the Education Commission

Background Paper
The Learning Generation

USE 2030

Exploring Impacts, Costs and Financing

Janet R. Dickson, Mohammod T. Irfan, and Barry B. Hughes
Frederick S. Pardee Center for International Futures
Josef Korbel School of International Studies, University of Denver

USE 2030:
Exploring Impacts, Costs, and Financing

Background Paper for the
International Commission on Financing Global
Education Opportunity

Respectfully submitted by the
Frederick S. Pardee Center
for International Futures
Josef Korbel School of International Studies
University of Denver

Janet R. Dickson, Mohammod T. Irfan, and
Barry B. Hughes

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Executive Summary

Sustainable Development Goal 4 calls for inclusive and equitable quality education and lifelong learning opportunities for all. The first target of that goal motivates this report: "By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes." We focus on the broad human and social development impacts of reaching universal secondary education in low- and lower-middle-income countries. We consider also the costs of, return to, and financing for universal secondary education by 2030. We use a long-term forecasting system called International Futures to develop a Base Case (the path we seem to be on), a USE2030 scenario that represents changes in education participation across all levels, and an aggressive but reasonable variation (USEAbR) that is more tailored to the starting conditions and potential of individual countries, even as it remains ambitious.

In analyzing impacts of USE2030, we look out to 2050, and sometimes 2060, because it takes time for newly educated students to have broad impact. We measure impact relative to the Base Case, which also shows continuing, but slower, advance in education participation. For low-income countries, USE2030 increases GDP per capita at PPP by 3 percent in 2030 and 25 percent in 2050. Life expectancy advances by 0.7 and 1.9 years, while infant mortality drops by 1.9 and 5.9 per thousand. USE2030 reduces fertility by 0.19 and 0.51 children per woman, leading to populations that are 3.9 and 59 million lower than the Base Case.

Lower-middle-income countries show lesser gains because their educational changes in USE are smaller relative to their starting point. For example, in 2015 the upper secondary gross enrollment rate for lower-middle-income countries was 56 percent, while that for low-income countries was just 29 percent. Even so, USE increases the average low-middle-income country GDP per capita at PPP by 1.2 percent in 2030 and 8.4 percent in 2050.

Turning from the many benefits of USE2030 in terms of human well-being, the large investments needed to reach USE2030 would pay for themselves in 25 years just in terms of cumulative rise in GDP for both low-income and lower-middle-income countries. That return would rise steadily and sharply in subsequent years. By 2050, it would be $1.6 trillion for low-income countries, while for lower-middle income countries (with a much higher GDP base) it could be $5.4 trillion.

The incremental education spending needs in low-income countries relative to the roughly 4.5-5.0 percent of GDP spent on education in the Base Case rise by about another 6 percent in the early 2030s (1.6 percent for lower-middle-income countries). Constraining the natural push of new secondary graduates into tertiary education would limit those rises considerably; at Base Case tertiary enrollment rates, low-income countries would reduce incremental costs to 3.0 percent of GDP. Shares of GDP directed by donors to foreign aid would need to rise significantly simply to maintain a steady contribution to the GDP of recipient countries because of the latter's more rapid economic growth. Much or most of the incremental costs will require additional domestic revenue raising or private spending in low-income countries.

1 The Context for this Study

The Sustainable Development Goals (SDGs) adopted by the United Nations General Assembly in September 2015 constitute the global post-2015 development agenda. The SDGs have set extremely ambitious targets across a broad array of development goals, including education, for the period from 2015-2030.

This study focuses on one of the SDG education targets—namely, universal upper secondary education. Specifically, we focus on low-income and lower-middle income countries, and we use the International Futures (IFs) integrated forecasting system to explore (1) key impacts of a push to universal secondary education by 2030 (and a somewhat slower variant of that); and (2) the costs of such a push and the possible funding streams for it.

We present our impact analyses out to 2050 (and sometimes beyond) because of the time lag between attainment by a school-age cohort and the accumulation of education across the broader population, as well the time it takes the more-educated populace to implement change in broader systems. We also estimate the incremental costs of universal secondary education by 2030 and explore various avenues for funding them.

The foundation for our study is the unprecedented growth in education participation and attainment that has occurred in recent decades. In particular, the push for universal primary education provided by the Jomtien Declaration in 1990 and the Millennium Declaration in 2000 contributed to extraordinary rates of enrollment growth in low-income and lower-middle income countries, and not only at the primary level. Nonetheless, the work remains incomplete even at the primary level, and a very great amount of effort is needed if individuals and countries are to realize the benefits that accompany increased participation at lower secondary and, especially, upper secondary levels. Our hope is that this work aids that effort by identifying and attempting to quantify those benefits.

2 Our Approach

International Futures (IFs), the platform that we use for our exploration, is a large-scale, long-term, integrated global modeling system (Hughes and Hillebrand 2006; Hughes 2016). Within IFs, there are sociopolitical, economic, demographic, health, education, energy, agriculture, and environmental models for 186 interacting countries. The models of IFs are heavily rooted in the work of others in these specialized areas, and IFs, in turn, contributes to that work and helps integrate it. An extensive database of over 3,500 variables, going back to 1960 whenever data are available, provides another foundation for our forecasts, which can extend to 2100. The IFs system has great flexibility for interventions by users and therefore for scenario analysis. The IFs modeling effort is based at the Frederick S. Pardee Center for International Futures at the University of Denver's Josef Korbel School of International Studies, and the tool is open source for others to use. The Base Year of the model for this analysis is 2014, and the model version number is 7.21.

Appendix 1 contains very important information for those who wish to better understand the IFs system:

- a short description of the education model in IFs;
- an overview of the entire forecasting tool, with introductions to structures and foundations of models within it; and
- a survey of the wide range of users and uses of the IFs system across intergovernmental organizations, non-governmental organizations, governments and others, including extensive citations on the tool and work done with it.

Here we focus on the scenarios used in this project and analyzed in the following sections of the report.

1.1 International Futures and its Base Case Scenario

Because of the multiple and integrated models of IFs, its large database, and the representation of countries, our forecasts reflect complex interacting connections—connections that are historically rooted, but changing over time. Analyses with IFs begin with a Base Case forecast, a portrayal of where countries, regions, and the world as a whole appear to be going with respect to the many interacting variables in the IFs system. Typically, analysis then leads to alternative scenarios that represent different assumptions about development paths and/or interventions and their effects. Comparisons of the Base Case with alternative scenarios help expand the boundaries of our thinking about the future. In fact, that is the central purpose of IFs—to serve as a thinking as opposed to a predicting tool.

The Base Case itself is not a simple extrapolation of variables in multiple issue areas, but rather the dynamic, nonlinear output of the fully integrated IFs system (including the education model) on a country-by-country basis. It honors the individual starting points of countries and their historical patterns of progression[1].

We frequently compare Base Case forecasts to other forecasts, such as those of the United Nations Population Division and the World Bank (see Figures 2.1-2.3 and a more extensive comparison in Hughes et al. 2009: 56-71). As a general rule, the IFs Base Case produces behavior quite similar to medium variant or reference forecasts of such analyses. For instance, our long-term global population forecast is somewhat lower than the UNPD's 2015 revision median scenario, but higher than the central shared socio-economic pathway scenario (SSP2) of the IIASA/Wittgenstein Center (KC and Lutz 2015).

The first few years of our economic growth forecasts (Figure 2.1) actually are those of the IMF's periodic *World Economic Outlook* series (most recently through 2021 from the April 2016 release).[2] And our endogenous growth rates for GDP in the longer term are very similar to those of SSP2 from both IIASA (Cuaresma 2015) and the OECD (Delink et al. 2015).

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[1] Formulations for many key variables incorporate impetus for gradual long-term convergence to global patterns estimated cross-sectionally across development levels.

[2] The IMF forecasts of GDP are at MER. IFs produces both MER and PPP forecasts of GDP. The dominant functions produce MER forecasts and, as the text indicates, those are identical to the IMF forecasts through 2021. IFs computes GDP forecasts at PPP from those at MER. Because the long-term SSP forecasts from IIASA and the OECD are at PPP, Figures 2.1 and 2.2 show the IFs PPP forecasts rather than those at MER.

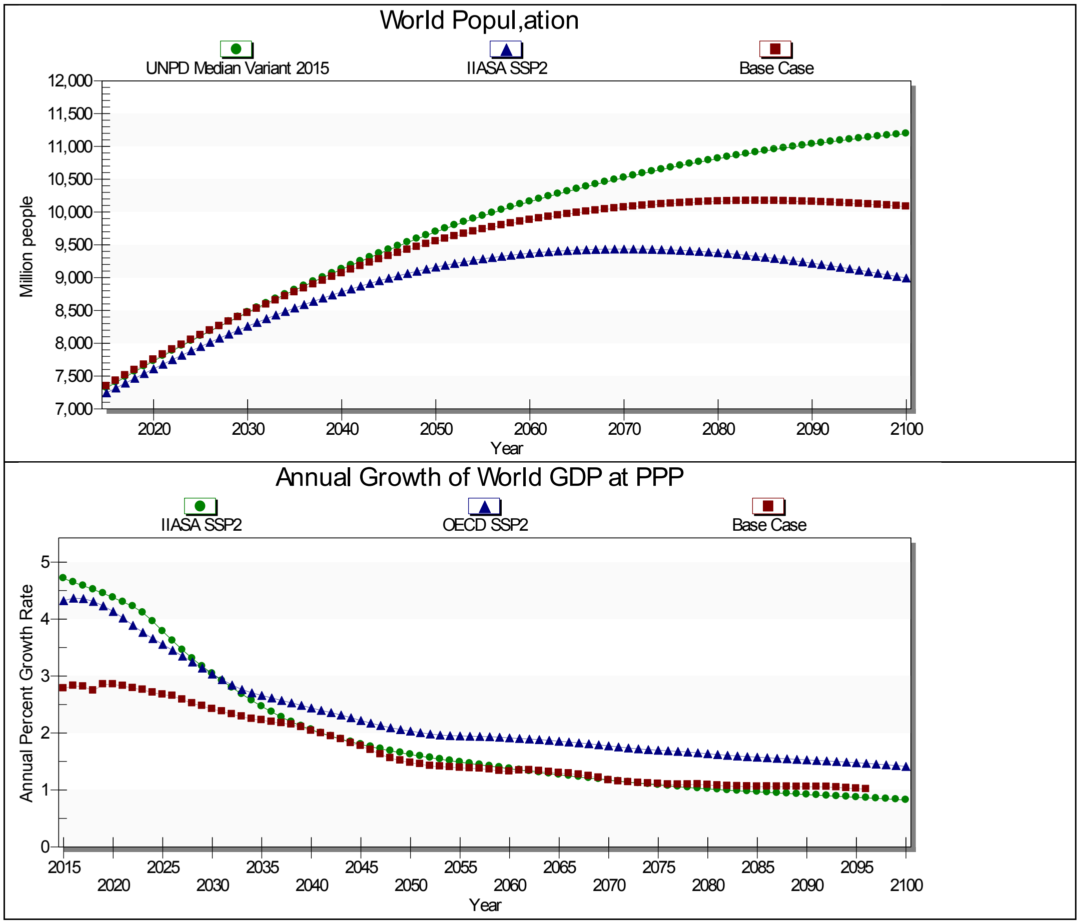

Figure 2.1 IFs Base Case forecasts compared with other world population and GDP forecasts
Note: UNPD is United Nations Population Division; IIASA is International Institute for Applied Systems Analysis, and the OECD's Shared Socio-economic Pathway2 (SSP2) is similar to a median variant.

Although this report gives some attention to upper-middle-income and high-income countries, our principal focus is on lower-middle-income and especially on low-income ones, using the July 2015 classifications of the World Bank.[3] Our forecasts of low-income country economic growth have, until recent years, tended to be slightly more optimistic than most other analyses, but others have now moved their forecasts upwards and we have moved ours downward somewhat for this project (again, they are in the middle of the IIASA and OECD SSP forecasts). See Figure 2.2.

[3] There are 31 low-income and 50 lower-middle-income countries in the World Bank July 2015 country economy groups.

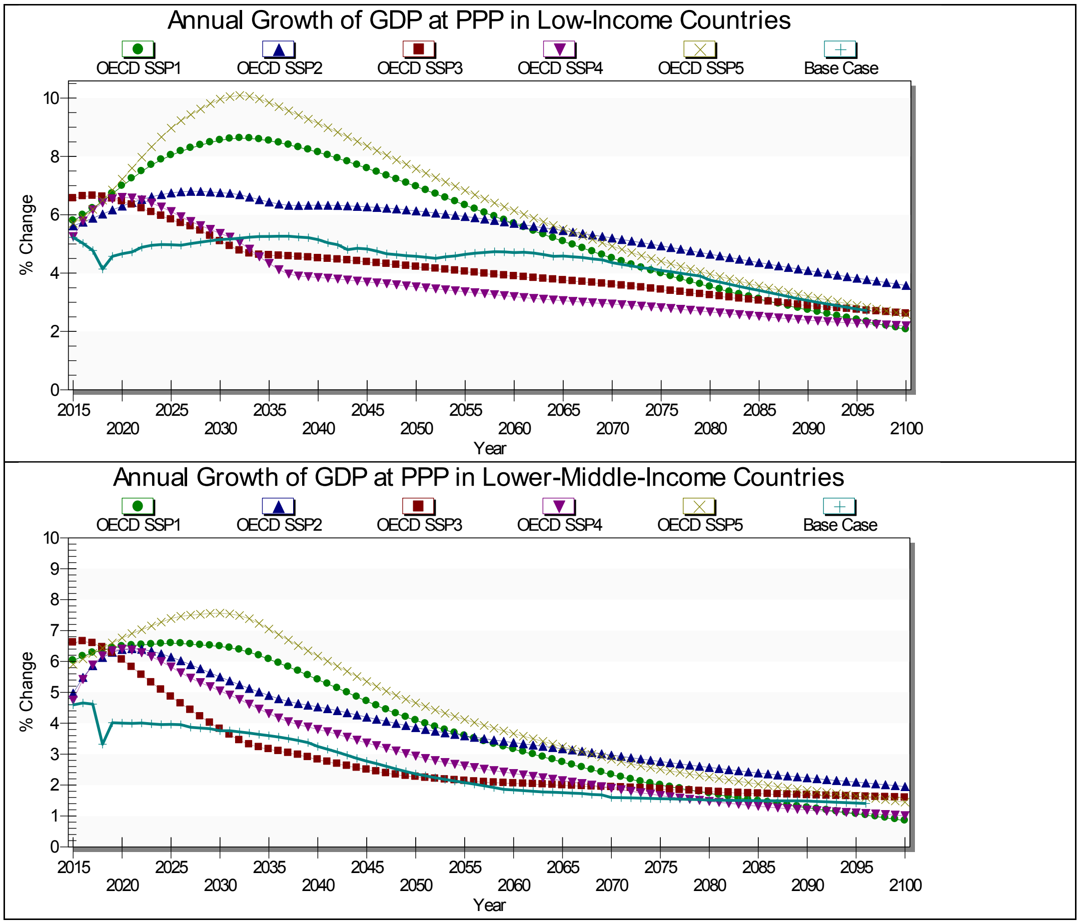

Figure 2.2 IFs Base Case forecasts of low-income country GDP growth compared to those of OECD SSP scenarios

Note: IFs GDP forecasts through 2021 replicate those of the IMF World Economic Outlook (April 2016).

Turning to human development variables, the top panel in Figure 2.3 compares the IFs Base Case forecast of adult education attainment to the IIASA SSP2 forecast; although the estimates of starting values have different sources (ours are from Barro and Lee 2015), the forecasts parallel each other. The same pattern appears in the comparison of the IFs Base Case with IIASA and UNPD forecasts of life expectancy (bottom panel in Figure 2.3).

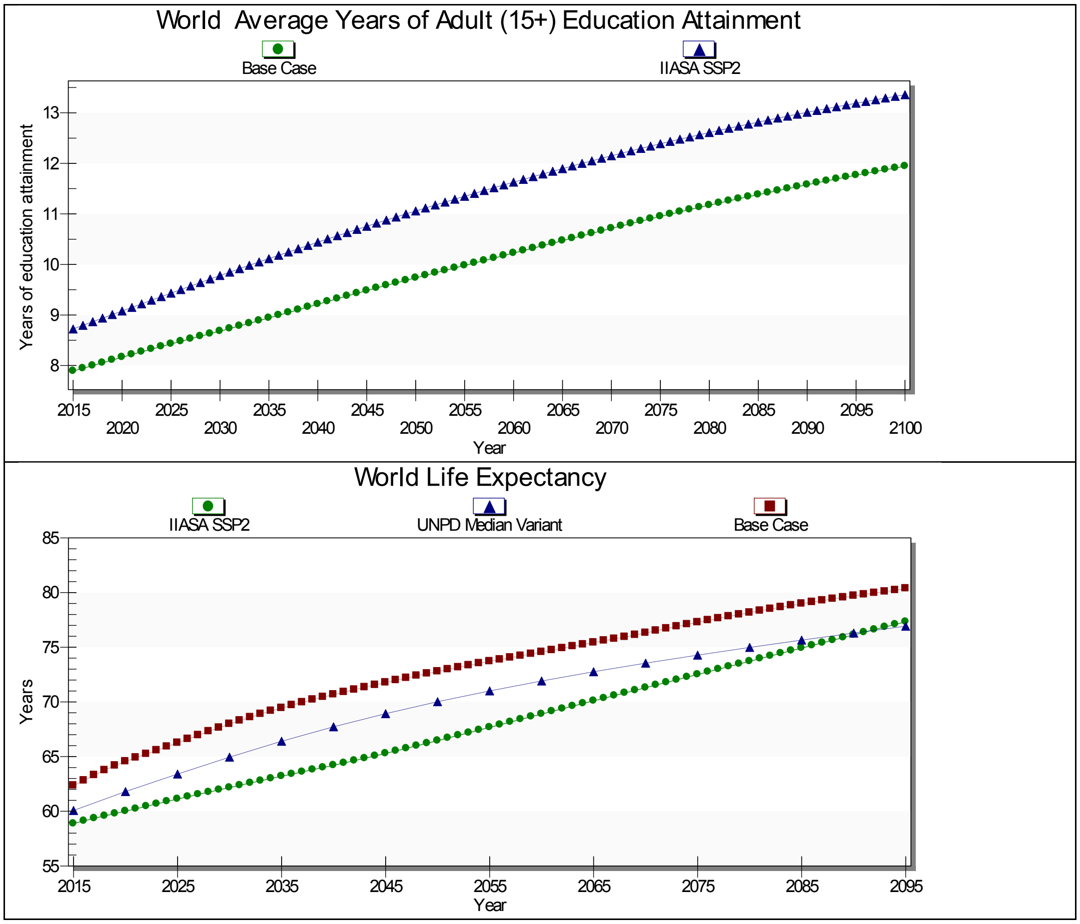

Figure 2.3 IFs Base Case forecasts compared with other world education attainment and life expectancy forecasts

Note: UNPD is United Nations Population Division; IIASA is International Institute for Applied Systems Analysis, and the Shared Socio-economic Pathway2 (SSP2) is similar to a median variant.

