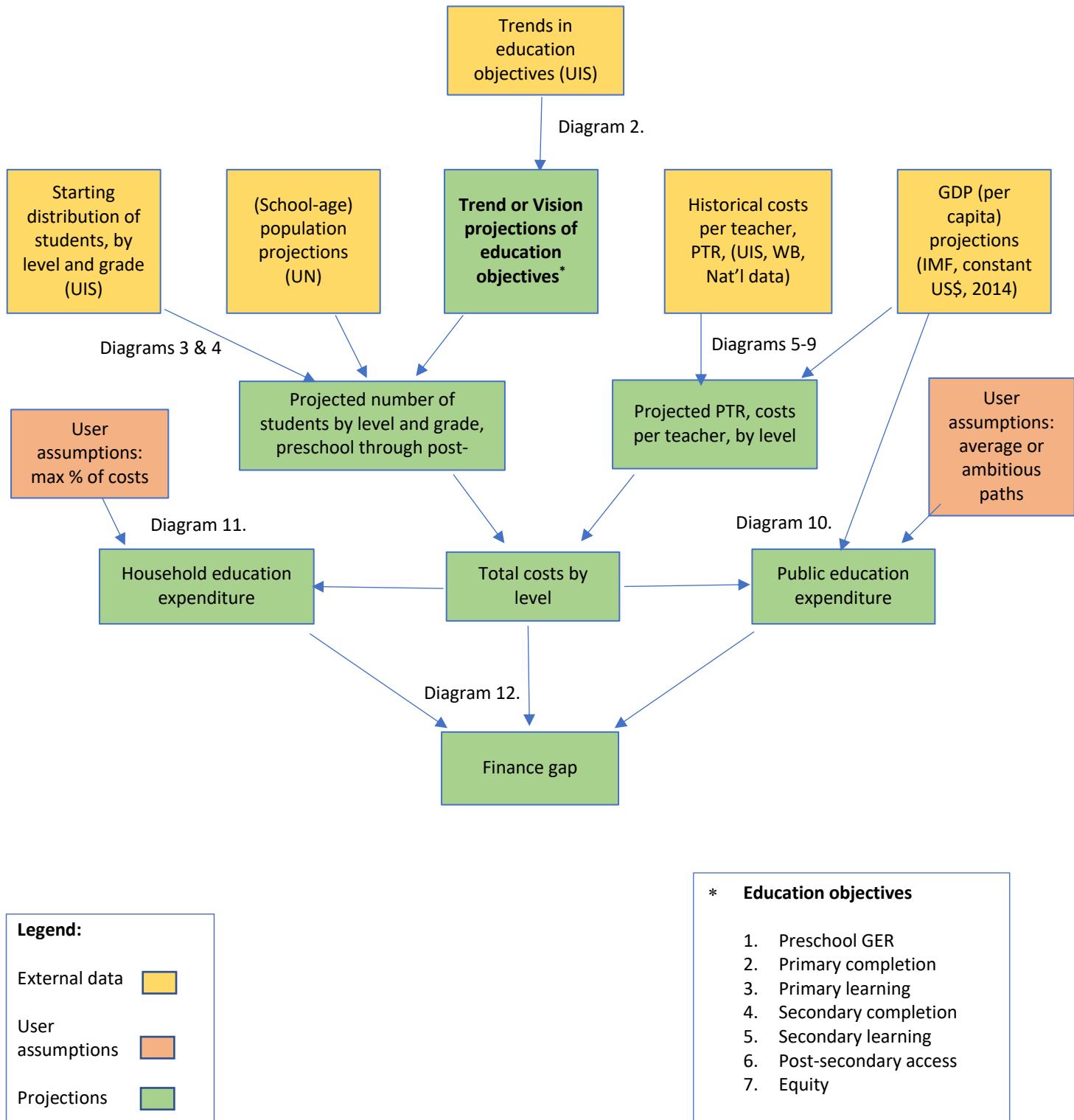
Model Diagram 2: Detailed level diagram of Trend and Vision projections of education objectives, by country, and education level

Note: for the learning objectives, these *are* the projections, no further computations. Projections for all other objectives are further computed taking other demographic and economic factors into account.

Eq 1. $\Delta actual = (X_{2015} - X_{2010})/(2015 - 2010)$
(Δ is average change; X_{2015} is observed value in year 2015; years can change as per actual observations approximately five years apart from most recent observation)

Eq 2. Regression = f(Δ, X_{2010}).

Eq 3. $\Delta predicted = f((\Delta, X_{2010})$

Eq 4. Create ratio $\Delta actual/\Delta predicted$, pick the 25 percent of countries that have the highest ratios.

Eq 5. Regression = f($\Delta Top25, XTop25_{2010}$).

Eq 6. $Xprojected_{yrT} = (X_{yrT-1} * \Delta), where\ \Delta = f(X_{yrT-1})$. Year-by-year projection of education objective X, dependent on the value in prior year and growth rate associated with that value according to the function found in Eq 5.

Model Diagram 3: Preschool students

Projected preschool age population (UN)		Trend or Vision projections for preschool GER

Eq. 7

Projected number of preschool students

Eq 7. $S^{Preschool} = GER * Pop^{Preschool}$
For every year, the projected preschool students equal the projected preschool GER
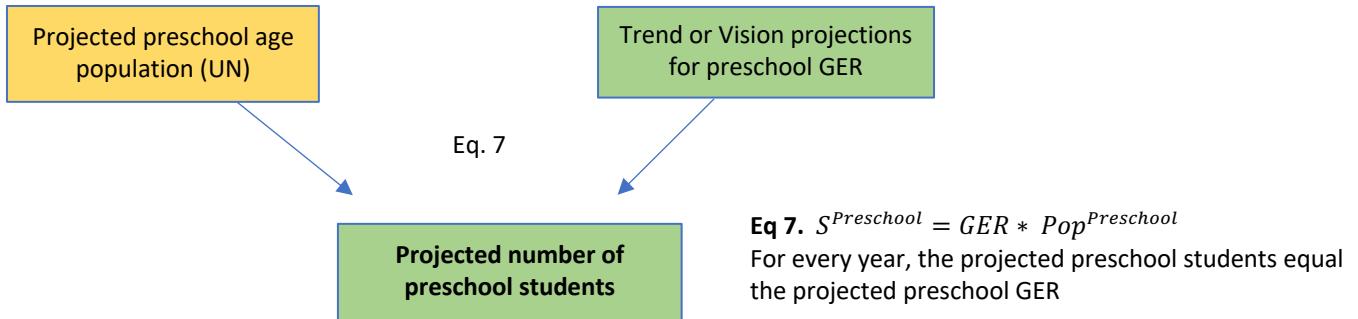
Model Diagram 4: Primary and secondary school students