1.2 Scenarios Developed for this Study and Plan for this Report

Just as in the Base Case, our USE2030 scenario begins with each individual country's 2014 values on student flow variables. However, in contrast to the Base Case, it then uses a linear pattern to force each country's primary and secondary intake, survival, and transition rates to 100 percent by the years needed in order to reach universal transition to the upper secondary level by 2030 and universal upper secondary survival thereafter. While the SDG goal is universal secondary completion in 2030, we chose universal transition as the target for this study in order to correspond to the metric being used by the Global Monitoring Report team and to extend their analyses.[4] The USE2030 scenario also calculates the costs associated with the push to universal secondary education, and assumes, for the analysis of potential impacts of USE, that there are no constraints on resources to cover those costs (in Section 4 of this report we turn to resource considerations and implications) .

[4] See, for example, Wils 2015 (June).

As will become clear in our discussion, it is unlikely that the goal of universal transition to upper secondary (let alone universal completion) is realistic for a number of low-income and some lower-middle-income countries in just 15 years, even with effort, funding support, and political will. We therefore also develop and explore what we call an "aggressive but reasonable" alternative scenario (USEAbR) to push toward universal secondary education (see Box 2.1 for both scenarios). [5]

Box 2.1 The USE2030 and USEAbR Scenarios

In the USE2030 scenario, we followed in large part the approach of Wils and the Education for All Global Monitoring Report (November 2014; July 2015 GMR update) to move countries to universal secondary. We ramped up the intake rates for primary education, the transition rates to higher levels, and the survival rates of children at each level to 100 percent on a staggered basis, so as to move progressively to universal transition to upper secondary by 2030 and universal upper secondary survival thereafter. From 2015, we moved all countries to universal levels by 2021 for primary, by 2027 for lower secondary, and by 2030 for upper secondary. With respect to tertiary, our USE2030 scenario does not force it upward to any particular level or any particular rate, but allows the model structure and parameterization (rooted heavily in historical and cross-sectional data analysis) to determine patterns of growth. We assumed adequate funding and worked to largely protect health, infrastructure, and R&D from significant reductions.

In the USEAbR scenario, we built upon an approach that Dickson, Hughes and Irfan (2010) developed earlier. The approach analyzed historical patterns in rates of increase in intake/transition and survival rates across all countries; we searched for very aggressive and yet achievable rates of increase. For the current project, we focused on the 80th percentile (top 20 percent) in terms of speed of rise to determine rates that were aggressive, but reasonable. That led us to the following: 2.2 percentage point annual growth in primary intake; 2.0 percentage point growth in transition to lower secondary, transition to upper secondary, and survival in both lower and upper secondary; and 1.5 percentage point growth of survival at the primary level. We also accelerated movement to gender equality at all levels. These rates interact with many algorithms in the model that lead to S-shaped patterns of change (generating these maximum rates near the inflection point of increase but lesser rates at low levels and in the saturating approach to universality).

[5] Many other potential variations on the USE2030 scenario could be useful to consider, if time would permit. First would be a variation that explores some of the likely consequences in other areas targeted for development (e.g., health, R&D, and physical infrastructure) if countries had to divert funding from other categories of government expenditure in order to support the education push. A second variation would explore some of the consequences of constraining growth in tertiary enrollment in order to further target education spending on primary through secondary education. A third variation would look at the possibility of increased government revenues to help support the increased costs of the modeled education push and investigate the broader development consequences of such a choice.

There are also algorithms that reflect the interaction between bottom-up pressure for funding of both USE2030 and USEAbR scenarios with top-down availability of funds in the larger representation of government revenue raising (domestic and potentially via ODA) and government expenditures, both on transfers and on more direct categories of activity (military, health, education, R&D, infrastructure, and other, including administrative). These algorithms require that there be no free lunch and that expenditures do have an origin in revenues. They also, however, simulate reality in the other direction, in that additional spending directed to education will inevitably support both additional students and some additional spending per student. The IFs model is not an optimization tool, but rather a simulation that attempts to reflect typical patterns of systemic behavior, even when goal-seeking.

The analyses of findings in the next section of this report focus on the impacts of the Base Case versus USE2030 on education attainment and on economic outcomes, health, and population size and structure. We will see not only that outcomes on a number of key development variables differ measurably (and often substantially) between the Base Case and USE2030, but also that the situation is quite different for the low-income countries than for the lower-middle-income countries which, as a group, are closer to realistically reaching universal transition to upper secondary by 2030. We also more briefly consider impacts with the USEAbR scenario, the relationship of USE2030 to other foundational SDG goals,[6] and the implications of USE2030 for upper-middle-income and high-income countries.

We then turn to a discussion of the costs, returns, and financing of USE2030 and (to a lesser degree) of USEAbR. The central questions addressed there concern the total costs, the extent to which increases in GDP provide a benefit that offsets part or all of the costs (we will see that it is all, but with delay), and the possible streams of financing for the expenditures of the scenarios beyond those of the Base Case.

[6] As an adjunct effort to this report, we turned our analytical attention to exploration of the consequences of selective "pushes" in support of other development targets in place of, or in addition to, the push for universal secondary education. Specifically, we looked at three levers or interventions that are fundamental to progress in human development: (1) reduced fertility; (2) access to safe water and improved sanitation; and (3) governance quality. Our analysis focused on the impacts of interventions in each of these areas separately, and then on the combined impacts of interventions in these areas both with, and without, the push to universal secondary education.

3 Impacts of Education's Advance

The importance of education for both personal and societal development has long been asserted and generally understood. Undeniably, education's advance has historically tracked with improvements in many aspects of development, and these underlying relationships provide the basis for formulations in IFs that include education attainment as a driver of change in other key development variables.[7]

To explore those impacts, we compare IFs forecasts of a set of such variables in our Base Case with forecasts in the USE2030 scenario in which we assume that resources are mostly sufficient to cover the incremental costs of USE2030 without diverting funds from other areas of government spending. This assumption allows us to explore the full range and magnitude of possible impacts from universal secondary education without significant negative impacts on, and from, other categories of government expenditure. Obviously, however, resources are not unlimited, and a later section of the report will look at resource and funding issues.

In this section, we look first at the education outcomes, and then turn to their impact on selected economic, health, and demographic outcomes. We also consider two combined measures of education's impacts: (1) the Human Development Index, and (2) education/age/sex/population distributions. Our focus is on the low-income and lower-middle income countries; in some cases, we refer to high-income country values for context and comparison.

3.1 Education Outcomes

The differences in the assumptions and methodology of the IFs Base Case versus the USE 2030 scenario produce, as expected, very different education outcomes for both country groups, but especially for the low-income countries. We include three types of education outcomes as we compare the Base Case with USE2030: (1) primary and secondary completion rates; (2) average years of adult education attainment; and (3) gender parity.

3.1.1 Primary and lower and upper secondary completion rates

Table 3.1 presents the estimated weighted average gross primary and secondary completion rates for the 31 low-income and 50 lower-middle-income countries in 2015, and then the forecasts for 2030 and 2050 in both the Base Case and the USE2030 scenario.

One of the most striking features of the table is the comparison of the two country groups in 2015. Despite the MDG goal of universal primary education by 2015,

[7] Chapter 8 of *Advancing Global Education* summarizes such relationships in the empirical literature and describes how they are treated in IFs (see Dickson, Hughes, and Irfan 2010). IFs formulations typically use average years of education of populations 15 or 25 years of age and older as the drivers of education's impact on other development variables.

estimation based on data suggests a low-income country gross primary completion rate just under 69 percent in 2015. Lower-middle-income countries were almost at the MDG goal, with a primary completion rate around 96 percent in 2015.

	2015	2030		2050	
	Estimate	Base Case	USE 2030	Base Case	USE 2030
Low-income countries					
Primary completion rate	68.5	85.6	106.7	93.8	100.3
Lower secondary completion rate	32.9	50.8	110.1	63.7	100.3
Upper secondary completion rate	16.6	35.0	102.1	46.5	100.5
Lower-middle-income countries					
Primary completion rate	95.8	96.0	101.9	98.5	100.2
Lower secondary completion rate	73.8	80.0	103.1	84.9	100.1
Upper secondary completion rate	43.5	52.9	98.3	67.3	100.3

Table 3.1 Primary and lower and upper secondary gross completion rates in low-income and lower-middle-income countries: Base Case and USE2030

Differences between the two country groups are also notable in lower and upper secondary completion rates. The estimated gross lower secondary completion rate for low-income countries in 2015 was 32.9 percent, while for lower-middle-income countries it was 73.8 percent. Corresponding values at the upper secondary level were 43.5 percent for the lower-middle-income countries and only 16.6 percent for the low-income countries.

The forecasts of our Base Case completion rates in 2030 and 2050 build on each country's starting points and trajectory of change at primary, lower secondary, and upper secondary levels. The USE2030 forecasts also begin with individual country starting points but then, regardless of those rates, force phased and overlapping linear increases of universal primary intake and survival, then universal transition to lower secondary and lower secondary survival, and finally to universal transition to upper secondary by 2030, with subsequent universal upper secondary survival.[8]

The very great gap between the Base Case forecasts and the USE2030 forecasts for the low-income country group reflect how extremely aggressive the push to universal secondary transition by 2030 would be for those countries. It is hard, if not impossible, to imagine conditions under which upper secondary completion

[8] In IFs, lower and upper secondary completion rates are calculated from year-by-year gross enrollment and survival. In the USE scenario, the rapid ramp-up of intake, transition, and survival rates draws upon the available pool of over-age students. For many countries, this results in calculated gross completion rates at or somewhat above 100 percent by 2030, even though the USE scenario does not force upper secondary completion. The values do not represent universal completion by of-age students.

rates could increase from an average of just under 17 percent to 100 percent in only 15 years.

Lower-middle-income countries as a group show sizable completion rate gaps between the Base Case and USE2030 at the secondary levels also (although not at the primary level), but for many of these countries a push to universal transition to upper secondary by 2030 appears more likely to be attainable.

3.1.2 Years of adult education attainment

Average years of education are a key indicator of human capital in a society, and as such they are used in IFs as a driver for education's impacts on a range of development variables. We use data from Barro and Lee for our historical series and initial year values of education attainment.

Figure 3.1 compares the progression of average years of education for the population 15-to-24 years of age under the conditions of the Base Case and the USE2030 scenario for both low-income and lower-middle-income countries.[9] This age group is where we expect first to see the results of expanding education participation rates, and one of the first things to note from the figure is that individuals in this age cohort already reflect the push to expand primary education.

We also see that growth in average years of education increases steadily over the period in the Base Case, so that the low-income country population from 15-to-24 years of age in 2050 has, on average, 7.6 years of education (compared to 5.3 years in 2015). USE2030 increases that 2050 value by just over two years, to 9.8 average years.

[9] Throughout this section, we frequently display results in a two-panel figure. Whenever we do so, low-income-countries are represented in the top panel and lower-middle-income countries are represented in the bottom panel.

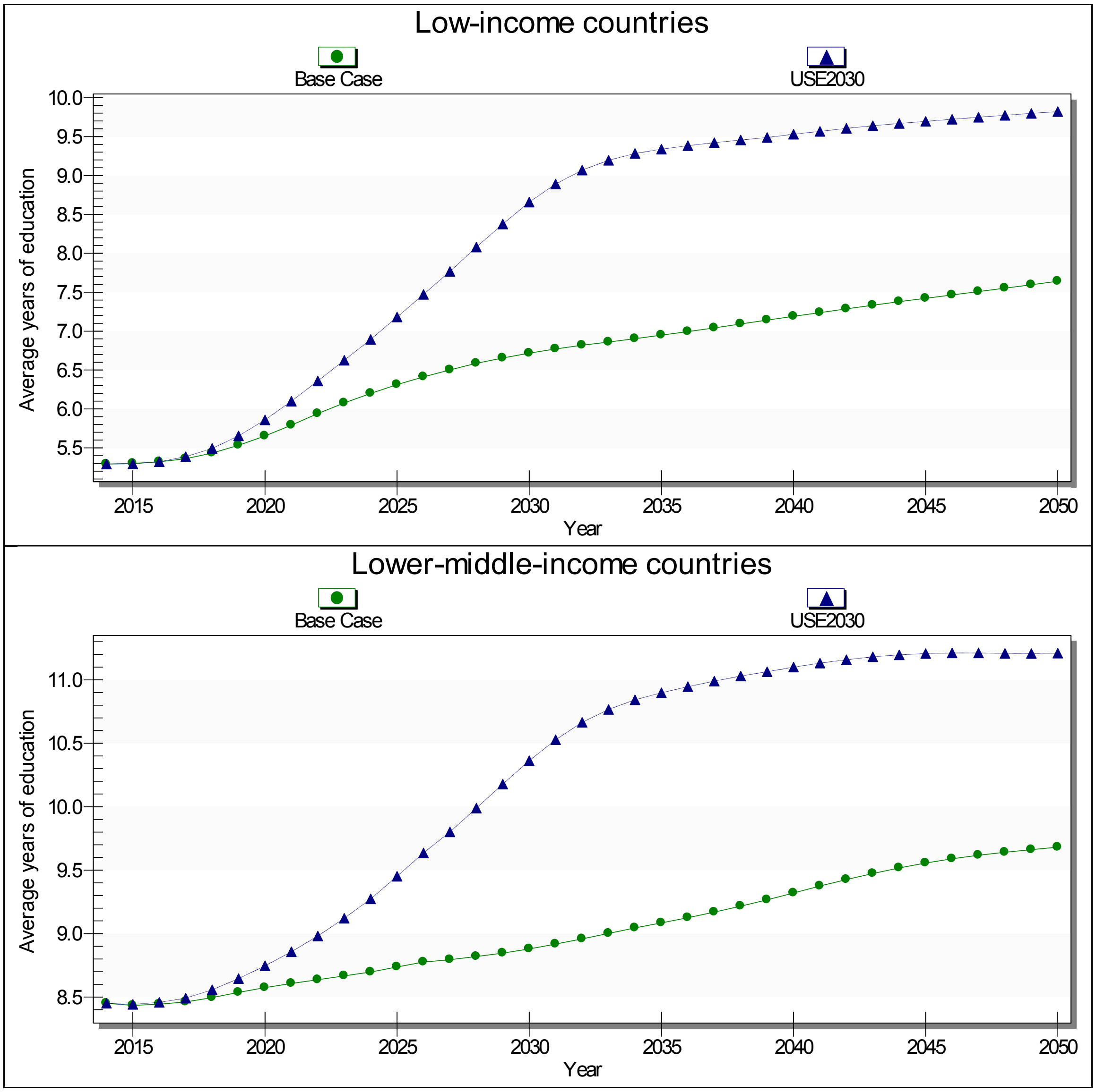

Figure 3.1 Average years of education of those 15-to-24 years of age in low-income and lower-middle income countries: Base Case and USE2030

The 15-to-24 age cohort in lower-middle income countries reaches an average of 9.7 years of education in 2050 with the Base Case (compared to 8.4 in 2015). USE2030 increases the 2050 value by about a year and a half to 11.2.[10] [11]

Across time, two patterns of change in the age structure of education emerge. First, it takes some years in the USE2030 scenario for the greater enrollment rates at higher levels of education to push years of education for those in the 20-to-29 age range definitively above those in the 15-to-24 year old category. For example, in low-income countries, these two groups both have about 7.2 years of education in 2025, but by 2040 the gap between them reaches almost three years (12.5 years vs. 9.5 years), and continues to grow slowly with expansion of tertiary education.

Second, it takes two to three generations for the increase in education of a younger population to spread across the entire population, and there will always be some lag if enrollment rates are continuing to increase at the tertiary level. In 2015, 15-to-24 year olds in low-income countries have about 1.2 years more education than the average adult of age 25 or older (5.3 vs. 4.1 years). By 2050 in USE, the two age groups have essentially the same number (9.8 years). However, the average 20-to-29 year-old has three and a half additional years by that time, reflecting the push upward to the tertiary level.

There is a similar pattern of slow spread of increased years of education across all age groups in the lower-middle-income countries.

Expected years of education for entering primary cohorts provide another forecast measure of education attainment. In low-income countries, school life expectancy for students entering in 2015 was 9.4 years. For students entering in 2030, it has grown to 10.6 years in the Base Case and 14.9 years with USE 2030; the USE value for the 2050 entering cohort remains about the same, while the Base Case forecast for the entering cohort that year has increased to 11.6 years.

Expected years of education are greater for entering cohorts in the lower-middle-income countries. Entering cohorts in 2015 had a school life expectancy of 11.3 years (almost upper secondary completion). The expected years of schooling grow

[10] The 15-to-24 age cohort displays the highest average years of education when participation is expanding from low educational levels. However, because those at the lower end of this age range are not old enough to have completed upper secondary in most countries, nor to have enrolled at the tertiary level, they do not reflect the full gains of expansion to, and beyond, the upper secondary level. Some years after upper secondary enrollment rates have taken off, change in the 20-to-29 age cohort will begin to be more rapid than that in the younger cohort.

[11] We will consistently see this pattern of lesser magnitude change for the lower-middle-income countries from USE2030 compared to the Base Case because their starting values are higher than those in low-income countries. At the same time, despite the lesser magnitude differential with USE2030, their forecasted ending values are typically higher than those of the low-income country group, again because they have the benefit of higher starting values on most development variables.

over the forecast period to about fourteen and a half years in USE2030 and 12.7 years in the Base Case. While neither country group reaches the level of high-income countries, whose expected years of schooling for entering cohorts range from 15.8 to 16.8 over the period (depending on Base Case vs. USE2030), their gaps in school life expectancy are significantly narrowed in the Base Case, and quite dramatically so in USE2030.

3.1.3 Gender parity

The gender parity index is calculated as the female participation or attainment rate at any level of education divided by the male participation or attainment rate at that level. A value of 1.0 indicates parity; values below 1.0 indicate female rates below those of males (female disparity), while values above 1.0 indicate female rates above those of males (male disparity).

The greatest female disparities are evident when we look at attainment levels across the adult population of all ages. For example, in 2015, the gender parity index for average years of education attainment across all adults 15 years-of-age and older was 0.75 for low-income countries and 0.82 for lower-middle-income countries. Even in the USE scenario, the 2050 values for the total population are not yet at 1.0 (although they are both getting close at 0.92), as there are surviving members of older populations that had fewer educational opportunities for both men and women, but especially for women.

The picture changes when we look at the average years of education attainment of the population 15-to-24 years of age. In 2015, the weighted-average gender parity index for this age group was already 0.92 in low-income countries and 1.01 in lower-middle-income countries, in large part reflecting the push from the Millennium Development Goal of universal primary education by 2015 for girls and boys. Even though universal primary education was not achieved by 2015 in these country groups, significant progress was made toward that goal, including its gender parity component.

The goal for gender parity in education attainment is all but achieved for the 15-to-24 age group by 2031 in the low-income countries in both the Base Case and USE2030. Assuming continued parity for subsequent cohorts of 15-to-24 year olds, parity in education attainment will slowly extend through the broader low-income country population. Meanwhile, IFs produces forecasts of continued slight female advantage in overall years of education for the 15-to-24 age group in lower-middle-income countries in both the Base Case and USE2030 (a gender parity ratio of 1.01 to 1.04). The dynamics that result in the higher female attainment are continuing somewhat higher female survival rates and higher female tertiary enrollment rates, patterns that also characterize high-income countries.

3.1.4 Commentary

We close this section with two quite different observations and cautions. First, as we noted earlier, there has been generally rapid enrollment growth in low-income and lower-middle income countries over the last two decades. Even so, 11 of the 31 countries in the low-income group have not yet reached 100 percent primary gross enrollment rates—an obvious precondition some years prior to 100 percent primary completion. In addition, 14 of the 50 countries in the lower-middle-income group have not yet reached 100 percent primary gross enrollment rates. For these 25 countries, and especially for a small number among them whose enrollment rate progress has stalled in recent years, the challenge to reach universal secondary education by 2030 is especially steep, if not impossible.

The second observation and caution relates to tertiary level participation rates. The 2015 tertiary gross enrollment rate in the low-income country group was just 7.6 percent. In the Base Case, it grows to 15.4 percent in 2030 and 25.77 percent by 2050. It grows much more rapidly in the USE2030 scenario, following the extremely rapid growth in secondary enrollment rates in that scenario and cross-sectional patterns of relationship between upper secondary and tertiary enrollment rates. In the low-income countries, USE2030 takes the tertiary enrollment rate to 32.8 by 2030 and 53.7 by 2050. For the lower-middle-income countries, it goes from a 2015 value of 23.1 percent to 45.7 in 2030 and 64.8 in 2050 with the USE scenario (for comparison purposes, the 2015 rate in high-income countries was 72.4 percent).

There are numerous cautions we might raise about the USE2030 tertiary forecasts: the feasibility of such rapid growth and the expense associated with it, especially given characteristically much higher tertiary per-student costs compared to other levels, are two. While the next section on paying for USE will discuss how reasonable such tertiary rates are in USE2030, a different caution needs to be raised here. Throughout this report, the impacts of the USE2030 scenario include the USE2030 tertiary enrollment forecasts. If tertiary enrollments are constrained below those levels, the forward-linkage outcomes of the USE scenario would also need to be adjusted.

3.2 Economic Outcomes

IFs represents the impact of education on economic outcomes via its contribution to multifactor productivity (MFP) through changes in human and social capital. The education variables that affect MFP are the average years of adult education and the level of spending on education as a percent of GDP (as a rough proxy for quality of education). In both cases, IFs compares the value of those variables in each country with those expected in cross-sectional analysis and computes positive or negative shifts in MFP (see Dickson, Hughes, Irfan 2010).

Here we consider three aspects of economic impact: GDP, GDP per capita, and poverty reduction.

3.2.1 GDP

Figure 3.2 presents IFs forecasts of GDP at market exchange rates for the period from 2015 to 2050 and helps us highlight significant aspects of their progression.

First, we see a very positive trajectory in GDP growth in both the Base Case and in USE2030 for both country groups. Second, the impact of USE2030 is considerably greater for the low-income country group because of their far greater divergence between Base Case and USE2030 education outcomes than in the lower-middle-income countries. The fact is the lower-middle-income countries are already realizing substantial economic benefits from greater education participation and attainment.

Finally, we see again the time factor in realizing education's impacts. In the low-income country group, we do not begin to see an appreciable GDP impact of the secondary education push until 2025 ($619.3 vs. $615.4 billion), and until 2032 in the lower-middle-income group ($16.5 vs. $16.2 trillion). By 2050, GDP in USE2030 is 31 percent higher than that of the Base Case in the low-income country group and just over 10 percent higher in the lower-middle-income country group.

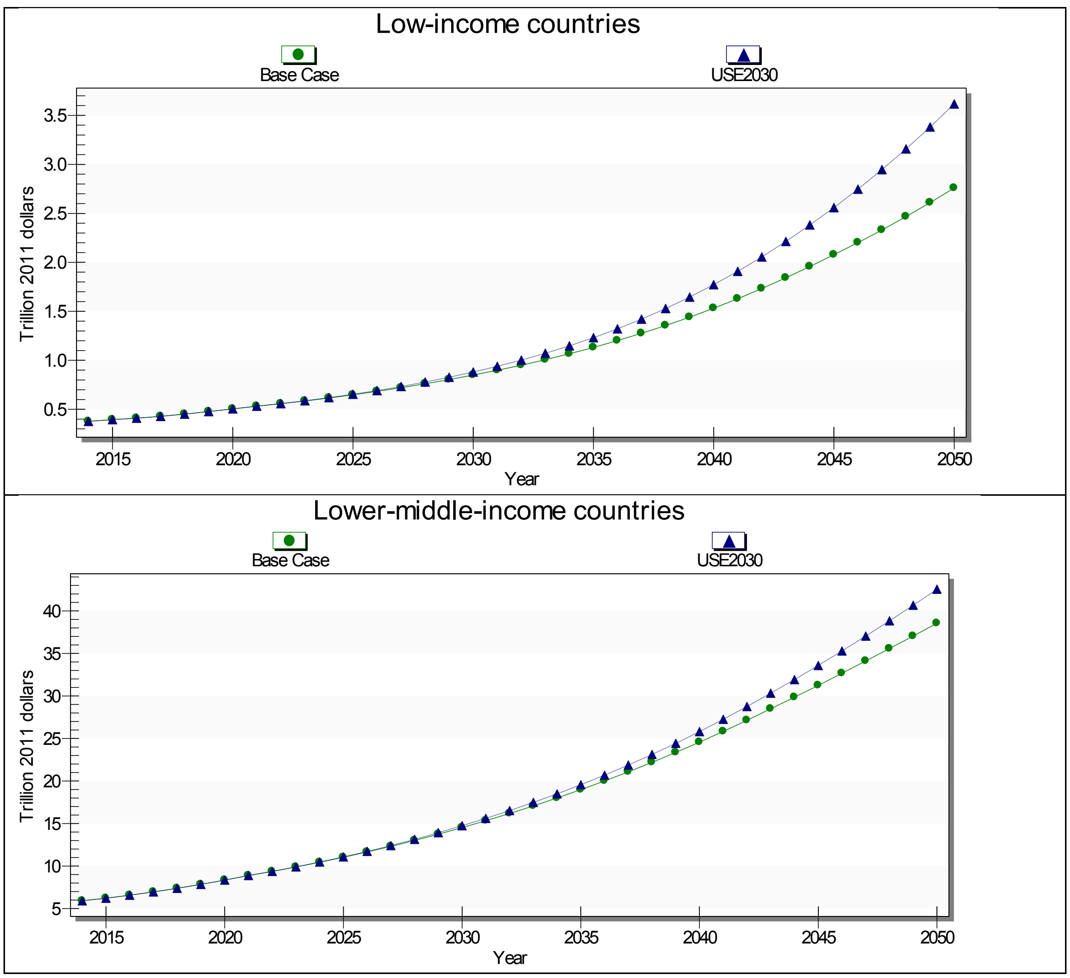

Figure 3.2 Forecasts of GDP at Market Exchange Rates in low-income and lower-middle income countries: Base Case and USE2030

3.2.2 GDP per capita

Figure 3.3 displays GDP per capita at purchasing power parity over the same period. By 2050, the differences are noteworthy and, as expected, much greater for the low-income countries: per capita income in that year is 8.3 percent higher in lower-middle-income countries in the USE2030 scenario vs. the Base Case ($16,170 vs. $14,920), and a full 25 percent higher in low-income countries ($4,906 vs. $3,925).

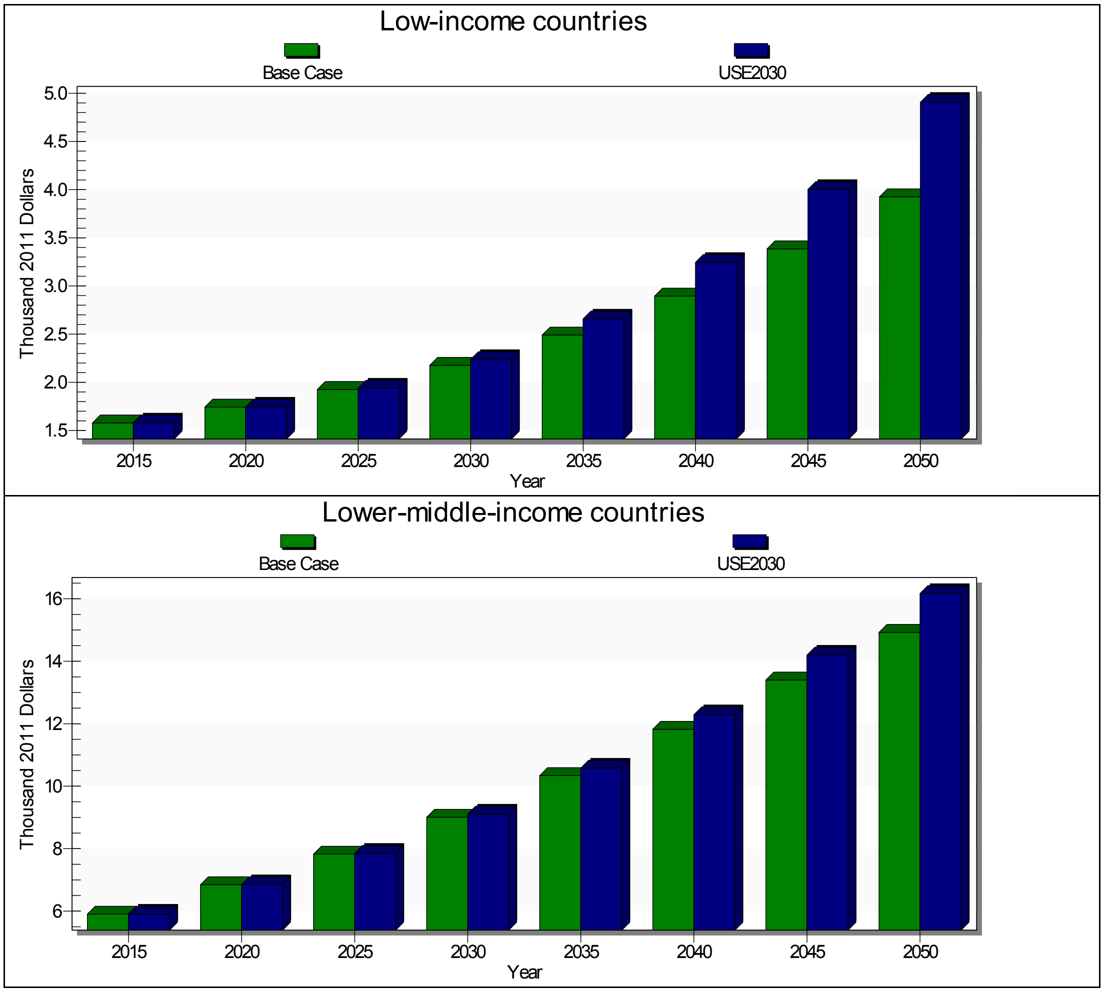

Figure 3.3 Forecasts of GDP per capita at Purchasing Power Parity in low-income and lower-middle income countries: Base Case and USE2030

GDP per capita is an especially good example of not only the initial time lag associated with many of the manifestations of education's impacts, but also of the extended period over which the gains continue to grow. In 2060, GDP per capita in the lower-middle-income countries in the education push scenario is 11.6 percent greater than in the Base Case (compared to 8.3 percent in 2050) and 40.5 percent higher in the low-income countries (compared to 25 percent in 2050).

The differential gains of USE2030 on GDPPC continue to grow beyond 2050 because of ongoing virtuous cycles (positive feedback loops) between education and other development variables. For instance, higher GDP per capita (as well as greater education attainment) contribute to improved health in many ways, including lower rates of childhood undernutrition and life-long stunting as well as reduced morbidity and mortality rates at all ages. These improvements in health further raise productivity and therefore additionally advance education. Similarly, higher GDP per capita contributes to more rapid improvement of infrastructure with its own feedbacks to still more economic and human development.

3.2.3 Poverty

Poverty declines significantly even in the Base Case (see Table 3.2 below). In 2015, the estimated poverty rate (proportion of the population living on less than $3.10 per day) in the low-income country group was a startlingly high 71.1 percent, and almost half of all individuals (46.7 percent) lived in extreme poverty (less than $1.90 per day). In the Base Case, the low-income country poverty rate falls to 60.3 percent in 2030 and 43.1 percent in 2050, and the extreme poverty rate drops to 38.4 percent in 2030 and 26.0 percent in 2050.

USE2030 further reduces the poverty rate by 1.2 percentage points and the extreme poverty rate by almost one and a half percentage points by 2030. By 2050, the differences are substantial: with the education push, the overall poverty rate in the low-income country group is 32.8 percent and the extreme poverty rate is down to 18.0 percent.

	2015	2030		2050		2060	
	Estimate	Base Case	USE 2030	Base Case	USE 2030	Base Case	USE 2030
Low-income countries							
Poverty rate (% < $3.10/day)	71.1	60.3	59.1	43.1	32.8	32.6	19.2
Extreme poverty rate (% < $1.90/day)	46.7	38.4	37.0	26.0	18.0	18.7	9.4
Lower-middle-income countries							
Poverty rate (% < $3.10/day)	47.0	25.0	24.1	15.3	11.5	13.4	8.8
Extreme poverty rate (% < $1.90/day)	19.2	9.3	8.8	5.8	3.9	5.3	3.0

Table 3.2 Forecasts of poverty and extreme poverty rates in low-income and lower-middle income countries: Base Case and USE2030

For lower-middle-income countries, as in the other outcomes we have looked at, USE makes a difference, but a much smaller one: by 2050, extreme poverty is 5.8 percent in the Base Case and 3.9 percent in the USE scenario. The corresponding values for the poverty rate are 15.3 percent and 11.5 percent.

The final set of columns in Table 3.2 show a comparison of forecasted poverty rates in 2060. Directly related to the analysis of increases in GDP per capita with USE2030, we see the beneficial effects of the education push extending and increasing beyond 2050.

3.2.4 Commentary

Poverty levels reflect both average GDP per capita and its distribution.[12] Although some countries like Equatorial Guinea and South Africa with especially unequal distribution are exceptions, most countries with GDP per capita at PPP of $5,000 or more have largely eradicated extreme poverty (incomes less than $1.90 per day). We have seen above that low-income countries are likely in the Base Case to reach on average only $4,000 per capita even by 2050, but that they might be very nearly at $5,000 in the USE2030 scenario. Hence, as seen in Table 3.2, our USE2030 scenario makes a tremendous difference in future poverty levels of low-income countries, bringing extreme poverty rates down by one-third in 2050 and one-half in 2060 relative to the Base Case. The pathway for this is economic growth, which averages 6.5 percent for low-income countries between 2015 and 2050 in the USE2030 scenario, compared to 5.7 percent in the Base Case. The difference results from the greater human capital effect of additional education on multifactor productivity.

3.3 Health Outcomes

Forward linkages from average years of education directly affect many of the health variables in IFs, using formulations that build on those of the World Health Organization's Global Burden of Disease Project (Hughes et al. 2011). Education also affects health through its direct impact on other variables (especially GDP and GDP per capita, and to a lesser extent to physical infrastructure) that, in turn, have forward linkages to health. Here we consider the impact of USE2030 on three health measures: life expectancy, infant mortality, and diarrheal infections.

3.3.1 Life expectancy

In 1960, average life expectancy in today's low-income countries was 38.2 years, compared to 67.2 years in today's high-income countries (a gap of 29 years). By 2015, life expectancy was 61.1 years in the low-income country group, compared to 79.1 years in the high-income countries, reflecting an important narrowing of the gap to 18 years, despite HIV/AIDS.

Even in the Base Case, life expectancy in the low-income country group continues to advance steadily and quite rapidly over our forecast horizon (see Figure 3.4 below). However, USE2030 adds seven-tenths of a year by 2030 (68.6 vs. 67.9 years) and 1.9 years by 2050 (74.6 vs. 72.7). In USE2030, the forecast life expectancy gap between the low-income and high-income country groups narrows further, to 12.8 years by 2030 and 9.2 years by 2050.

[12] In our forecasts, the Gini index of household consumption distribution rises by about 0.04 points on the 0-1 Gini scale (with higher values being more unequal) between 2015 and 2050 in both the Base Case and the USE2030 scenario, and for both low-income and lower-middle-income countries. Such rise is common with fast growth in developing countries. Although important in its impact on computation of poverty rates, an assumption of constant Gini would not significantly change the pattern of results described here.