Students and repeaters by grade in recent years (UIS)

Eq. 8

Trend or Vision projections, primary and secondary completion	Gross enrolment in each grade and repetition in each grade	Duration of primary and secondary (UIS)

Eq. 9

Projected population of school entry age (UN)	Projected entry and promotion rates	

Eq 10

Projected students and repeaters, by grade

Indices such as GER, GIR, GPI, completion

Eq 8.
$GER(x)_{yrT} = GER(x)_{yrT-1} * (1 + g_{ger} * (1 - GER(x)_{yrT-1}))$
– Gross enrolment of non-repeaters in grade x in year T = Gross enrolment in grade x in year T-1 times one plus Vision or Trend growth coefficient for enrolment, g, times one minus Gross enrolment in grade x in year T-1.

$r(x)_{yrT} = r(x)_{yrT-1} * (1 - g_r * (1 - GER(x)_{yrT-1}))$
- repetition in grade x in year T = repetition in grade x in year T-1 times one minus Vision or Trend growth coefficient for quality, g, times one minus Gross enrolment in grade x in year T-1.

Eq 9. $S(G)_{yrT} = GER(G)_{YrT} * Pop1_{yrT} + S(F)_{yrT-1} * r1_{YrT-1}$
Students grade G = GER(G) * population of school entry rate plus students grade F (one prior to G) times repetition rate

Eq 10. Projected GIR = $GER(1)_{yrT}$ – Gross intake rate in grade 1 = gross enrolment of non-repeaters in grade 1 in year T.

$pF_{yrprojected} = SG * (1 - rG_{YrT})/SF_{yrT-1}$
- promotion grade F prior year = non-repeating students in grade G in current year divided by the total students in previous grade F in prior year.

Model Diagram 5: Post-secondary access, graduates, number of students

Eq a. Projected ratio CR/PS this lets completion rate limit post-secondary access: $r_{t=0} = cr(s)_{t=0}/ps_{t=0}$, and $r_t = t_{t=1} + (1 - r_{t-1})/(2030 - t + 1)$, where r_t is the ratio, $cr(s)$ is secondary completion, ps is post-secondary access rate.

Eq b. Adjusted post-secondary access: $ps'_t = \min(ps_t, r_t * cr(s)_t)$.

Eq c. Projected number of youth accessing post-secondary: $PS_t = ps'_t * Pop(ps)_t$, where $Pop(ps)_t$ is the population of post-secondary entry age from UN medium projection.

Eq d, Eq d', Eq d'' Number of youth starting each stream (T, PSNT, New): $PS(x)_t = \%(x)_t * PS_t$, where the percentages are dynamic values based on starting distribution, and user-set targets with linear interpolation from start to target.

Eq e, Eq e', Eq e'' Number of students in each stream (T, PSNT, New) is entrants times official duration of stream (assumes dropout and some repetition balance out): $TotPS(x)_t = dur(x) * PS(x)_t$, where $dur(x)$ is the duration in each stream.

Eq f, Eq f', Eq f'' Number of graduates from each stream: $GrPS(x)_t = gr(x) * PS(x)_{t-dur}$, or graduation rate times number who entered N years

Model Diagram 6: Detailed diagram of teacher salaries
by country, and education level (preschool, primary, secondary)
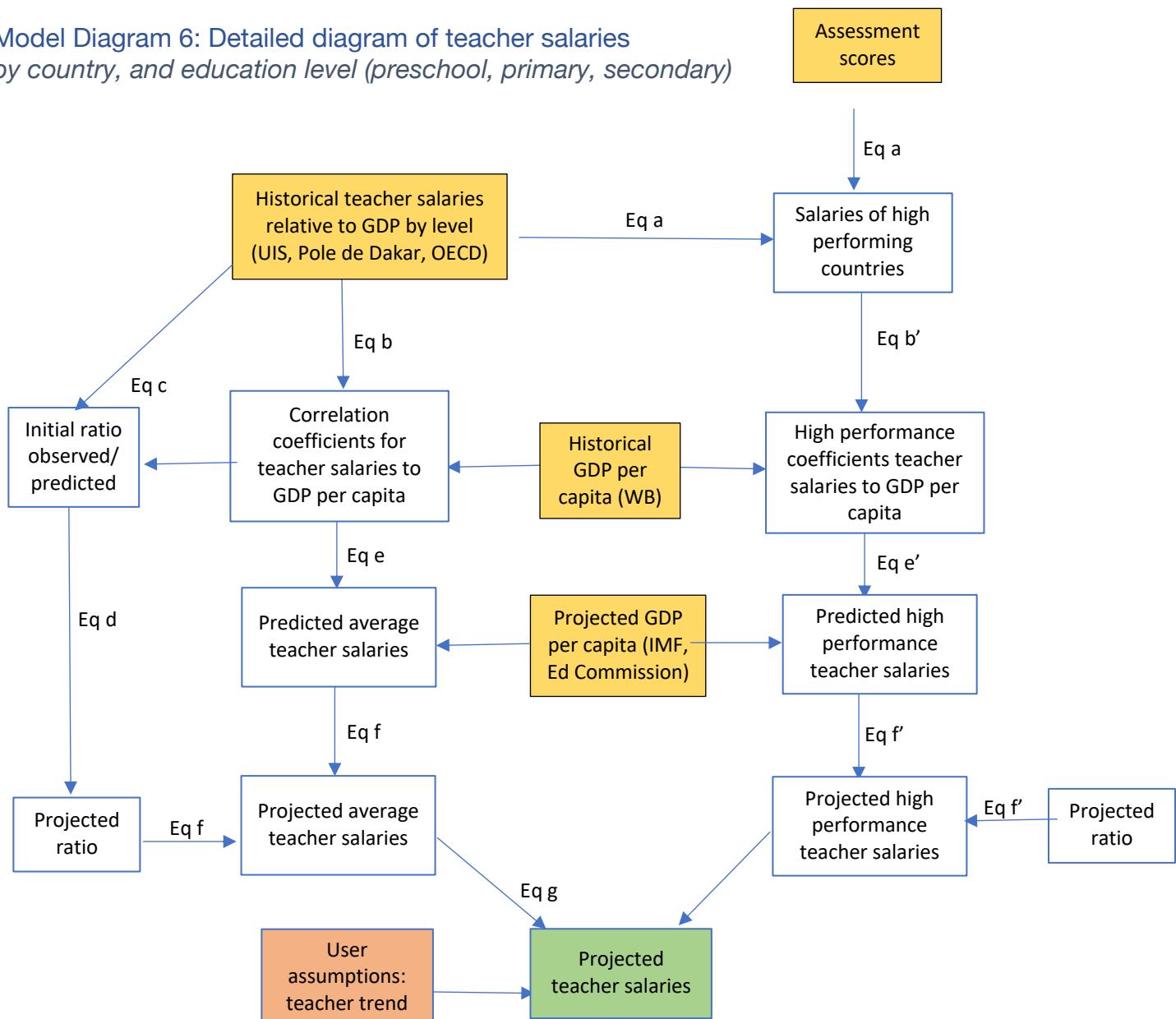
Eq a. Selection of salaries in high-performance countries (top improvers by international/regional assessment, see text). Alternative with similar result: Create ratios $sal(obs)/sal(trend)$, pick the 25 percent of countries that have the highest ratios.