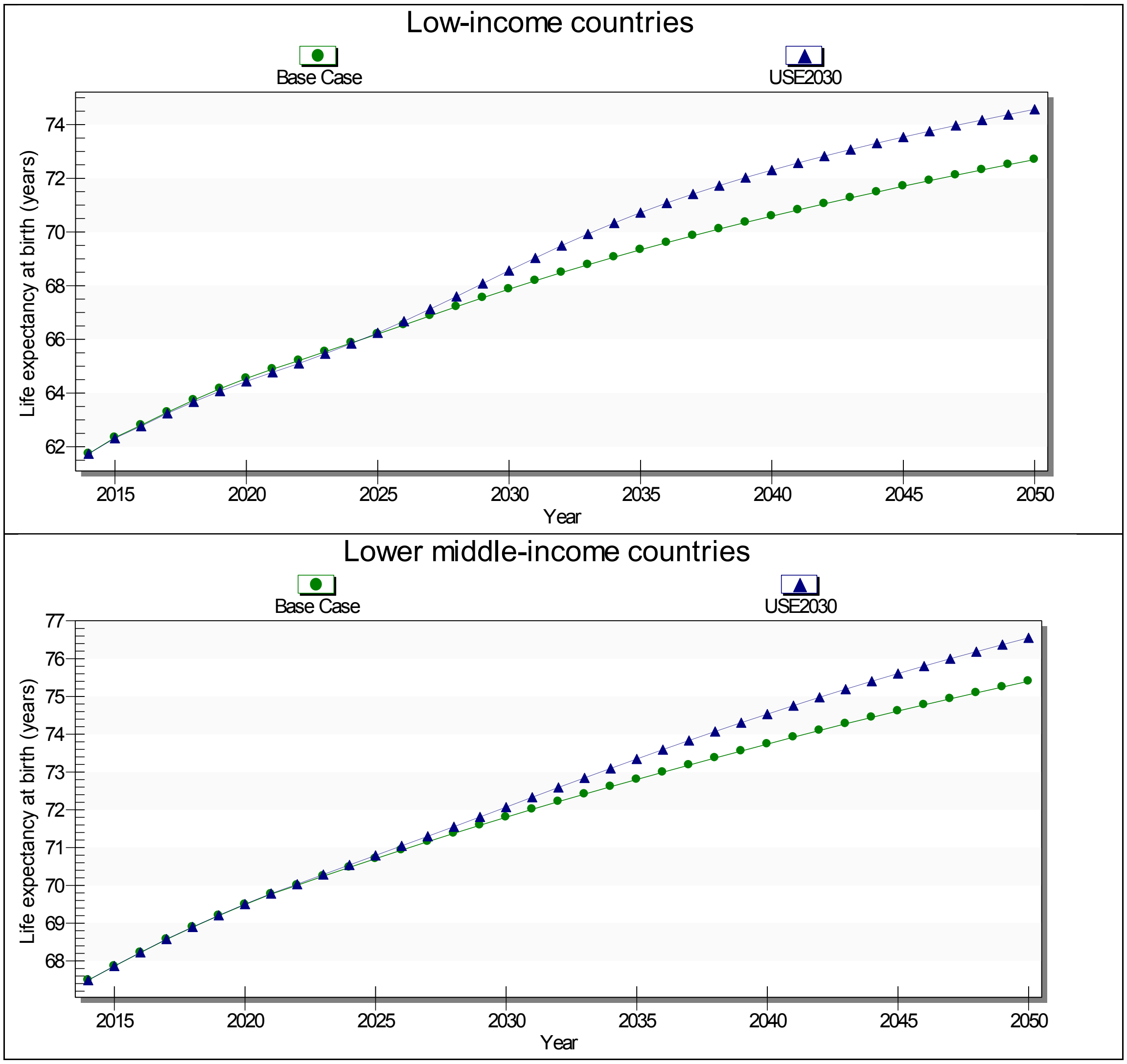

Figure 3.4 Forecasts of life expectancy at birth in low-income and lower-middle income countries: Base Case and USE2030

As with other outcomes, lower-middle-income countries see less of an impact on life expectancy because of the smaller difference in their education levels between the Base Case and USE2030. In the Base Case, their life expectancy is 71.8 in 2030 and 75.4 in 2050; the corresponding values in USE2030 are 72.1 and 76.6. By 2050, with USE2030 their gap with high-income country forecasts for that year is 7.2 years.

3.3.2 Infant mortality

Looking again at a broad historical span, in 1960 the infant mortality rate was 168 per 1,000 live births in the low-income country group and 141 in the lower-middle-income group. Since then, there has been a steady and quite steep decline in infant mortality, so that by 2015 the respective values were 53.0 and 38.7.

In the Base Case, the rate of decline in low-income countries begins to attenuate after 2028 as the more easily addressed causes of infant mortality are increasingly controlled; even so, it declines to 32.7 per 1,000 in 2030 and 19.1 in 2050. USE2030 enables it to continue its steeper decline until around 2040, and to end the period with 13.2 deaths per 1,000 live births in 2050 (see Figure 3.5).

The gap with high-income countries, which was 128 deaths per 1,000 in 1960 and 48 in 2015, narrows to just under 11 by 2050 with USE2030 (high-income country values for those years are 30.4, 5.2, and 2.6 deaths per 1,000 respectively).

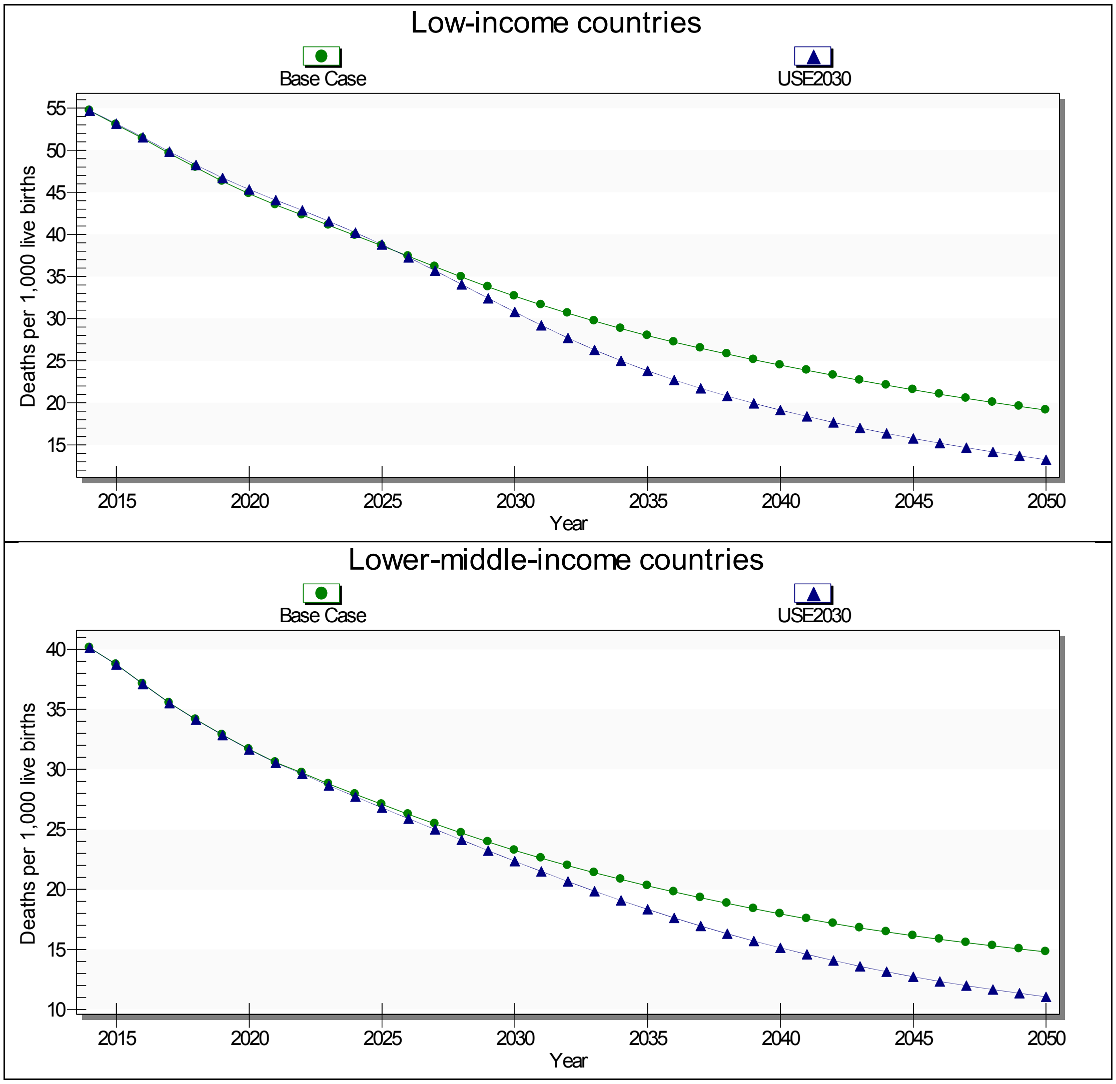

Figure 3.5 Forecasts of infant mortality rates in low-income and lower-middle income countries: Base Case and USE2030

Lower-middle-income countries display a similar pattern, albeit with less difference between the Base Case and USE2030. As a group, their respective forecasts in 2030 are 23.3 vs. 22.4 deaths per 1,000 live births; in 2050, they are 14.8 vs. 11.1. With USE2030, their forecast gap with high-income countries is 8.5 deaths per 1,000 in 2050.

3.3.3 Diarrheal disease

The IFs health model represents 15 specific and grouped clusters of causes of mortality and morbidity. Here we look in more detail at one of them—namely, diarrheal disease, which declines in a direct relationship with education in the IFs health formulations. Diarrheal disease is also strongly affected by infrastructure—specifically, by access to safe water and improved sanitation, which increase somewhat faster in USE2030 because of the greater economic growth associated with accelerated advance in education.

Diarrheal infections occur across all age groups, but disproportionately affect children under 5. Thus, a measure of life expectancy gap captures their effect more clearly than a simple number of deaths or of death rates across the population. The measure we use here is years of life lost (YLL), which represents the number of years that a person loses upon dying compared to his/her potential life expectancy at the time of death.[13]

For the low-income countries, USE2030 averts 100.9 million years of life lost from diarrheal disease between 2015 and 2050 compared to the Base Case. USE2030 has a considerably lesser impact on the rate of decline in lower-middle-income countries (see Figure 3.6). Even so, the smaller difference in the rate of decline results in 146.9 million additional averted years of life lost over the period in lower-middle-income countries because of the much larger population in that country group (about four and a half times larger than the low-income country group in 2015, and three times larger in 2050).

It is important to note that despite the cumulative number of averted YLLs when we look out to 2050, slightly more years of life are lost to diarrheal infections in the early years of the period in the USE scenario than in the Base Case. This is because in those early years, some funds are diverted from health spending to cover the education ramp-up.[14] That is, longer-term benefits may follow a relatively short period of increased costs if government funds are diverted from other expenditure categories to cover the costs of USE.

[13] The potential measure looks to the life expectancies of males and females in the country with the highest ones, which is currently Japan.

[14] The structure of IFs allows us mostly to protect expenditures in other areas from the ramp-up of those in education, but USE2030 nonetheless has some variations from the Base Case.

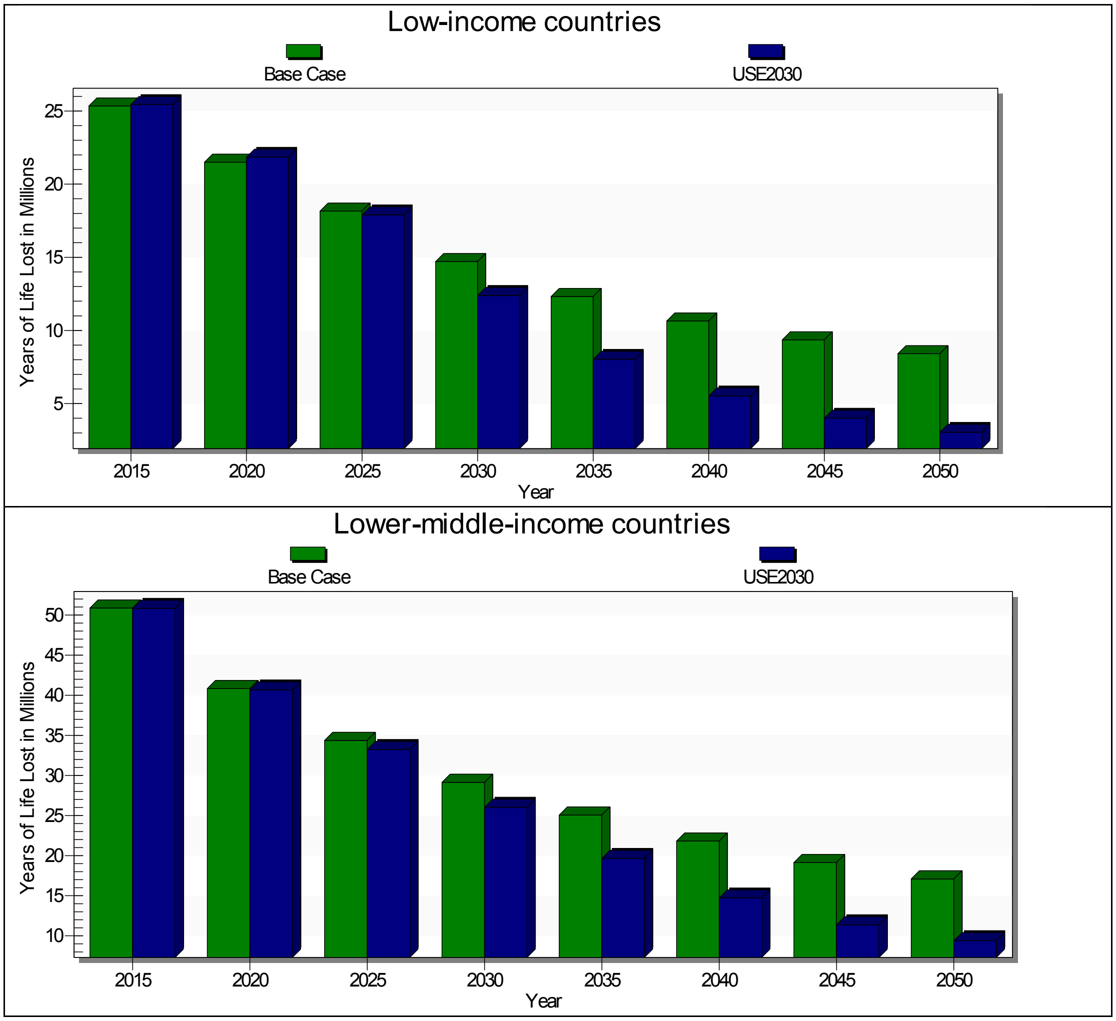

Figure 3.6 Forecast of years of life lost due to diarrheal infections in low-income and lower-middle income countries: Base Case and USE2030

3.3.4 Commentary

While the direct impact of the advance of education on health has been overwhelmingly positive, not all of the health outcomes indirectly associated with education's advance have been. For example, as per capita income has increased, the incidence of certain risk behaviors (e.g., smoking and obesity) and their contribution to associated noncommunicable diseases (e.g., cardiovascular disease, cancer, diabetes and chronic respiratory conditions) have also increased. Certain kinds of accidents also tend to increase with GDP per capita.

We turn to road traffic accidents to illustrate the complexity of the relationship of education's advance with increased health risks. In summary, what happens is that the growth in the number of vehicles as a result of increased GDPPC is so great that, despite reductions in the death rate per vehicle with USE2030, the death rate per 1,000 population actually increases. We illustrate these relationships below.

As seen in Figure 3.7, IFs forecasts extraordinary growth in vehicles per 1,000 persons in both country groups over the period from 2015 to 2050 in the Base Case, and more so in USE2030.

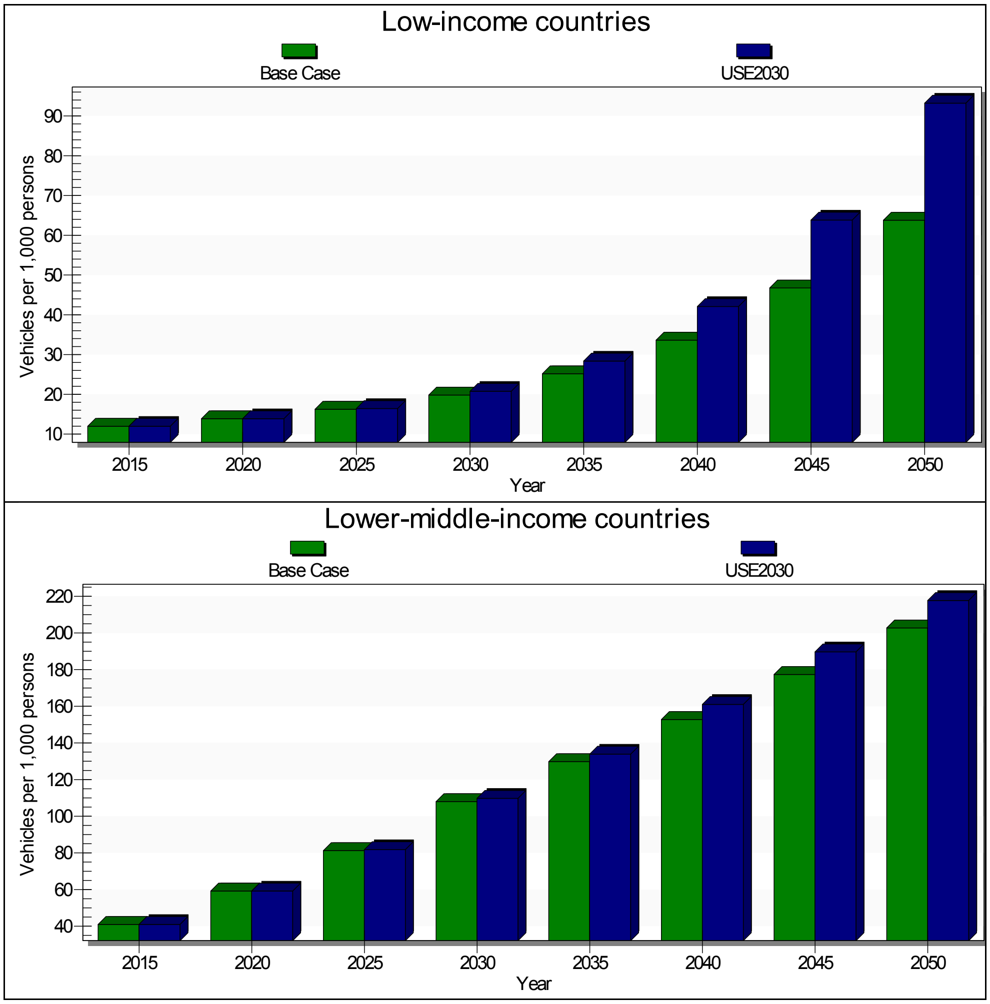

Figure 3.7 Forecasts of vehicles per 1,000 persons in low-income and lower-middle income country groups: Base Case and USE2030

At the same time that vehicle numbers will rise, we also forecast a significant downward trajectory in the rate of deaths per 1,000 vehicles—a trajectory that is enhanced by universal secondary education (see Figure 3.8 below). It is reasonable to assume that the increased income and knowledge that accompany education's advance result in better roads, safer vehicles, and (hopefully) improved driving. Thus, the direct and indirect effects of education ameliorate some of the impact of the new risk associated with the modernization it helps generate.