Eq b. Coefficients for a trendline fit to observed pupil teacher ratios $sal(obs)$ and GDP per capita (using excel trendline function). Best fit for trendline with the function $sal(pred) = c\,y^{\beta}$, where c is a constant, β is an exponent, y is GDP per capita.

Eq b'. As Eq a, using only high-performing selection

**Eq c.** Create initial ratio $r_{t=0}$ = $PTR(obs)_{t=0}/PTR(pred)_{t=0}$ /predicted salaries.

Eq d. Projected ratio: r_t =1 by 2030, with linear change from start value: $r_t = r_{t-1} + (1 - r_{t-1})/(2030 - t + 1)$

Eq e. Predicted average salaries based on GDP per capita over time: $Asal(pred)_t = c\,y_t^{\beta}$

Eq e'. Predicted high-performance salaries, $Hsal(pred)_t$, as Eq e using only high-performing selection.

Eq f. Projected average salaries: $Asal(proj)_t = r_t * Asal(pred)_t$

Eq f'. Projected high-performance salaries, $Hsal(proj)_t$, as Eq f using only high-performing selection.

Eq g. User selected average or high-performance salaries.

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Model Diagram 7: Detailed diagram of projected number of teachers needed, by country and education level (preschool, primary, secondary)
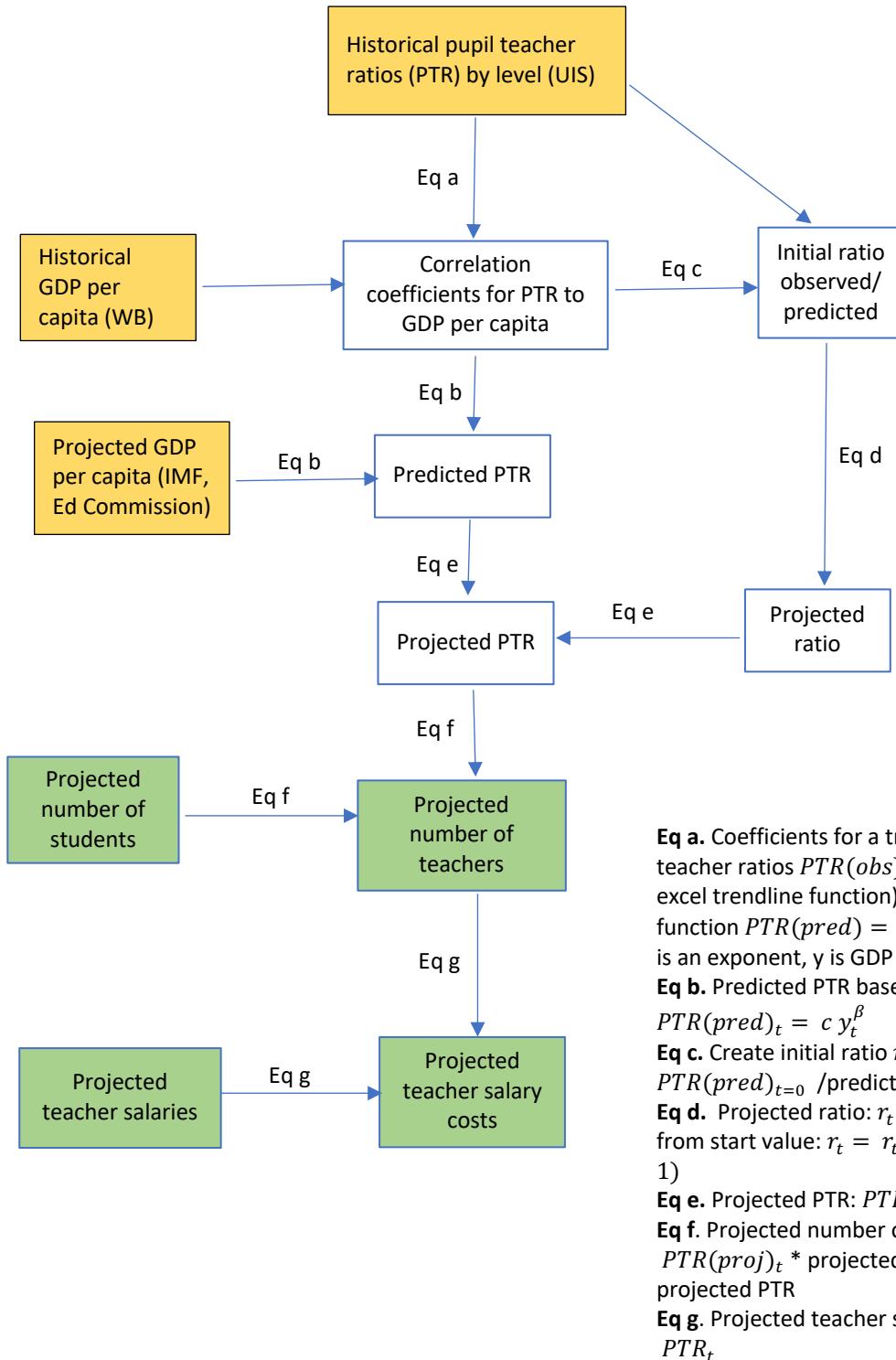
Eq a. Coefficients for a trendline fit to observed pupil teacher ratios $PTR(obs)$ and GDP per capita (using excel trendline function). Best fit for trendline with the function $PTR(pred) = c\, y^\beta$, where c is a constant, β is an exponent, y is GDP per capita.

Eq b. Predicted PTR based on GDP per capita over time: $PTR(pred)_t = c\, y_t^\beta$

Eq c. Create initial ratio $r_{t=0} = PTR(obs)_{t=0}/ PTR(pred)_{t=0}$ /predicted salaries.

Eq d. Projected ratio: r_t =1 by 2030, with linear change from start value: $r_t = r_{t-1} + (1 - r_{t-1})/(2030 - t + 1)$

Eq e. Projected PTR: $PTR(proj)_t = r_t * PTR(pred)_t$

Eq f. Projected number of teachers: $T_t = S_t * PTR(proj)_t$ * projected number of students * projected PTR

Eq g. Projected teacher salary costs: $Sal(proj)_t = T_t * PTR_t$

Model Diagram 8: Detailed diagram of classroom costs, by country and by education level (preschool, primary, secondary)
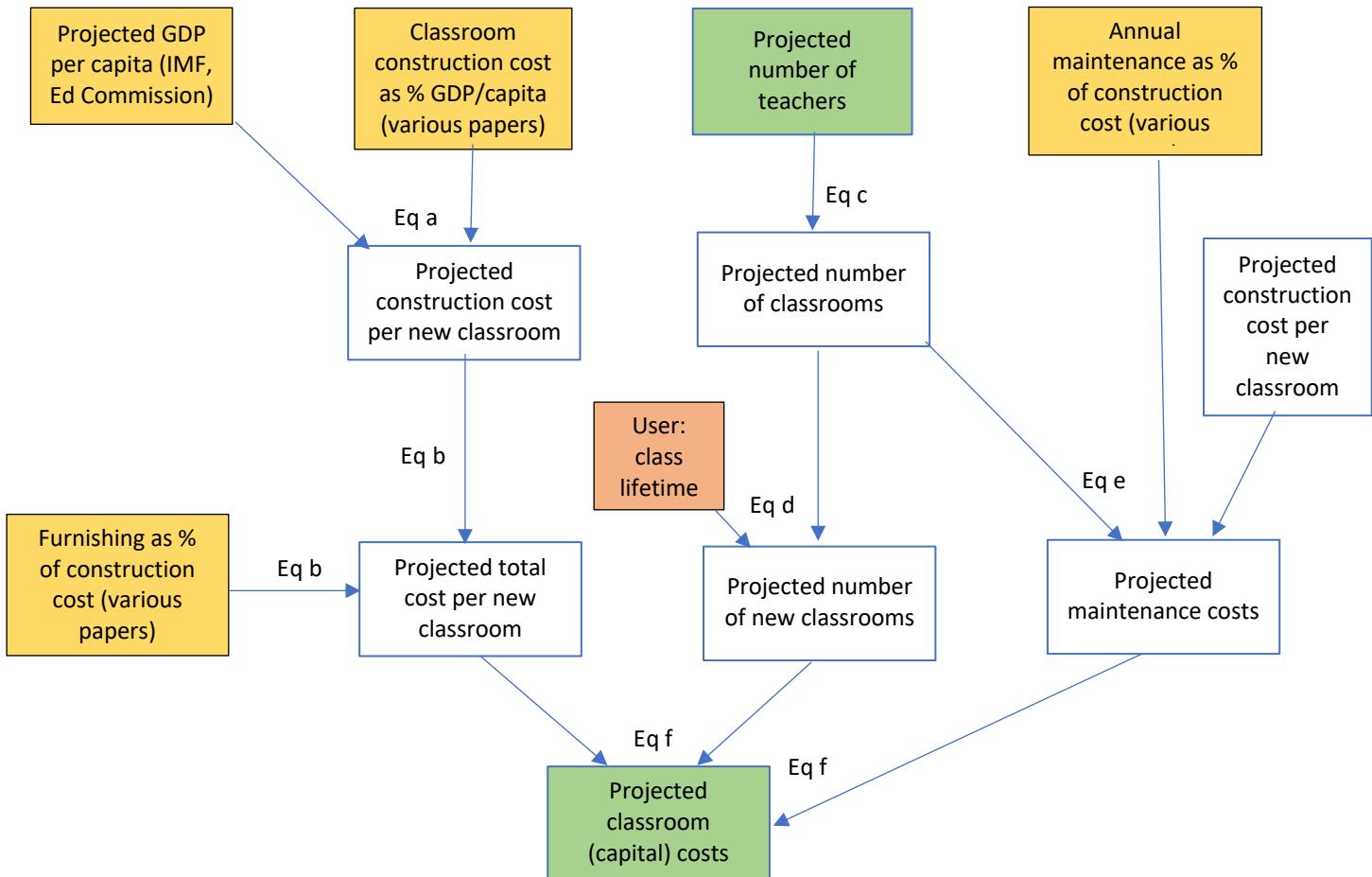
Eq a. Projected construction cost per new classroom: $CLC_t = my_t$, where m = construction cost as multiple of GDP (country-specific, fixed over time); y_t is projected GDP/capita.

Eq b. Projected total costs per new classroom: $CLT_t = fCLC_t$, where f = furnishing as % of construction cost (same constant all countries, fixed over time).

Eq c. Projected number of classrooms: $CL_t = T_t$, where CL_t is classrooms needed in year t, and T is number of teachers.

Eq d. Projected number of new classrooms = change in classrooms needed + replacement classrooms needed. Change in classrooms needed: $\Delta CL_t = \min(0, CL_t - CL_{t-1})$. Replacement classrooms needed: $RCL_t = CL_{t-1}/l$, where l is average lifetime of classrooms (user defined). New classrooms needed: $\Delta CL_t + RCL_t$.