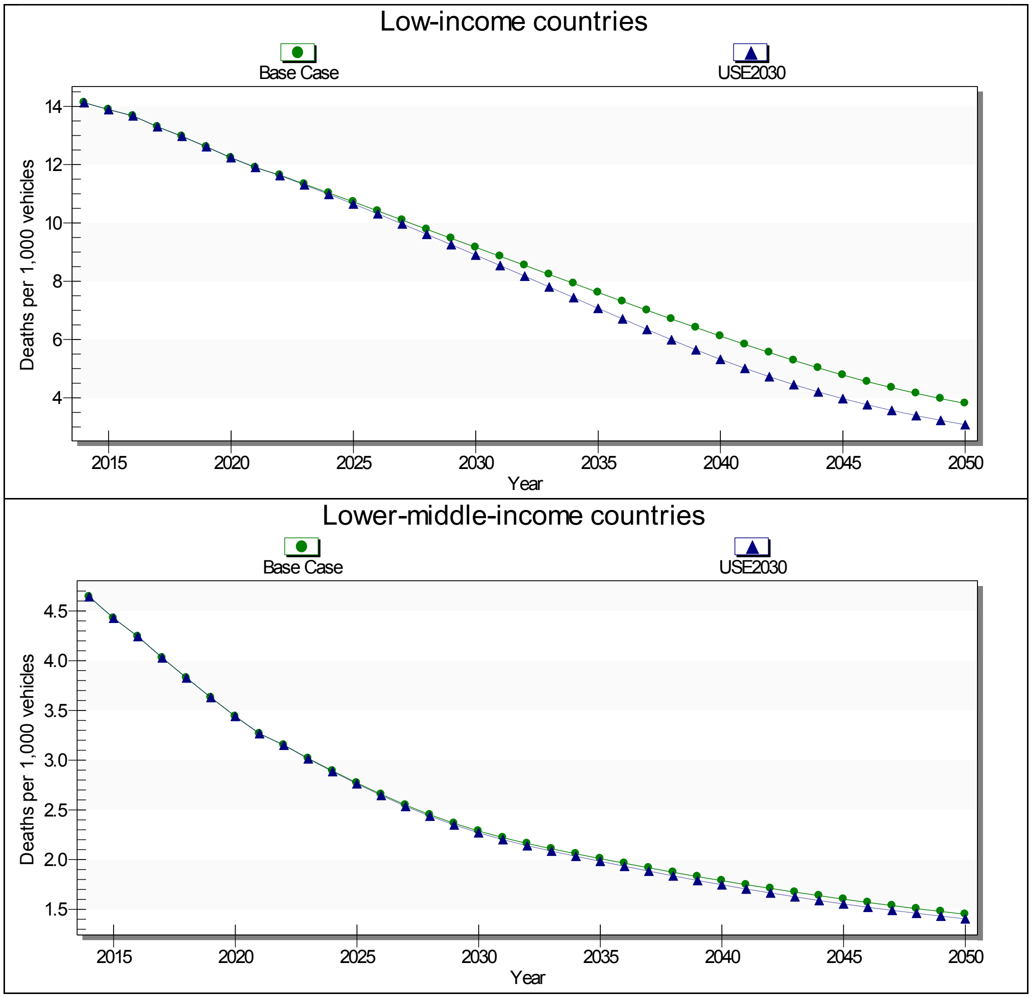

Figure 3.8 Forecasts of death rates per 1,000 vehicles in low-income and lower-middle income country groups: Base Case and USE2030

The aggregate impact of these changes—the rise in vehicle ownership rates and the fall in death rates per vehicle—is a modest overall increase in the death rate per 100,000 persons from road traffic accidents (not shown). For the low-income countries, with USE2030 it climbs from 16.6 deaths per 100,000 persons in 2015 to 18.5 in 2030 and 28.7 in 2050 (the corresponding Base Case values are 18.2 and 24.3).

The 2015 vehicular death rate per 100,000 persons in lower-middle-income countries was 18.1; the USE2030 forecasts are 24.9 deaths per 100,000 persons in 2030 and 30.6 in 2050 (the corresponding Base Case values are 24.7 and 29.4). These contrast with a rate of just under 10 per 100,000 in high-income countries throughout the forecast period.

In summary, modernization brings a variety of new health risks and challenges in addition to benefits.[15] With effort, education may help today's developing countries learn from the historical experiences of the high-income countries in order to lessen the impact of the new challenges. In fact, it could even lead globally to technological advance, such as autonomous vehicles, that could reverse the tendency for more vehicles to increase accident numbers.

3.4 Population Outcomes

Education affects population because of its impact on mortality, as discussed above. It also affects population because of the impact of education on the fertility function in IFs, and the forward impacts from that to population growth rates and size.

3.4.1 Fertility rate

For the low-income countries as a group, fertility declined only from 6.5 live births per woman in 1960 to 6.3 in 1990. This reflects, almost entirely, the delayed start of the fertility transition in sub-Saharan Africa (particularly Eastern, Central, and Western Africa) compared to the developing countries of all other regions.[16] After 1990, the rate of fertility decline in low-income countries began to accelerate, resulting in 5.7 live births per woman in 2000 and 5.0 in 2010.

In the Base Case, we forecast a continued steady decline in the fertility rate of the low-income country group, to 3.8 in 2030 and 2.7 in 2050. With USE2030, we see additional decline beginning as early as 2021, resulting in a fertility rate of 3.6 in 2030 and 2.2 in 2050 (see Figure 3.9).

[15] Omran (1971) first articulated the concept of an epidemiological transition, in which dramatically reduced communicable disease rates are partially offset by increased noncommunicable disease rates as developing countries proceed through a demographic transition fueled, in substantial part, by education.

[16] Of the 31 countries in the World Bank low-income country group at the time of this study, only 5 are not in sub-Saharan Africa (Afghanistan, Cambodia, Haiti, North Korea, and Nepal).

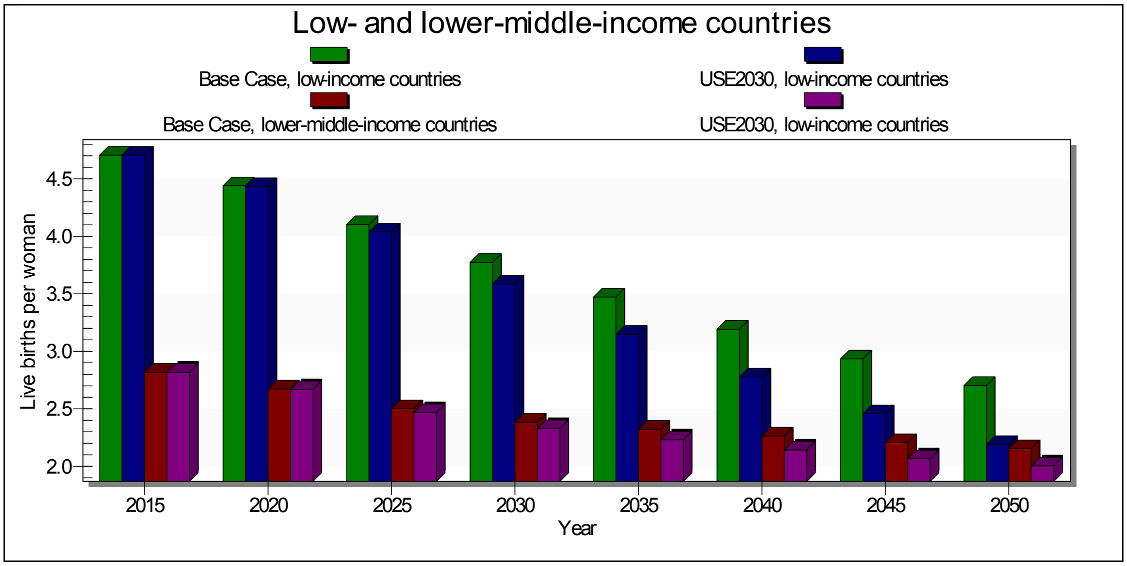

Figure 3.9 Forecast fertility rates in low-income and lower-middle income country groups: Base Case and USE2030

Lower-middle-income countries begin the forecast period with a much lower fertility rate (2.8 in 2015, down from 5.9 in 1960, 5.0 in 1980, and 3.4 in 2000). In other words, they had already gone through the period of most rapid fertility decline by the beginning of our forecast period. Moving forward, their fertility continues to decline, albeit at modest rates in both the Base Case and USE2030. USE2030 does accelerate the lower-middle-income country rate of decline slightly: in 2030, the Base Case value is 2.4 and the USE2030 forecast value is 2.3. By 2050, the Base Case value is 2.15, and the USE2030 forecast value is 2.00.

In summary, the USE2030 forecast fertility rates bring low-income and lower-middle income countries to replacement fertility levels around 2050, even though they remain above the 1.7-1.8 of the high-income country forecasts.

3.4.2 Population growth rate and size

The continued decline in fertility significantly reduces the low-income country group population growth rate even in the Base Case, and even with the increase in life expectancy over the forecast period. Further, although the fertility rate decreases only moderately faster in USE2030 than in the Base Case, differences in the population growth rate under the two scenarios begin to emerge early in the forecast period (see Figure 3.10).

Low-income countries as a group begin the forecast period with a 2.6 annual population growth rate in 2015. Lower-middle-income countries start the forecast period with a much lower annual population growth rate of 1.4. (In contrast, the annual population growth rate of high-income countries was a much lower 0.5 in 2015.)

By 2050, the low-income country Base Case population growth rate is 1.5; the USE2030 growth rate is 20 percent lower at 1.2 (less than half the 2015 rate). For the lower-middle-income countries, USE2030 brings the population growth rate to 1.0 in 2030 and 0.5 in 2050; the corresponding Base Case values are 1.0 and 0.6. Thus, by the end of the forecast period, the population growth rate of the lower-middle-income countries with USE2030 is about at the level where high-income countries started the period; low-income countries are not forecast to reach that level until 2079 with USE2030 and 2088 in the Base Case.

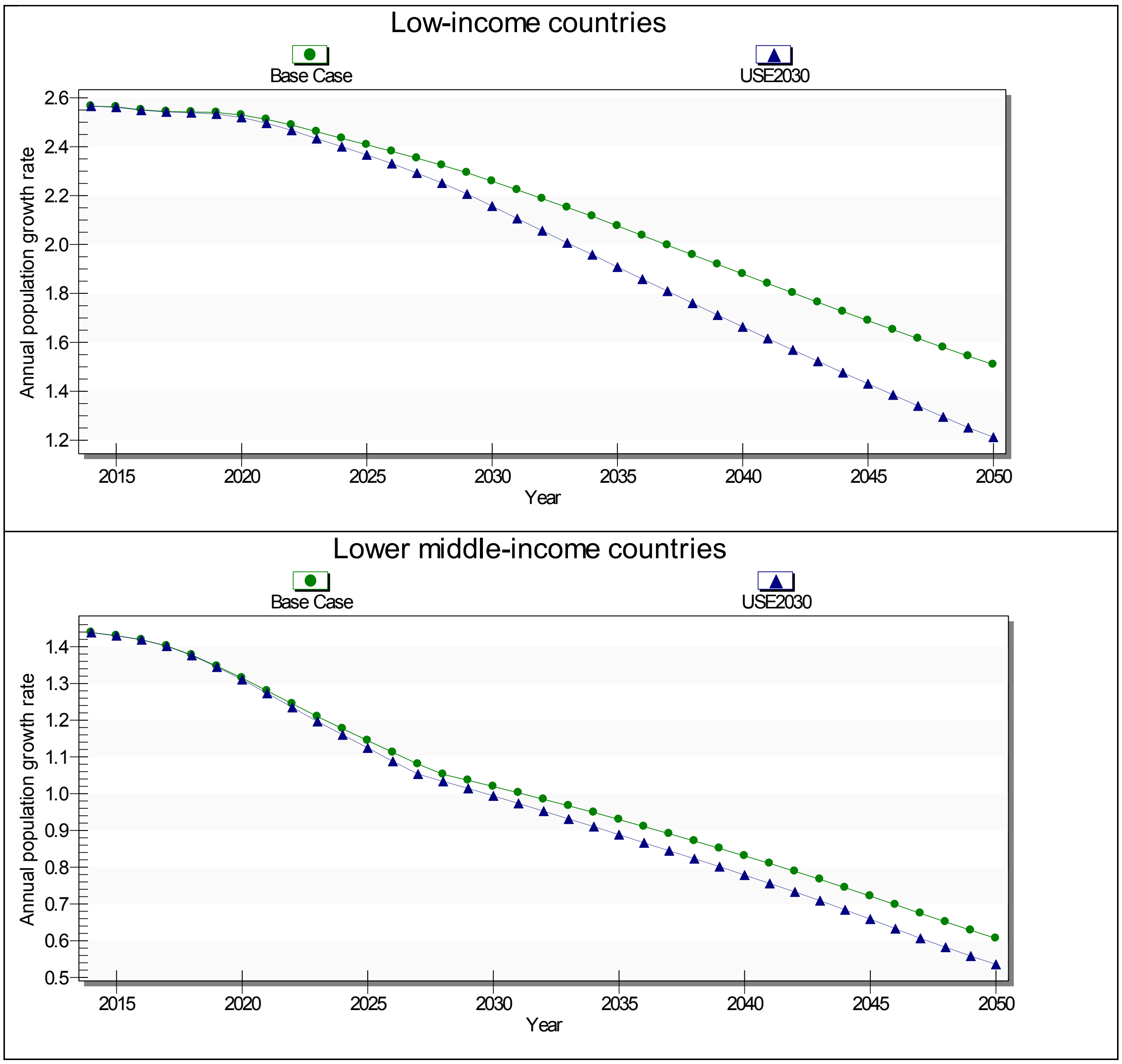

Figure 3.10 Forecasts of population growth rates in low-income and lower-middle income country groups: Base Case and USE2030

With USE2030, the low-income country population forecast is 1.28 billion in 2050, compared to 1.34 billion in the Base Case. Corresponding values for the lower-middle-income countries in 2050 are 4.22 and 4.29 billion. And, as with other variables such as GDP and GDP per capita, the benefits of the USE scenario continue to grow over time. By 2060, the low-income country population is 1.43 billion with

USE2030 and 1.53 in the Base Case, a difference of 100 million persons. The corresponding numbers for lower-middle income countries in 2060 are 4.29 vs. 4.37 billion, a difference of about 80 million persons.

3.4.3 Population under 5 years-of-age

The variables we have been considering interact to change the age structure across the total population. Both fertility rate decline and increases in adult life expectancy reduce the child population as a percentage of the total population, even as declines in infant and child mortality boost the numbers of children relative to earlier periods.

Table 3.3 portrays the results of these interacting variables by looking at the percentage of the total population represented by children under 5 years of age. The table includes values out to 2060, as this is one of the variables where the differential impacts between the Base Case and the USE scenario are relatively slow to materialize, but then persist and gain in strength far into the future.

	2015	2030		2050		2060	
	Estimate	Base Case	USE 2030	Base Case	USE 2030	Base Case	USE 2030
Population under-5 years of age							
Low-income countries	16.0	13.9	13.5	10.7	9.0	8.9	7.6
Lower-middle-income countres	10.9	8.8	8.6	7.4	7.0	6.7	6.3

Table 3.3 Forecasts of percent of population under 5 years of age in low-income and lower-middle income country groups: Base Case and USE2030

The age structure of a society is a key variable affecting its development opportunities or constraints. Other things being equal, a lower percentage of young children translates into increased development opportunities, both for the society as a whole and for individuals within it. With the USE scenario, the percentage of the under-5 population in the low-income country group declines from its starting point (16.0) by more than half by 2060. (For comparison, the 2015 average in high-income countries was 5.8 percent.)

3.4.4 Commentary

One of the most important factors in providing the foundation for a sustainable future and the realization of the SDG goals is the restraint of population growth. While the SDG process mentions fertility reduction without setting a specific target level or year, getting to replacement rate fertility (or below) is an obvious goal. In the USE2030 scenario, the low-income countries reach the replacement fertility rate of 2.1 in 2053, whereas in the Base Case they do not reach it until 2064 (the years for lower-middle-income countries are 2043 and 2047).

Already in earlier years, however, the fertility patterns of the USE2030 scenario have important implications for the attainment of the scenario. In 2030, the population of those under 15 in low-income countries is 1 percent lower than in the Base Case and by 2050 it is 13 percent lower. This reduction in numbers of those who need an education means that the very significant costs of financing the scenario are proportionately that much lower. Thus, the causal loop linking education with fertility and back to student numbers needing education is one that can help make USE2030 possible.

3.5 Combined Measures of USE2030 Impacts

To this point, we have been looking at the impact of universal secondary education on other variables one at a time, albeit acknowledging interaction effects, such as those between fertility and mortality rates in determining population size and age structure. To conclude this section, we turn to two explicit portrayals of combined impacts of the USE scenario.

3.5.1 Human Development Index

The Human Development Index (HDI) developed by the United Nations Development Program combines measures of life expectancy, education, and income into a single value intended to represent the overall level of human development within a country. HDI values are scaled from 0.0 to 1.0. In 2014, scores ranged from 0.348 on the low end (Niger) to 0.944 on the high end (Norway). The world average was 0.711.[17]

The HDI weighted average values for both low-income countries and lower-middle-income countries fall well below the world average. The value for low-income countries in 2014 was 0.454, and that for the lower-middle-income group was 0.605.

By 2030, the value for the low-income country group rises to 0.533 in the Base Case and 0.578 in the USE scenario (an increment of 8.4 percent with USE2030); in 2050 the forecast values are 0.623 in the Base Case and 0.713 in the USE scenario (a 14.4 percent increment with USE).

For lower-middle-income countries, the value rises to 0.676 in 2030 in the Base Case and to 0.704 with USE. In 2050, the forecast values are 0.750 in the Base Case and 0.803 in the USE scenario (a 7.1 percent increment with USE). The USE scenario clearly makes a difference on this composite measure of human well-being.

[17] See http://hdr.undp.org/en/content/human-development-index-hdi for explanation of methodology and 2014 country values and ranking.

3.5.2 Education/age/sex population distributions

Figures 3.14 and 3.15 are visual representations of the dramatic demographic and educational consequences of USE2030 for, respectively, the low-income country group and the lower-middle-income group. Each figure has three pyramids that convey education/age/sex/population distributions for 2015 and then Base Case and USE2030 forecasts for 2050.

The color coding in the pyramids shows the very great change in education attainment levels by age group between 2015 and 2050, even with the Base Case, and dramatically so with USE2030. The three panels in each county-group set have the same scale, so that overall changes in population size and structure are apparent also. For example, by 2050 with the USE scenario we can see the results of both fertility rate reduction for the young cohorts and increased life expectancy for the more elderly ones. We also can see from the pyramids how long it takes fertility reductions to significantly impact overall population size.