Eq e. Projected maintenance costs: $CLM_t = m * CLC_t * CL_t$, where m is maintenance costs as percent of classroom construction costs (TU-IP, 2010, Delivering Cost Effective and Sustainable School Infrastructure).

Eq f. Classroom (capita) costs: $CostCL = CLT_t * (\Delta CL_t + RCL_t) + CLM_t$

Model Diagram 9: Detailed level diagram of basic costs projections, by country and basic education level (preschool, primary, secondary)
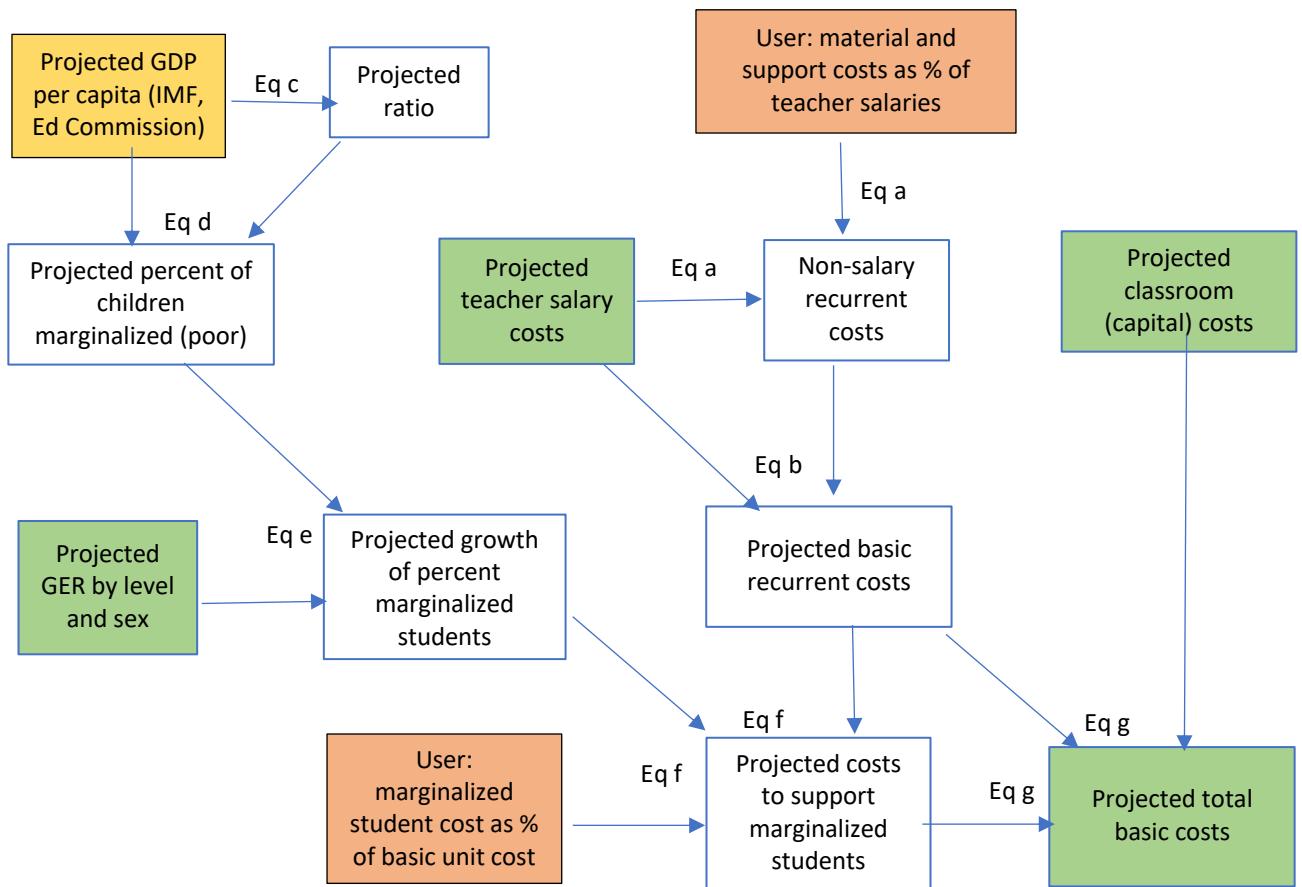
Eq a. Non-salary recurrent costs: $NSal(proj)_t = Sal(proj)_t * nsm$, where nsm is a multiplier from TU-IP, 2010, Delivering Cost Effective and Sustainable School Infrastructure.

Eq b. Projected basic recurrent costs $CostB_t = NSal(proj)_t + Sal(proj)_t$

Eq c. ratio of predicted percent poor and projected percent (see equations b-e on diagram 6 for PTR as example): Predicted % poor based on GDP per capita over time: $Pr(pred)_t = c\ y_t^\beta$; initial ratio $r_{t=0} = Pr(obs)_{t=0}/Pr(pred)_{t=0}$; rrojected ratio: r_t =1 by 2030, with linear change from start value: $r_t = r_{t-1} + (1 - r_{t-1})/(2030 - t + 1)$

Eq d. Projected percent of children marginalized (poor): $Pr_t = r_t * Pr(pred)_t$.

Eq e. Projected % of students marginalized needing additional support in two steps. Total % of students marginalized: $Mr_t = GER_t * (1 - Pr_t)$ – essentially, non-poor students attend school first, then GER increases with poor students. Model assumes that in start year, the poor students attending are already receiving support they need to attend *in that year* (evidenced by current attendance). For computing additional support needed, we compute projected growth of percent marginalized students: $\Delta Mr_t = \min(0, Mr_t - Mr_{t=0})$. Note that two dynamics influence the outcome: a) influx of students over time, and b) the percent of children who are poor declining as GDP per capita increases over time.

Eq f. Projected costs to support marginalized students: $CostMr_t = mrm * \Delta Mr_t * CostB_t$, where mrm is a multiplier set by the user per level of schooling.

Eq e. Projected total costs for basic education: $CostT_t = CostB_t + CostMr_t + CostCL_t$.