Turning specifically to the low-income country group, between 2015 and the Base Case pyramid for 2050 we see a shift to all-but-universal completion of primary education for the younger age groups. We also see significant growth in completed secondary and tertiary education. In the 2050 USE pyramid, we see truly universal primary and dramatically-more completed secondary and tertiary education. In both 2050 pyramids, gender parity spreads throughout the population.

The lower-middle-income country pyramids show the greater education attainment levels of those countries compared to the low-income country group in 2015 and at 2050. The growth in tertiary attainment by 2050 with the USE scenario is especially noteworthy. As with the low-income country group, the shape and size of the pyramids shows the effects of reduced fertility rates combined with increased life expectancy. And, again, we see educational gender parity spreading throughout the population as more educated cohorts move up the pyramid between 2015 and 2050.

For both country groups, the pyramids show clearly that transformational demographic, and therefore societal, change accompany the advance of education attainment.

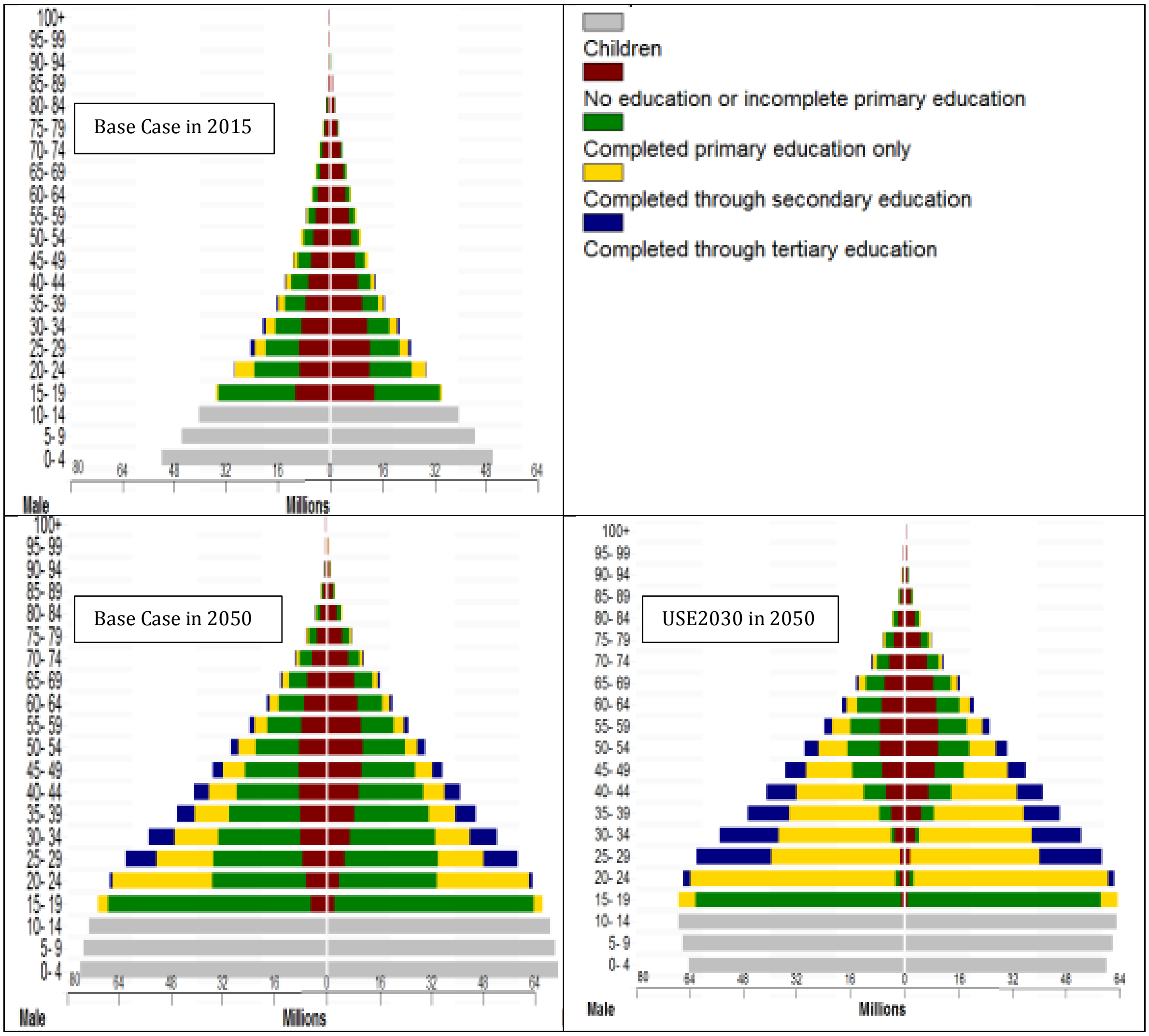

Figure 3.14 Population distribution across low-income countries by age, sex, and education level: Base Case and USE2030

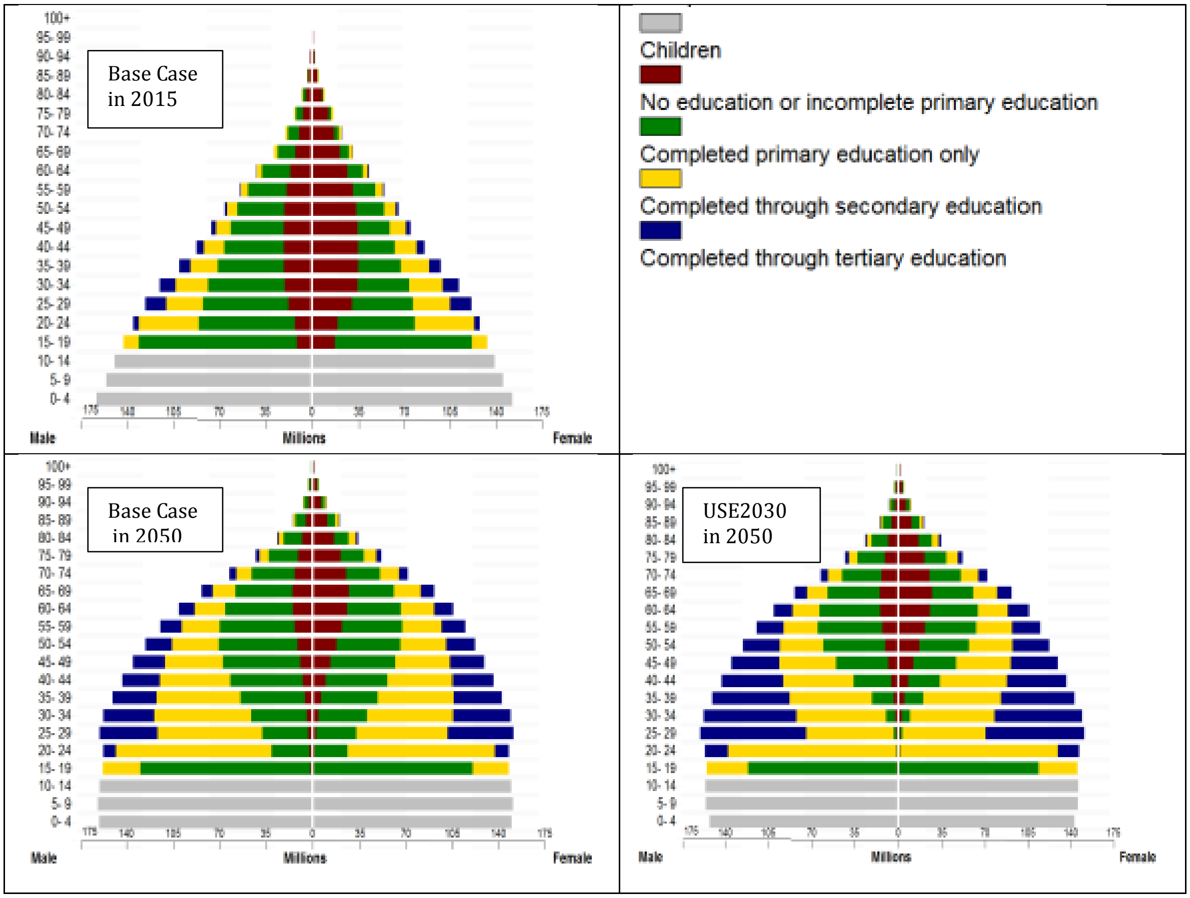

Figure 3.15 Population distribution across lower-middle-income countries by age, sex, and education level: Base Case and USE2030

3.6 Extending Our Analyses of Outcomes

In this section, we extend our analyses of the outcomes associated with rapid advance of education in three ways. First, we turn to the education scenario based on aggressive but reasonable rates of expansion in education participation (USEAbR) introduced in Section 2.2. That scenario does not set common end target dates for all countries as does the USE2030 scenario, but rather focuses on rates of progress toward the same universal education goals. We next briefly discuss upper-middle-income and high-income countries in the context of the USE2030 and USEAbR scenarios. We end our consideration of the extended analysis of USE2030 with brief comments on education's synergistic relationship with selected alternative SDG-related interventions.

3.6.1 Considering USEAbR

Throughout the analysis to this point, we have focused on universal secondary education by 2030 for all countries. In reality, both within and across the low-income and lower-middle-income country groupings there are large variations in terms of current education participation rates and trajectories of expansion. For example, estimated upper secondary gross enrollment rates within the low-income country group in 2015 ranged from 5 percent (Central African Republic) to 60 percent (Cambodia), while the population-weighted average for the group was 32.3 percent. Among the lower-middle-income countries, the corresponding range was 5 percent (Zambia) to Sri Lanka (99 percent), with a weighted average of 58 percent.

Obviously, the feasibility of reaching universal participation in upper secondary by 2030 is extremely low, if not literally impossible, for countries at very low participation rates in 2015. A climb from 5 to 100 percent secondary enrollment in 15 years would require an average of 6 percentage point increases every year, on top of rapid increases at lower educational levels, for such countries. For these countries, perhaps the greatest value of the USE scenario is that, by providing evidence of the benefits that might be expected to accompany expansion of secondary education, it encourages both the individual countries and the international community to focus and accelerate efforts to expand participation rates at the secondary level.

Because of the very great (and frankly unrealistic) stretch that USE2030 places on countries with the lowest current enrollment and transition rates, we developed a second education scenario as another aid to thinking about education's expansion. That scenario, which we call USEAbR, couples the 2015 starting points of individual countries with what might be called "aggressive but reasonable" rates of expansion.[18] Thus, rather than a common USE target date for all countries, regardless of their circumstances, something close to "best practice" rates of progress determine each country's individual trajectory. In the USEAbR simulation, most low-income countries, and many lower-middle-income countries, do not reach universal upper secondary transition by 2030, but all make progress considerably beyond that in the Base Case.

Tables 3.4 and 3.5 summarize the low-income and lower-middle-income country outcomes for the key variables considered throughout this report for both USE2030 and USEAbR. In general, in 2030 the USEAbR scenario produces education, economic, health, and demographic outcomes that are roughly midway between the Base Case and USE2030. However, by 2050 the USEAbR scenario outcomes are very much closer to those of USE2030 for that year. Thus, despite the fact that although most low-income, and many lower-middle income, countries do not reach completely universal participation up to and including transition to upper secondary by 2030 in the USEAbR scenario, by 2050 accelerated aggressive but reasonable rates of expansion have impacts almost as great as those of USE2030. In addition, that approach could help avoid the negative consequences that accompany

[18] Our approach focused on analyzing recent rates of expansion at primary, lower secondary, and upper secondary levels. We looked at average, median, and maximum expansion rates, and at the rates of countries at the 75th, 80th, and 90th percentile in terms of growth in participation. After looking at the data, we chose the rates of countries at the 80th percentile as a foundation for the growth rates in our USEAbR scenario. The rates in USEAbR are 2.2 percentage point annual growth in primary intake; 2.0 percentage point annual growth in transition to lower secondary, transition to upper secondary, and survival in both lower and upper secondary; and 1.5 percent annual growth in survival at the primary level. We also accelerated movement to gender equality at all levels.

unrealistic common year targets, while simultaneously encouraging accountability for what commitment and focused effort could accomplish. The approach would also have some positive implications (particularly for the USE2030 peak years) for the costs and funding of expansion that Section 4 will consider.

Low-income countries	2015	2030 Forecasts			2050 Forecasts		
	Estimate	Base Case	USE 2030	USEAbR	Base Case	USE 2030	USEAbR
EDUCATION OUTCOMES							
Primary completion rate	68.5	85.6	106.7	95.3	93.7	100.3	100.2
Lower secondary completion rate	32.8	50.8	110.1	82.7	63.7	100.3	99.9
Upper secondary transition rate	58.8	65.2	99.9	80.8	71.3	100.0	98.3
Average years of education, population 15-24	5.3	6.7	8.7	7.6	7.6	9.8	9.5
Average years of education, population 20-29	5.6	7.3	9.8	8.4	8.8	13.3	12.4
Average years of education, population 15 and older	4.4	5.6	6.6	6.1	7.0	9.8	8.9
Average years of education, population 25 and older	4.1	5.2	5.7	5.4	6.9	9.8	8.7
Gender parity index, population 15-24	0.92	0.99	0.99	0.98	1.04	1.02	1.03
Gender parity index, population 15 and older	0.75	0.82	0.84	0.82	0.89	0.92	0.92
Expected years of education, entering cohort	9.4	10.6	14.9	12.7	11.6	14.7	14.3
ECONOMIC OUTCOMES							
GDP growth rate (annual)	4.79	5.69	6.42	6.08	5.74	6.97	6.55
GDP at MER (trillion 2011 USD)	0.395	0.849	0.880	0.868	2.759	3.617	3.218
GDP per capita at PPP (thousand 2011 USD)	1.58	2.18	2.24	2.21	3.93	4.91	4.46
Poverty rate (% of pop below $3.10 a day)	71.1	60.3	59.1	59.5	43.1	32.8	36.7
Extreme poverty (% of pop below $1.90 a day)	46.7	38.4	37.0	37.5	26.0	18.0	20.7
HEALTH OUTCOMES							
Life expectancy (years at birth)	62.3	67.9	68.6	68.2	72.7	74.6	74.0
Infant mortality (deaths per 1,000 births)	53.0	32.7	30.8	31.9	19.1	13.2	15.0
Diarrheal infections (million years-of-life-lost)	25.3	14.7	12.4	13.7	8.4	3.0	4.2
POPULATION OUTCOMES							
Fertility rate	4.71	3.77	3.59	3.68	2.70	2.19	2.36
Population growth rate (annual)	2.56	2.26	2.16	2.21	1.51	1.21	1.31
Population size (millions)	638	919	915	917	1,340	1,282	1,307
Population under 5 years of age (% of total pop)	16.0	13.9	13.5	13.7	10.4	9.0	9.5
SUMMARY DEVELOPMENT IMPACT							
Human Development Index	0.460	0.533	0.578	0.556	0.623	0.713	0.687

Table 3.4 Forecasts of USE2030 and USEAbR outcomes for low-income countries

Lower-middle-income countries	2015	2030 Forecasts			2050 Forecasts		
	Estimate	Base Case	USE 2030	USEAbR	Base Case	USE 2030	USEAbR
EDUCATION OUTCOMES							
Primary completion rate	95.8	96.0	101.9	100.3	98.5	100.2	100.2
Lower secondary completion rate	73.8	80.0	103.1	99.4	84.9	100.1	99.9
Upper secondary transition rate	77.0	80.4	100.0	95.9	86.1	100.0	99.4
Average years of education, population 15-24	8.4	8.9	10.4	10.2	9.7	11.2	11.1
Average years of education, population 20-29	8.9	9.8	11.7	11.5	11.3	14.3	13.9
Average years of education, population 15 and older	6.3	7.4	8.0	7.9	8.7	10.5	10.2
Average years of education, population 25 and older	6.1	7.3	7.7	7.6	8.7	10.6	10.3
Gender parity index, population 15-24	1.01	1.02	1.02	1.02	1.04	1.03	1.03
Gender parity index, population 15 and older	0.82	0.87	0.87	0.88	0.92	0.92	0.93
Expected years of education, entering cohort	11.3	11.7	13.9	13.4	12.7	14.4	14.1
ECONOMIC OUTCOMES							
GDP growth rate (annual)	5.30	5.69	5.95	5.90	4.05	4.63	4.52
GDP at MER (trillion 2011 USD)	6.23	14.53	14.75	14.72	38.55	42.55	41.72
GDP per capita at PPP (thousand 2011 USD)	5.91	9.01	9.11	9.10	14.92	16.17	15.93
Poverty rate (% of pop below $3.10 a day)	47.0	25.0	24.1	24.3	15.3	11.5	12.0
Extreme poverty (% of pop below $1.90 a day)	19.2	9.3	8.8	8.9	5.8	3.9	4.2
HEALTH OUTCOMES							
Life expectancy (years at birth)	67.9	71.8	72.1	72.0	75.4	76.6	76.4
Infant mortality (deaths per 1,000 births)	38.7	23.3	22.4	22.6	14.8	11.1	11.5
Diarrheal infections (million years-of-life-lost)	50.9	29.1	26.0	26.9	17.1	9.4	10.2
POPULATION OUTCOMES							
Fertility rate	2.82	2.38	2.33	2.34	2.15	2.00	2.02
Population growth rate (annual)	1.43	1.02	0.99	1.00	0.61	0.54	0.54
Population size (millions)	2,917	3,513	3,507	3,508	4,151	4,103	4,111
Population under 5 years of age (% of total pop)	10.9	8.8	8.6	8.7	7.4	7.0	7.1
SUMMARY DEVELOPMENT IMPACT							
Human Development Index	0.611	0.676	0.704	0.698	0.750	0.803	0.794

Table 3.5 Forecasts of USE2030 and USEAbR outcomes for lower-middle-income countries

3.6.2 What about upper-middle-income and high income countries?

For very obvious reasons, our focus in this study has been on low-income and lower-middle-income countries. However, upper secondary education is not universal across the upper-middle-income and high-income countries either. In 2015, the weighted average transition rate to upper secondary was 97.7 percent in the high-income country group. Eight of the 57 high-income countries, however, had upper secondary transition rates below 97 percent, ranging from 96.1 percent down to 69.2 percent. The weighted average for the upper-middle-income group was almost identical at 97.6 (94.2 without China); however, 20 of the 48 countries had transition rates below 97 percent, ranging from 95.9 percent down to 61.7 percent.