Model Diagram 10: Detailed level diagram of post-secondary costs projections, by country
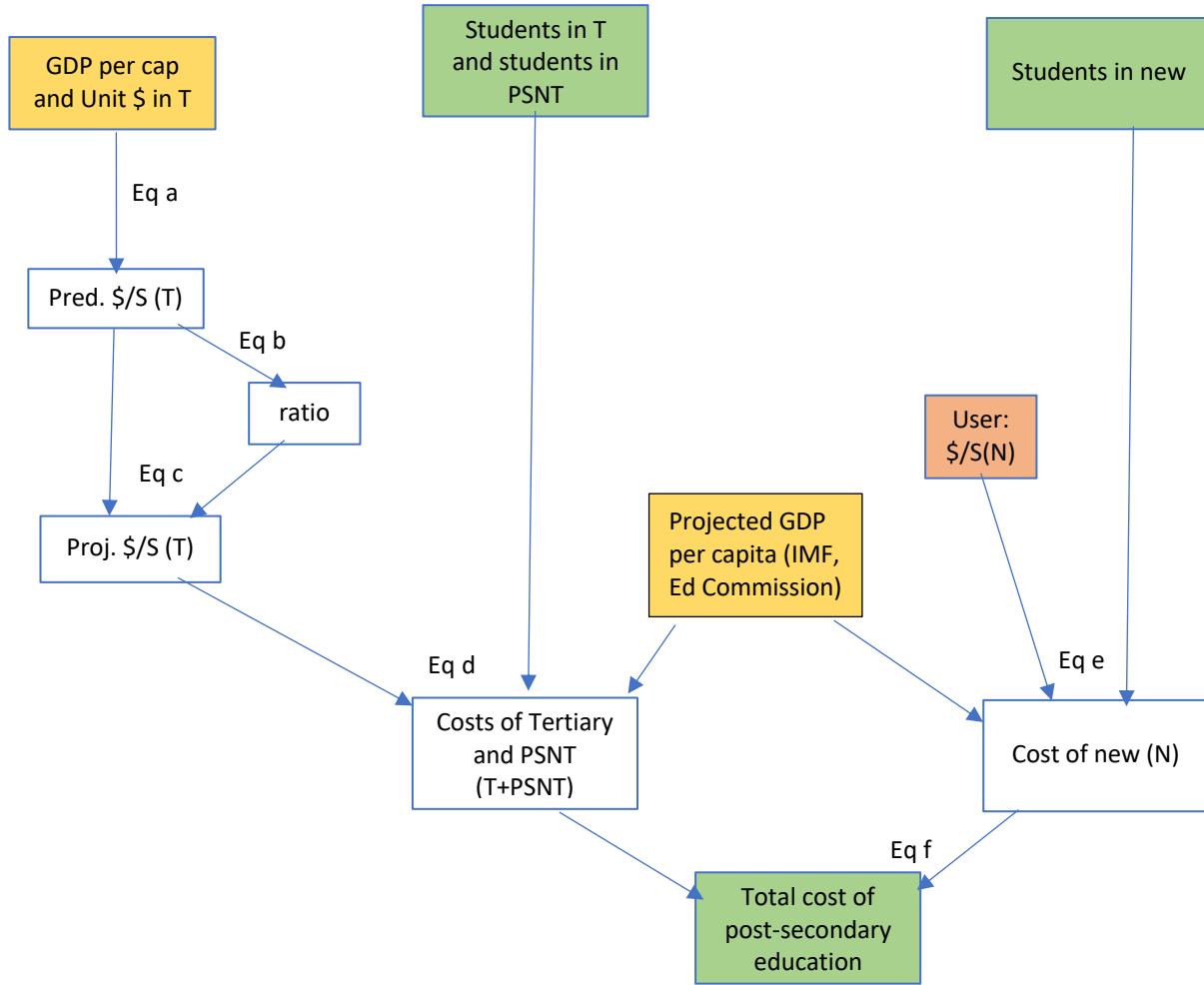
Eq a Predicted cost per student in tertiary (T) or post-secondary non-tertiary (PSNT) as a multiple of GDP per capita, based on regression of historical GDP per capita and cost per student: $c(pred)_t = c + \beta \ln(y_t)$ where c and β are coefficients from the regression.

Eq b. Ratio of predicted to projected per student cost as a multiple of GDP per capita: $r_{t=0} = c(obs)_{t=0}/c(pred)_{t=0}$ ratio of observed costs (as mult of GDP per capita) to predicted in the initial year; $r_t = r_{t-1} + (1 - r_{t-10})/(2030 - t + 1)$ linear interpolation to a ratio of 1 by 2030.

Eq c. Projected cost per student as a multiple of GDP per capita: $c(proj)_t = r_t * c(pred)_t$.

Eq d. Projected total costs of tertiary and post-secondary non-tertiary is product of unit costs and number of students: $C(TP)_t = c(proj)_t * y_t * (TotPS(T)_t + TotPS(P)_t)$

Eq e. Projected costs of new stream of post-secondary product of students, user-set costs as percent of GDP per capita: $C(N)_t = c(user)_t * y_t * TotPS(N)_t$.

Eq f. Total costs of post-secondary is sum of all streams together: $CostPS_t = C(TP)_t + C(N)_t$

Model Diagram 11: Projections of domestic government expenditure as percent of GDP and allocation to education, by country
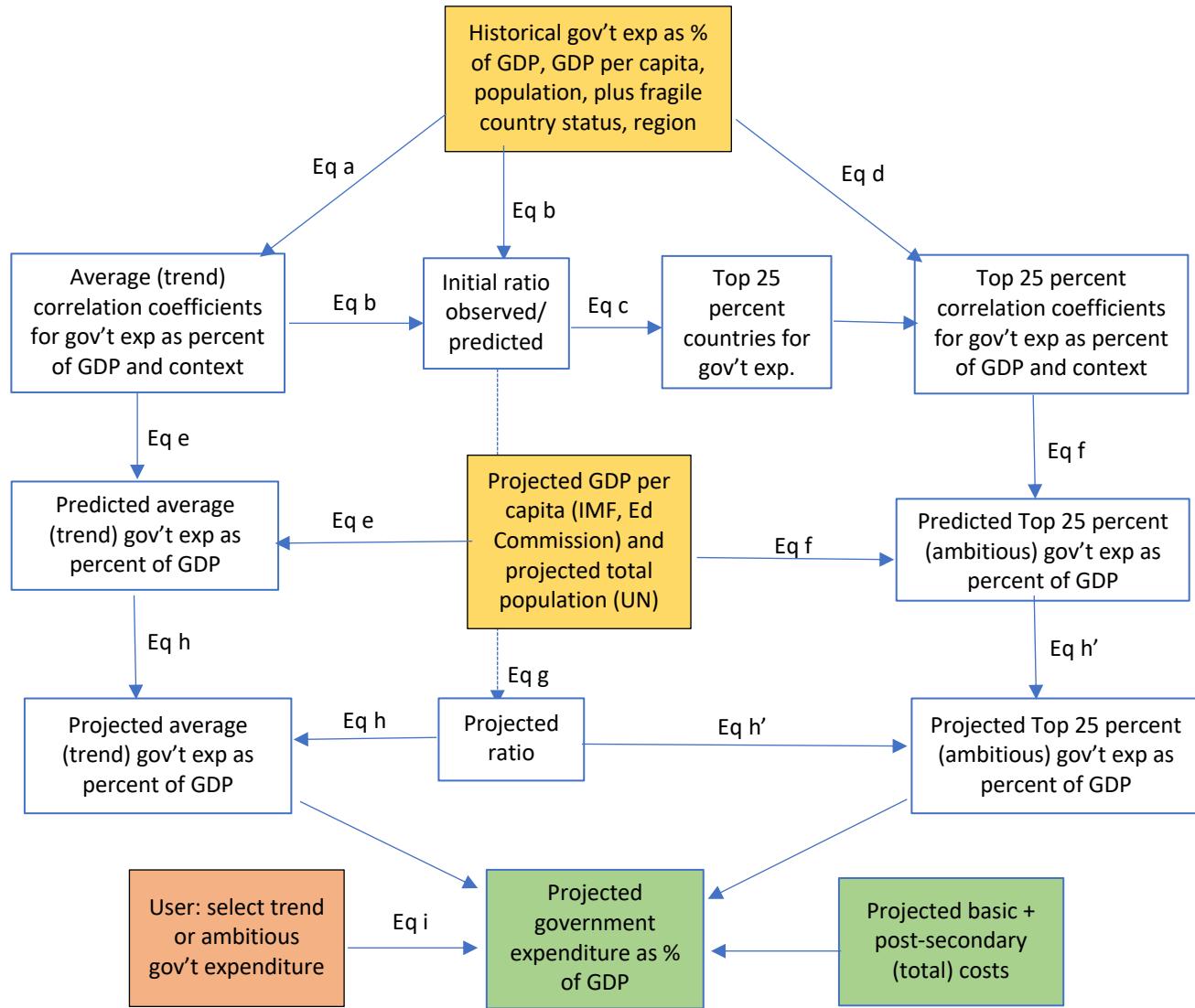
Eq a. Coefficients for gov't exp as percent of GDP found using multivariable linear regression with independent vars: (ln)GDP per capita, population, region, fragility status. Predicted gov't exp: $GX_t = c + \beta y_{t=0} + \gamma Pop_{t=0} + \delta frag + \varepsilon \, region)$

Eq b. Create ratio $r_{t=0}$ = observed gov't exp/predicted gov't exp.

Eq c. Select 25 percent of countries with highest ratios (highest expenditure *relative to* predicted expenditure)

Eq d. Using only the Top 25 percent of countries, coefficients for gov't exp as percent of GDP found using multivariable linear regression with independent vars: (ln)GDP per capita and population only. Predicted top 25 percent gov't exp: $25GX_t = c' + \beta' y_{t=0} + \gamma' Pop_{t=0}$

Eq e. Predicted gov't exp average trend: $GX(pred)_t = c + \beta y_t + \gamma Pop_t + \delta frag + \varepsilon \, region)$

Eq f. Predicted gov't expenditure ambitious trend: $25GX(pred)_t = c' + \beta' y_t + \gamma' Pop_t$

Eq g. Projected ratio of predicted to projected gov't exp. (provides gradual, dynamic approach to predicted levels, given country-specific starting levels). Create ratio $r_{t=0}$ = observed salaries/predicted salaries. Projected r_t =1 by 2030, with linear change from start value.

Eq h and h'. Projected trend gov't exp: $GX(proj)_t = r_t * GX(pred)_t$. Same for ambitious gov't exp. Actual projected gov't expenditure: user selected $GX(proj)_t$ or $25GX(proj)_t$

Eq i. min(User selects gov't exp. Projection, total cost)

Government allocation to education as percent of total government expenditure

Structure is identical to gov't expenditure, with one dependent variable added to the regression for coefficients: historical gov't exp as percent of GDP.