We included the upper-middle-income and high-income country groups in our USE2030 and USEAbR scenarios. Tables 3.6 and 3.7 display the outcomes for these country groups across the Base Case and the two USE scenarios. As we would expect, the differential impact of the USE scenarios is much less for these countries, because they are, for the most part, already very close to universal upper secondary education. However, even for them, we do see differential impacts in our forecasts. For example, in 2050, GDP per capita in the high-income group is forecast to be 63.4

thousand 2011 US dollars, while in USE2030 it is forecast at 67.0 thousand dollars (and 66.5 in USEAbR).

Upper-middle-income countries	2015	2030 Forecasts			2050 Foreasts		
	Estimate	Base Case	USE 2030	USEAbR	Base Case	USE 2030	USEAbR
EDUCATION OUTCOMES							
Primary completion rate	108.8	102.8	103.1	103.2	100.3	100.5	103.2
Lower secondary completion rate	85.2	93.2	100.7	99.3	95.5	100.0	99.9
Upper secondary transition rate	97.6	97.9	100.0	98.3	98.2	100.0	98.0
Average years of education, population 15-24	9.5	9.9	10.2	10.2	10.2	10.6	10.5
Average years of education, population 20-29	9.7	11.0	11.5	11.5	11.9	12.8	12.4
Average years of education, population 15 and older	8.6	9.6	9.8	9.8	10.9	11.5	11.3
Average years of education, population 25 and older	8.4	9.5	9.7	9.6	11.0	11.5	11.3
Gender parity index, population 15-24	1.03	1.04	1.03	1.02	1.04	1.03	1.02
Gender parity index, population 15 and older	0.92	0.95	0.95	0.95	0.99	0.97	0.97
Expected years of education, entering cohort	13.5	13.9	14.5	14.3	14.5	15.0	14.7
ECONOMIC OUTCOMES							
GDP growth rate	3.94	4.66	4.75	4.74	2.26	2.42	2.39
GDP at MER (trillion 2011 USD)	19.10	38.38	38.64	38.62	74.94	77.38	76.82
GDP per capita at PPP (thousand 2011 USD)	13.85	21.29	21.39	21.38	34.06	35.02	34.78
Poverty rate (% of pop below $3.10 a day)	14.6	8.5	8.4	8.4	4.7	4.2	4.3
Extreme poverty (% of pop below $1.90 a day)	4.9	3.2	3.1	3.1	1.8	1.6	1.6
HEALTH OUTCOMES							
Life expectancy (years at birth)	75.0	77.5	77.6	77.6	80.6	80.8	80.7
Infant mortality (deaths per 1,000 births)	14.8	10.2	10.0	10.1	6.8	6.2	6.4
Diarrheal infections (million years-of-life-lost)	6.4	3.8	3.6	3.7	1.6	1.1	1.2
POPULATION OUTCOMES							
Fertility rate	1.83	1.81	1.80	1.80	1.81	1.79	1.80
Population growth rate (annual)	0.74	0.23	0.23	0.23	0.15	0.16	0.16
Population size (millions)	2,390	2,566	2,566	2,566	2,597	2,594	2,594
Population under 5 years of age (% of total pop)	7.3	5.6	5.6	5.6	5.3	5.2	5.3
SUMMARY DEVELOPMENT IMPACT							
Human Development Index	0.751	0.806	0.813	0.811	0.868	0.884	0.878

Table 3.6 Forecasts of USE2030 and USEAbR outcomes for upper-middle-income countries

HIgh-income countries	2015	2030 Forecasts			2050 Forecasts		
	Estimate	Base Case	USE 2030	USEAbR	Base Case	USE 2030	USEAbR
EDUCATION OUTCOMES							
Primary completion rate	106.6	104.5	104.5	104.5	100.4	100.7	100.7
Lower secondary completion rate	86.3	90.6	101.0	99.9	96.3	100.0	99.2
Upper secondary transition rate	98.0	98.1	100.0	98.9	98.8	100.0	97.7
Average years of education, population 15-24	11.2	11.3	11.8	11.8	11.6	12.0	11.8
Average years of education, population 20-29	12.7	13.1	14.0	13.9	13.8	14.7	14.5
Average years of education, population 15 and older	11.5	12.2	12.4	12.4	13.1	13.6	13.5
Average years of education, population 25 and older	11.5	12.2	12.4	12.4	13.2	13.8	13.6
Gender parity index, population 15-24	1.02	1.04	1.02	1.01	1.04	1.01	1.00
Gender parity index, population 15 and older	1.00	1.02	1.01	1.01	1.04	1.01	1.01
Expected years of education, entering cohort	16.1	15.8	16.7	16.5	15.8	16.4	16.2
ECONOMIC OUTCOMES							
GDP growth rate	1.66	1.62	1.80	1.78	1.20	1.42	1.39
GDP at MER (trillion 2011 USD)	54.35	70.72	71.69	71.62	92.79	98.19	97.54
GDP per capita at PPP (thousand 2011 USD)	38.99	48.51	49.17	49.12	63.39	66.95	66.53
Poverty rate (% of pop below $3.10 a day)	0.5	0.6	0.6	0.6	0.7	0.6	0.6
Extreme poverty (% of pop below $1.90 a day)	0.3	0.4	0.4	0.4	0.4	0.4	0.4
HEALTH OUTCOMES							
Life expectancy (years at birth)	79.6	81.3	81.4	81.4	83.5	83.7	83.7
Infant mortality (deaths per 1,000 births)	5.2	3.9	3.8	3.9	2.8	2.6	2.6
Diarrheal infections (years-of-life-lost)	0.7	0.6	0.6	0.6	0.5	0.4	0.4
POPULATION OUTCOMES							
Fertility rate	1.74	1.74	1.74	1.74	1.78	1.78	1.78
Population growth rate	0.48	0.16	0.16	0.16	0.08	0.07	0.07
Population size (millions)	1,399	1,462	1,462	1,462	1,469	1,470	1,470
Population under 5 years of age (% of total pop)	5.8	5.1	5.1	5.1	5.0	5.0	5.0
SUMMARY DEVELOPMENT IMPACT							
Human Development Index	0.892	0.919	0.930	0.927	0.955	0.972	0.968

Table 3.7 Forecasts of USE2030 and USEAbR outcomes for high-income countries

3.6.3 Education with other SDGs

We noted in the opening of this paper that the Sustainable Development Goals (SDGs), adopted by the United Nations General Assembly in September 2015, have set extremely ambitious targets across a broad array of development goals for the period from 2015-2030. Together, there are 17 goals (of which education is one) and 100 indicators, many with specific, measurable targets (of which universal upper secondary education by 2030 is one).

Hopefully, throughout our analysis of education's impacts we have demonstrated the close connection that education has to human development and the ability of societies to achieve sustainable futures. Through developing personal capabilities, it enhances the opportunities for individuals and provides the foundation for a knowledge-based society. It increases well-being through economic growth (recall its impact on GDP per capita, for example) and the linkages from that growth to other development impacts (for example, health, infrastructure, and back again in positive feedback loops from those to both GDP per capita and education as a result of advance in those variables over time).

As part of our background work for this project, we considered not only universal secondary education, but also three other foundational elements of sustainable development: fertility reduction; universal access to safe water and improved sanitation; and improved governance. We developed goal scenarios within the IFs model for them, and compared the impacts of each of them to those of USE2030. We also looked at their combined impacts, first without USE2030 and then including it.

What did we find? First, we found that each individual scenario, not surprisingly, resulted in faster attainment of the single goal to which its intervention was directed—the fertility reduction scenario led to replacement rate fertility sooner than the other scenarios, and the water and sanitation scenario advanced access to safe water and sanitation most rapidly.

The more interesting results came from looking at the scenarios in combination. For the key development variables we analyzed (GDP per capita, poverty reduction, life expectancy, infant mortality reduction, and the Human Development Index), the combined scenarios enhanced the development outcomes, and sometimes quite dramatically, over the single interventions. We looked first at the combined alternative scenarios without education. In every instance, the outcomes were enhanced when education was added to the combination.[19] Rather than being competitive with each other, the scenarios were complementary and even synergistic, by providing additional impetus to the positive feedback loops of the larger development process. For instance, GDP per capita of low-income countries in 2050 reaches about $4,000 in the Base Case and about $5,000 in USE2030. Each of the other SDG-goal seeking scenarios individually also raises it above the Base Case levels, and together but without education they raise it by a factor of about 2.5. Notably, the combined scenario that includes USE2030 raises GDP per capita by a factor of about 3.5.

In conclusion, education's connections to development and well-being are both broad and foundational. Obviously, education cannot alone accomplish the full SDG agenda, but with support it can be not just a partner but a powerful leader in that effort.

3.7 Insights and Recurring Themes

Given our analysis, what can we say about the broad development implications of the pursuit of USE? We have learned a number of things. Throughout this report, we have repeatedly observed patterns associated with pursuit of a push to universal upper secondary education (see again Tables 3.4-3.7). These patterns are:

- USE has a positive impact, and sometimes a very large impact, across a wide range of variables associated with human and societal well-being

[19] Further information about the alternative SDG scenarios and analysis of their results, both singly and in combination with the USE2030 scenario, are available on request.

- The magnitude of USE impact is greatest for the low-income countries which, as a group, currently have the lowest education participation rates and therefore the most to gain via the forward linkages from accelerated expansion of secondary education

- The lower-middle-income countries show lower percentage gains from the USE scenario compared to the Base Case because their current enrollment rates are higher and they have less distance to cover in the intervening years to 2030. Two factors are at play here:

    - Lower-middle-income countries have already realized some of the benefits of expanding secondary education even though they are still far from universal participation

    - Because lower-middle income countries are making quite rapid progress in expanding secondary participation, the Base Case itself captures many of the positive forward linkage impacts of their continuing expansion

- Even though countries in the lower-middle-income group experience, on average, smaller percentage gains in impacts from the USE2030 scenario, their combined population (roughly four and a half times that of the low-income countries) means that even quite small percentage changes translate into appreciable impacts on an absolute scale

- The upper-middle-income countries and even the high-income countries also benefit from USE2030

- Whether we're looking at the Base Case or at the USE2030 scenario, there is an inevitable delay between the investment in education and the full realization of many, if not most, of its benefits across society:

    - It takes time for higher participation rates among today's youth to translate to significantly higher average years of education into even the middle-age groups of a society

    - It also takes time for many of the relatively more-immediate effects to be fully reflected in the societal conditions they in turn affect—for example, for reductions in fertility rates to translate to reduced population size

    - We saw in our analyses that some key impacts of targeted education expansion that begins in 2015 are still increasing in magnitude in

2050, 2060, and even beyond, via long-term virtuous feedback loops that increased years of education accelerate.

    - Because of education's often delayed and then accelerating impacts over time, the assessment of the consequences of education's advance, whether in the Base Case or in the USE scenario, needs to look a considerable number of years into the future.

- The starting points of many countries, lower-middle-income ones as well as low-income ones, are too low for them to realistically reach universal secondary education by 2030. Our analysis of costs and finances in Section 4 will reinforce this point. The USEAbR scenario, focused on aggressive but reasonable rates of expansion, is a more realistic yet still very ambitious approach—and, by 2050, it results in development outcomes that are very close to those of the USE2030 scenario.

- Focus on the advance of education is critical to accelerating human and socioeconomic development. Although the world will not meet the broad range of SDGs through attention to education alone (or, indeed, to any single intervention), education is, and will continue to be, foundational to that effort. The contributions it can make run both wide and deep.

We conclude this listing of insights and themes with an example of the delayed but accelerating and extraordinarily significant impact of USE2030. Over the USE ramp-up period (2015 to 2030), average low-income country GDP per capita is a relatively modest 4.1 percent greater in the USE2030 scenario than with the slower secondary expansion in our Base Case. Then, however, over the 20 years after ramp-up is complete (2030 to 2050), the average difference in GDP per capita climbs to a very remarkable 37.1 percent. In only 10 more years, by 2060, the difference rises even more sharply to 60.0 percent. The next section will provide more information on these strictly economic returns to education, even without monetizing the improvements in human well-being that accompany such returns (e.g., greater health, access to safe water and improved sanitation, and of course more education itself).

Tables 3.4-3.7 and other tables and figures throughout this section have provided basic information on the impacts of the USE2030 and USEAbR scenarios. We are also submitting extended Excel files with this report, the summary pages of which add 2020 and 2040 to the years shown in Tables 3.4-3.7. In fact, it is possible for the user to drill down to the database behind the summary sheets to view values for all years from 2015 through 2050. Further, the Excel files include a drop down menu that can be used to populate the summary spreadsheet with individual country values.

4 USE2030: Costs, Returns, and Financing

This section considers the cost of USE2030 relative to the Base Case; analyzes the economic return, in the form of GDP, that investment in USE2030 would generate; and then proceeds to explore various sources of possible funding for the increments of such investment relative to the Base Case.

4.1 USE2030 Costs and Economic Returns via Higher GDP

As Section 3 has made clear, education brings a great many benefits beyond higher GDP, including improved health and extended longevity. Rather than attempting monetization of those, we focus here only on GDP. Tables 4.1 and 4.2 provide the costs of the USE2030 scenario and the purely monetary return from higher GDP levels, respectively.

The first table shows annual and cumulative education costs[20] in the two scenarios and the difference between them. Through the year 2030, USE2030 would add a total of $237 billion to the anticipated cumulative education spending of the Base Case in low-income countries, and nearly $1.5 trillion in lower-middle-income countries. Those cumulative sums each grow exponentially and by about an order of magnitude by 2050, in significant part because of ongoing GDP growth. The investment in USE2030 would be very substantial.

[20] The next sub-section will elaborate per-student costs and enrollment by education level as the foundation of the calculation of total costs.

Low-income countries: Education costs (billion 2011 dollars)

	Annual			Cumulative		
Year	Base	USE2030	Difference	Base	USE2030	Difference
2015	18	18	0	35	35	0
2020	26	31	5	149	164	15
2025	34	52	18	304	378	74
2030	44	89	45	504	740	237
2035	58	135	77	764	1,325	561
2040	78	186	108	1,113	2,148	1,035
2045	105	252	147	1,583	3,272	1,689
2050	135	318	183	2,197	4,730	2,533

Lower-middle-income countries: Education costs (billion 2011 dollars)

	Annual			Cumulative		
Year	Base	USE2030	Difference	Base	USE2030	Difference
2015	266	268	2	516	518	2
2020	332	376	44	2,033	2,157	124
2025	434	550	117	3,978	4,531	553
2030	581	815	234	6,572	8,047	1,475
2035	766	1,107	341	10,011	12,995	2,984
2040	1,012	1,440	428	14,558	19,503	4,945
2045	1,300	1,825	525	20,472	27,844	7,372
2050	1,606	2,246	640	27,883	38,217	10,334

Table 4.1 Comparison of education costs in Base Case and USE2030 scenarios

Table 4.2 shows annual GDP over time (as discussed in Section 3.2) as well as cumulative totals across time. Comparison of the last columns in the table with the last columns of Table 4.1 provides an initial picture of the relative costs and GDP benefits of USE2030. While neither country grouping gains more GDP by 2030 than USE2030 would cost, each gains 2.5-3 times as much by 2050.

Low-income countries: Gross Domestic Product (billion 2011 dollars)

	Annual			Cumulative		
Year	Base	USE2030	Difference	Base	USE2030	Difference
2015	395	395	0	772	772	0
2020	505	505	0	3,043	3,043	0
2025	648	654	6	5,981	5,994	13
2030	849	880	31	9,798	9,905	107
2035	1,132	1,231	99	14,854	15,298	444
2040	1,532	1,772	240	21,658	22,986	1,328
2045	2,078	2,559	481	30,897	34,103	3,206
2050	2,759	3,617	858	43,265	49,953	6,688

Lower-middle-income countries: Gross Domestic Product (billion 2011 dollars)

	Annual			Cumulative		
Year	Base	USE2030	Difference	Base	USE2030	Difference
2015	6,226	6,226	0	12,147	12,147	0
2020	8,358	8,358	0	49,288	49,288	0
2025	11,033	11,084	51	98,927	99,039	112
2030	14,530	14,753	223	164,189	165,013	824
2035	18,986	19,564	578	249,778	252,697	2,919
2040	24,578	25,814	1,236	361,010	368,644	7,634
2045	31,251	33,588	2,337	503,590	520,504	16,914
2050	38,546	42,547	4,001	681,539	714,890	33,351

Table 4.2 Comparison of GDP in Base Case and USE2030 Scenarios

Table 4.3 extends the cost-and-return analysis. It shows the difference in the cumulative sums of education costs and GDP from Tables 4.1 and 4.2. The third column indicates that the return on educational investment would become positive by 2040 for each country grouping.

This delay in GDP return on education investment has another important implication for analysis of return on investment. It is common in cost-benefit analysis, when either costs (as in the impact of climate change on the economy) or benefits (as in this instance) are delayed relative to the other or ongoing across time, to apply an annual discount rate to both. There is much controversy with respect to appropriate rates to use to discount the value of future investments or returns. That has been true, for instance, with respect to analysis of investments today to mitigate the costs of future global warming. For instance, the Stern report (Stern 2007) drew criticism for using a discount rate of 1.4 percent for estimated future costs of warming rather than a more commonly used rate such as 3 percent (roughly the rate of real global GDP growth over long historical periods).[21]

[21] Figure 2.1 showed, however, long-term global economic forecasts from IIASA and the OECD as well as IFs that trend downward from near 3 percent to 2 percent or below by mid-century (in IFs 7.21 the value in the Base Case falls to 1.3 percent by 2100). Thus the Stern report value is not so unreasonable and 3 percent may provide conservative estimates of net return.

Table 4.3 therefore also shows the pattern of net return with discounting of both incremental education costs and incremental GDP, and it uses a 3 percent discount rate that compounds over time. Because the costs are relatively near-term (more on this below), and the GDP benefits accrue with a lag but for a long time into the future, the benefits in particular have lower value in such analysis, and the net returns, while still positive by 2040, are considerably lower. Yet, because the costs relative to the Base Case diminish over time and the GDP benefit not only persists but grows, the cumulative stream of increase in net return grows sharply through 2050 and beyond. Even between 2050 and 2060 the discounted net return for low-income countries grows from $1.6 trillion to $5.4 trillion and that for low-middle-income countries grows from $8.9 trillion to $25.9 trillion, veritable explosions of net benefit.