Model Diagram 12: Projections of household expenditures on education, by country
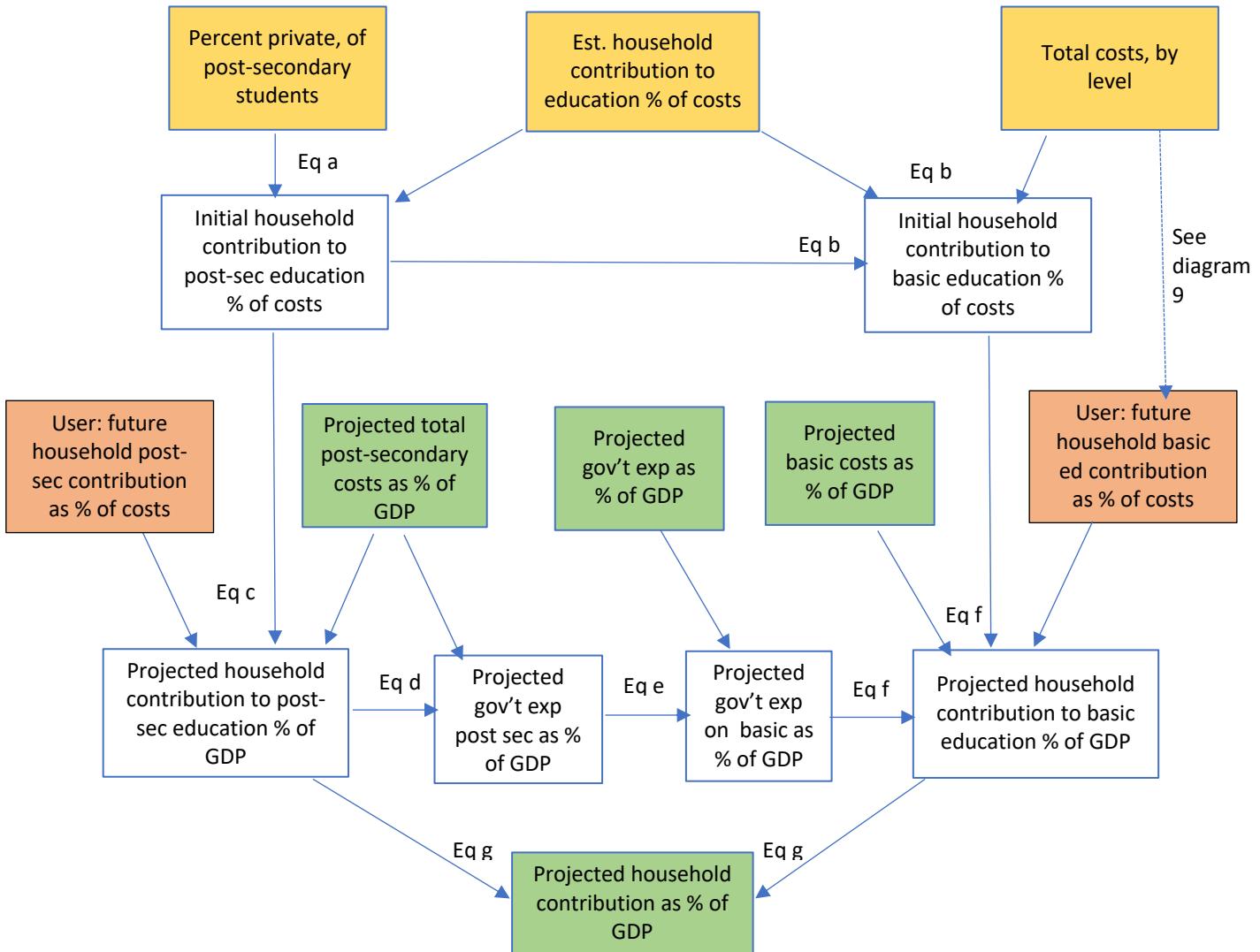
Basic ed defined as: preschool-secondary and youth/adult literacy training.

Eq a. Initial household contribution to post-secondary education as % of costs: $h\%(ps)_{t=0} = \min$ (% private students, household contributions % of costs).

Eq b. Initial household contribution to basic education as % of costs: $h\%(b)_{t=0} = [h\%(T)_{t=0} * CostT_{t=0} - h\%(ps)_{t=0} * CostT(ps)_{t=0}] / CostT(b)_{t=0}$, where, $h\%(T)_{t=0}$ Is household contribution as % of total costs; $CostT(ps)_{t=0}$ is total post-secondary costs; $CostT(b)_{t=0}$ is costs to basic education.

Eq c. Projected household contribution to post-secondary education as % of GDP: $h\%Y(ps)_t = c\%Y(ps) * (linear\ interpolation\ for\ h\%(ps)_t)$, where $c\%Y(ps)_t$ is post-secondary costs as % of GDP, found dividing total cost post-secondary in diagram 4 by GDP, and household contributions as % of post-secondary costs based on linear interpolation from starting to target level.

Eq d. Projected govt. exp. on post-sec as % of GDP: $g\%Y(ps)_t = c\%Y(ps)_t - h\%Y(ps)$, essentially, costs post-secondary minus household contribution (external finance need based solely on basic ed, but country-specific distribution is fungible).

Eq e. Projected gov't exp. on basic education as % of GDP: $g\%Y(b)_t = g\%Y(T)_t - g\%Y(ps)_t$.

Eq f. Projected household contribution to basic ed as % of GDP: $h\%Y(b)_t = \min (c\%Y(b) * linear\ interpolation\ for\ h\%(b)_{t_t}$, $c\%Y(b)_t - g\%Y(b)_t)$, lesser of household contribution based on linear interpolation from starting to target level, or residual of costs – gov't exp on basic ed as % of GDP.

Eq g. Projected household contribution to education as % of GDP: $h\%Y(T)_t = h\%Y(ps)_t + h\%Y(b)$,
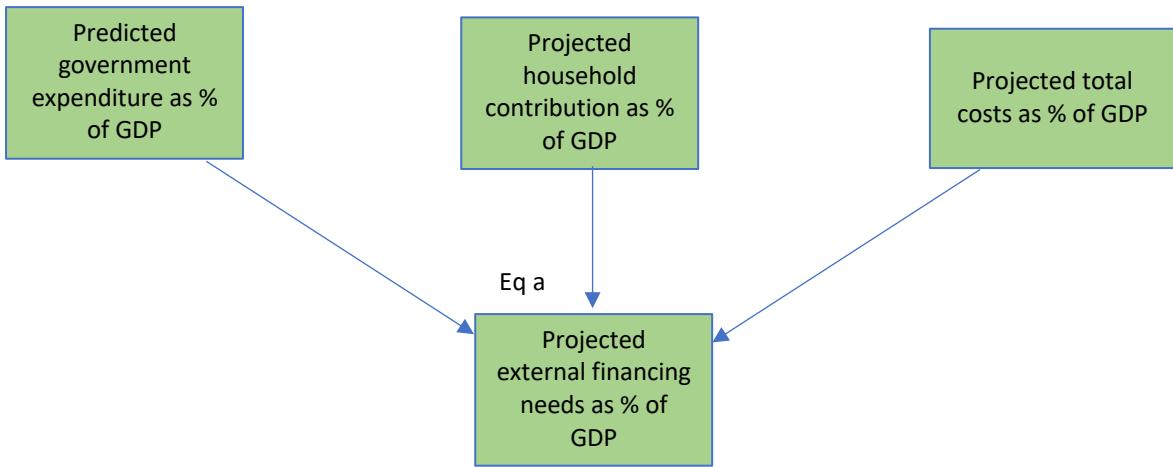
Eq a. Projected external finance needs as % of GDP, or finance gap as % of GDP: $x\%Y(T)_t = c\%Y(T)_t - g\%Y(T)_t - h\%Y(T)_t$, costs minus government and household contributions.

All numbers can be multiplied by GDP to obtain absolute values.

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