Low-income countries: Cumulative Education Costs and GDP Rate of Return Analysis (billion 2011 dollars)

	USE2030-Base Case (No Discounting)			USE2030-Base Case (3 Percent Discounting)		
Year	Cost Differences	GDP Differences	Net return	Cost Differences	GDP Differences	Net return
2015	0	0	0	0.251	0	0
2020	15	0	-15	13.43	0.13	-13
2025	74	13	-61	58.15	9.971	-48
2030	237	107	-130	164.3	70.83	-93
2035	561	444	-117	348.4	260.7	-88
2040	1,035	1,328	293	580.7	692	111
2045	1,689	3,206	1,517	858	1,483	625
2050	2,533	6,688	4,155	1,166	2,750	1,584

Lower-middile-income countries: Cumulative Education Costs and GDP Rate of Return Analysis (billion 2011 dollars)

	USE2030-Base Case (No Discounting)			USE2030-Base Case (3 Percent Discounting)		
Year	Cost Differences	GDP Differences	Net return	Cost Differences	GDP Differences	Net return
2015	2	0	-2	2	0	-2
2020	124	0	-124	108	0	-108
2025	553	112	-441	433	83	-350
2030	1,475	824	-651	1,039	547	-492
2035	2,984	2,919	-65	1,897	1,730	-167
2040	4,945	7,634	2,689	2,860	4,032	1,172
2045	7,372	16,914	9,542	3,888	7,944	4,056
2050	10,334	33,351	23,017	4,971	13,929	8,958

Table 4.3 Rate of return analysis

Note: See tables 4.1 and 4.2 for foundation of cumulative differences in education costs and GDP.

4.2 USE2030 Costs Relative to the Base Case: Time Profile

Given the quite extraordinary eventual GDP returns to investment in education coupled with the delay in the emergence of that net economic benefit, it is critical to determine how to finance the near-to-midterm investment. This subsection lays the foundation for that by providing more information about the costs. The next will turn to the possible financing streams.

When estimating costs, it is common, including in Global Monitoring Reports, to analyze cumulative costs of sociopolitical interventions over time and also to consider the financing of them in terms of cumulative dollar values from a base year. We can and sometimes do use that approach. With an intervention such as

USE2030, however, the time profiles of the costs and the benefits (see again Tables 4.2 and 4.3) are very important. And because the ability to pay costs rises with national income, as generally do the costs themselves (for instance, instructional salaries and thus GDP per capita highly influence the cost of providing education), we find it very useful to think about that time profile relative to the GDP. Thus, we will present most analysis in the rest of this section as percentages of GDP across time.

Figure 4.1 compares the educational costs for low-income and lower-middle-income countries in the Base Case and USE2030 as percentages of GDP—we add the USEAbR scenario discussed previously. We have already seen in Table 4.1 that, in 2015, the annual costs for primary, secondary, and tertiary education in low-income countries were 18 billion in 2011 US dollars. The costs rise in the Base Case to $44 billion in 2030 and $135 billion in 2050. In USE2030, the corresponding numbers are $89 and $318 billion. The cumulative costs from 2015 through 2030 are $504 billion in the Base Case and $740 billion in USE2030 and $2,197 and $4,730 billion through 2050 for the Base Case and USE2030, respectively.

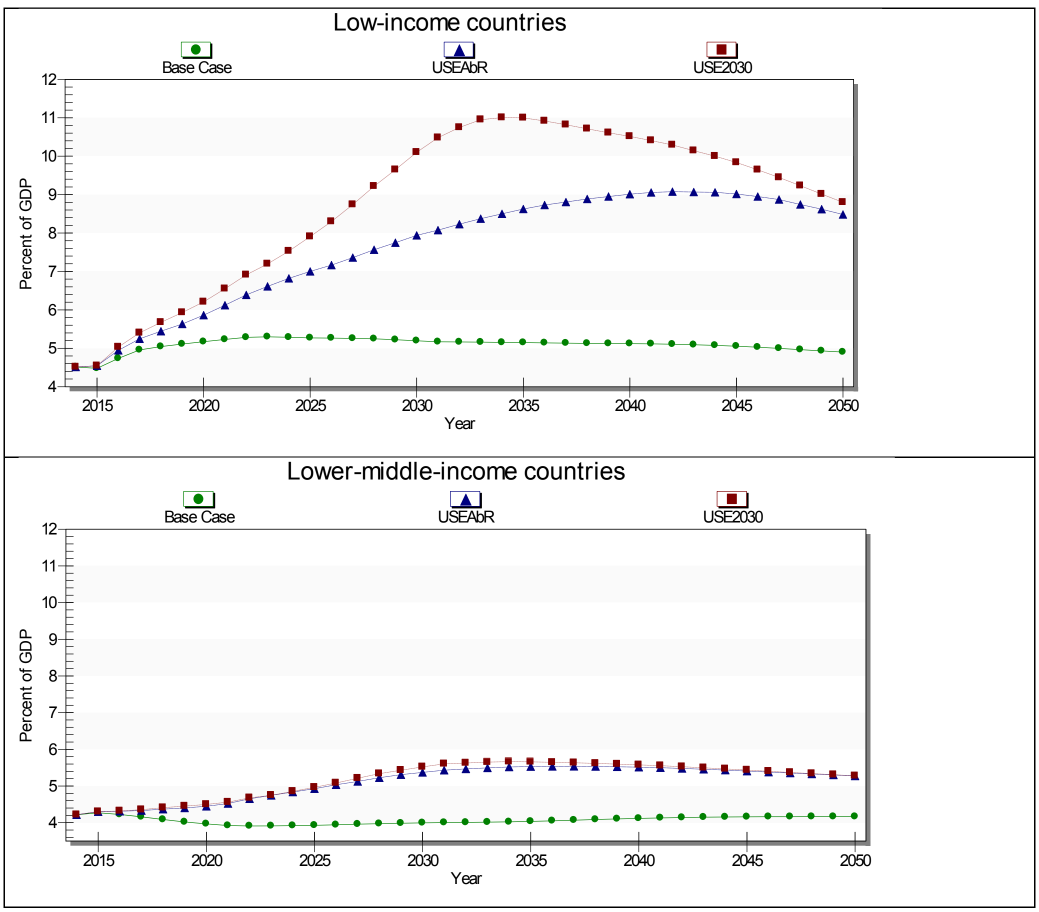

Figure 4.1 Education costs as percent of GDP: Base Case and USE2030

Expressed as a percentage of GDP, low-income country costs were 4.5 percent in 2015. In the Base Case, the total expenditures stay quite close to this, at around 4.5-

5.0 percent, rising and falling a bit over time.[22] In the USE scenario, the costs rise as many more students fill the system, progressively expanding enrollments at primary, lower secondary, and upper secondary levels, and then also at the tertiary level. Therefore, costs as a percentage of GDP in the USE2030 scenario steadily rise to just above 11 percent of GDP in 2034-2035 (a 6.5 percentage point increase over current expenditure levels and 5.9 percentage points above the Base Case in 2034). Costs then decline again as demographic change begins to slow the entrance of students and as tertiary costs per student continue to decline (to be discussed below).

Figure 4.1 uses the same scale of expenditures as a percent of GDP to compare annual education costs in USE2030, USEAbR, and the Base Case for the lower-middle-income countries. The maximum level of expenditures they need (as a group) as a percentage of GDP is 5.7 percent in 2033-35, compared to 4.0 percent in the Base Case for those years and 4.2 percent in 2015.[23] The difference or incremental funding need for this group of countries is thus a maximum of 1.7 percent relative to the Base Case (1.1 percent in 2050), a much more modest figure that the 6.5 percent for low-income countries. In fact, for lower-middle-income countries, there is almost no difference between the costs of the USE2030 and USEAbR scenarios (a maximum of 0.15%).

There is, of course, much country variation. Even in lower-middle-income countries the gap between USE2030 and the Base Case reaches 10.5 percent in Vanuatu, 9.5 percent in Zambia, and more than 6 percent also in Nigeria (a demographic giant), Senegal, and Papua New Guinea. In some of the other demographic giants of the grouping, it would appear to be a more manageable challenge: 0.6 percent in India, 1.1 percent in Indonesia, 1.2 percent in Bangladesh, and 2.1 percent in Egypt. (Nigeria's large gap is in part because of its slow rate of decline in fertility.)

Because of the especially great financial challenges that USE2030 poses for the low-income countries, we focus most of our analysis on them in the rest of this section. That analysis is relevant to the lower-middle-income countries with larger holes to fill for USE2030.

4.2.1 Student numbers and costs across all educational levels

The summary comparisons of costs to this point have provided an overview of the incremental costs of the USE2030 scenario. To understand them better, it is useful

[22] In IFs there is always variation in forecasts over time rather than completely smooth behavior. In Figure 4.1 that variation represents (1) the interaction of many variables, including demographic patterns and saturation of changes in enrollment patterns; and (2) the aggregation into groups of many countries with different underlying patterns.

[23] In the early years of Base Case forecasts, the relatively small upward shift of costs for low-income countries and downward shift for lower-middle-income ones reflect in part the somewhat surprisingly more favorable government fiscal balance positions of the former than the latter in the model's base year.

to drill down to see the details by level of education and across student numbers and costs per student, which we now do for the low-income country group.

Figure 4.2 shows student numbers across all levels in the USE2030 scenario, and Table 4.4 shows the increment of those relative to the Base Case. Student numbers reflect not just enrollment rates, but the length of the respective educational segments, the underlying population numbers for of-age students, and because these are gross numbers, the enrollment of above-age students. The enrollment of above-age students explains the negative numbers in the primary column of Table 4.4: there are more above-age students after 2030 at the primary level in the Base Case than there are in USE2030, under which universal enrollment of of-age students (100 percent net enrollment) is attained well before that period.

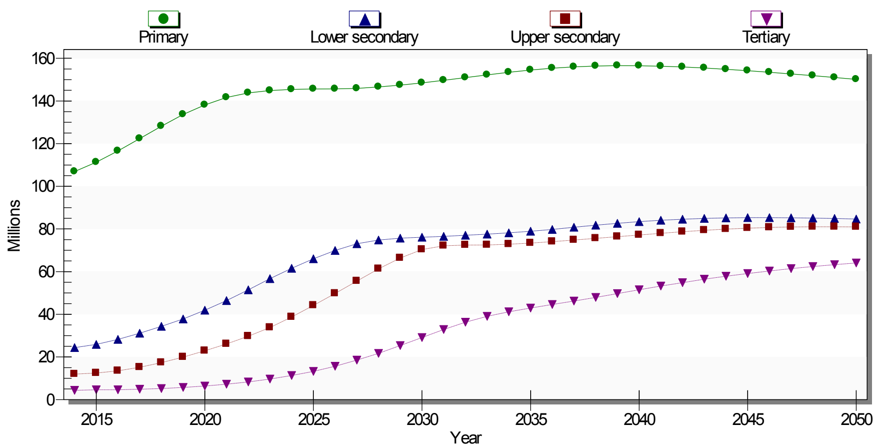

Figure 4.2 Total student numbers, USE2030, low-income countries
Note: Gross enrollments

Year	Primary	Lower secondary	Upper secondary	Tertiary	All levels
2015	1.30	0.36	0.12	0.00	1.78
2020	10.76	6.74	4.29	0.55	22.34
2025	15.16	23.38	18.53	4.26	61.33
2030	8.66	31.14	42.19	15.54	97.54
2035	3.45	27.37	42.45	25.90	99.17
2040	-2.73	25.11	41.59	30.17	94.14
2045	-11.17	21.80	40.32	32.63	83.58
2050	-18.99	16.39	36.64	32.67	66.72

Table 4.4 Incremental student numbers (millions) in USE2030 relative to the Base Case, low-income countries

In addition to student numbers, costs of education depend on the expenditure per student. Figure 4.3 shows per-student expenditures as a percentage of GDP per capita in USE2030. Those per-student expenditures typically rise across levels of education. Both the 2015 estimate, rooted in data, and the forecasts for subsequent years show an especially big step-up from the upper secondary to the tertiary level.

Facilities and teaching personnel at the tertiary level are typically scarce and especially expensive in low-income countries. Despite the very high starting value, our forecast is for very substantial decline (more than 50 percent for low-income countries) in tertiary per student costs over the period with rising GDP per capita, and implicitly with rising tertiary enrollment rates and ability to serve those students.

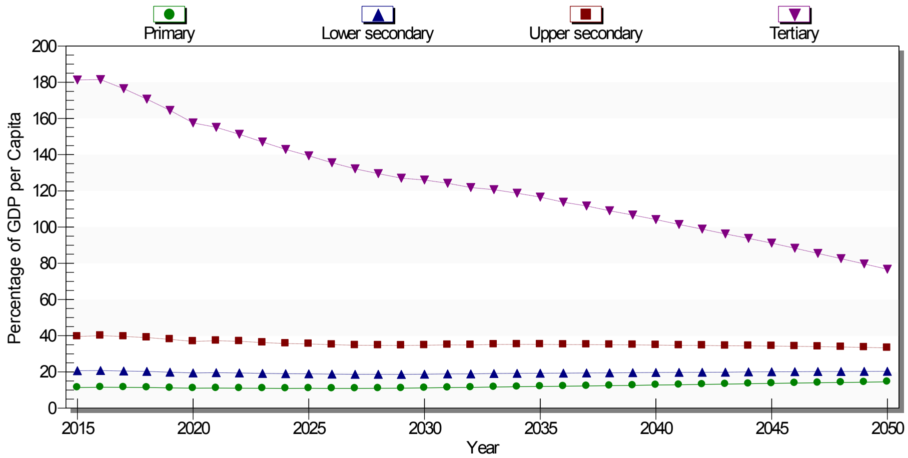

Figure 4.3 Per student education spending as percent of GDP per capita, USE2030, low-income countries
Source: IFs version 7.20

For reference, Table 4.5 shows the ratio of costs per student relative to GDP per capita in the USE scenario as a ratio of those in the Base Case. The overall pattern is of relatively higher costs per student in USE2030, moving gradually up to 12-18 percent above the Base Case rate. Why is this? As Section 2 explained, the IFs system is a simulation, not an optimization tool. If more funding flows to education in any scenario relative to the Base Case, much or most of this can go to supporting increased enrollments. But it is nearly inevitable, if only because of the scarcity of supporting resources including teachers, that costs per student will also rise and the algorithms of IFs reflect that. Moreover, the higher GDPs per capita of the USE2030 scenario would in any case tend to push up the spending per student as a percentage of GDP at the lower levels of education, because those are higher in countries with higher incomes; again, algorithmic logic in IFs reflects that.

Year	Primary	Lower secondary	Upper secondary	Tertiary
2015	1.00	1.01	1.01	1.01
2020	1.06	1.06	1.06	1.06
2025	1.05	1.05	1.05	1.07
2030	1.07	1.07	1.07	1.09
2035	1.12	1.12	1.13	1.17
2040	1.14	1.13	1.13	1.18
2045	1.16	1.14	1.13	1.19
2050	1.17	1.14	1.12	1.18

Table 4.5 Ratio of spending per student as percent of GDP: USE2030 relative to the Base Case, low-income countries

The student numbers and costs per student reviewed above for the Base Case and the USE2030 scenario are the foundation for our calculation of total costs. Table 4.6 shows those as a percent of GDP in the USE scenario, and Table 4.7 shows the increment (again as percent of GDP) relative to the Base Case. (See also Appendix 2 for full student and cost trajectories in the Base Case and USE2030 scenario.)

Year	Primary	Lower secondary	Upper secondary	Tertiary	All levels
2015	1.84	0.80	0.71	1.19	4.54
2020	2.26	1.24	1.24	1.46	6.21
2025	2.04	1.63	1.94	2.30	7.91
2030	1.86	1.63	2.64	3.98	10.10
2035	1.88	1.58	2.54	5.01	11.00
2040	1.82	1.54	2.37	4.79	10.52
2045	1.75	1.47	2.23	4.39	9.84
2050	1.67	1.37	2.04	3.72	8.80

Table 4.6 Education costs as percent of GDP, USE2030, low-income countries

Year	Primary	Lower secondary	Upper secondary	Tertiary	All levels
2015	0.03	0.02	0.01	0.01	0.07
2020	0.29	0.26	0.29	0.20	1.04
2025	0.30	0.63	0.86	0.84	2.64
2030	0.23	0.73	1.65	2.29	4.91
2035	0.26	0.67	1.60	3.32	5.85
2040	0.23	0.60	1.42	3.14	5.39
2045	0.18	0.54	1.28	2.78	4.78
2050	0.13	0.44	1.09	2.24	3.90

Table 4.7 Incremental education costs as percent of GDP, USE2030 relative to Base Case, low-income countries

In summary, these calculations provide a foundation for approaching the central question of this section—namely, "How might the costs of USE2030 be covered?" In particular, the calculations help us understand the magnitude of the incremental funding needs relative to our Base Case expectations, which, because they are quite stable as a percentage of GDP, are largely equivalent to current spending levels. Because low-income countries are already managing (with some help from foreign aid) to cover educational expenditures at the current level, we will focus on the difference, expressed as a portion of GDP, between current or Base Case expenditures and the USE2030 requirements.

To put it succinctly, the incremental need is basically the last column in Table 4.7 (see also again Figure 4.1). At its maximum, the gap is nearly 6 percent of GDP shortly after 2030.[24] The increment itself is more than what low-income countries (or for that matter any country income grouping) now spend annually on education, or are anticipated to spend at any point in the Base Case, as a percent of GDP. As a 15-year average between 2015 and 2030, the increment is 2.1 percent of GDP, and as a 35-year average between 2015 and 2050, it is 3.8 percent.

Before turning to the various potential sources for that funding, we should address one particular uncertainty about the size of the increment itself, namely the cost of tertiary education in the USE2030 scenario. In Table 4.7 above we saw that the single biggest different in USE2030 relative to the Base Case is the spending on tertiary education, shown there to reach nearly 3.3 percent of GDP more than in the Base Case.

How comfortable do we feel about that number? We have seen above that tertiary costs per student relative to GDP per capita are much higher than those for primary and secondary students in both the Base Case and the USE2030 scenario. Thus, if USE2030 assumes more tertiary students than does the Base Case, that is a potentially very important driver of total costs of the USE scenario. We explore this issue below before turning to the larger question of financing USE2030.

4.2.2 Uncertainty concerning tertiary student numbers and costs

There are at least three different ways of thinking about the potential tertiary enrollment level in a USE2030 scenario:

- One is what we might call a "natural push," meaning that there is both a logical and an observed tendency for higher secondary completion to lead to higher tertiary enrollment rates

[24] Why does the expenditure difference peak after 2030 rather than before 2030 or in that year? It is because the attainment of universal secondary enrollment pushes up the tertiary enrollments that we have seen to be very expensive per student. Section 4.2.2 further explores this and also considers alternative futures with slower growth at the tertiary level.

- Another possibility is restricted growth, meaning that the 2015 enrollment rates would be maintained throughout the period, resulting in no increase in tertiary enrollment

- The final possibility is a mixed case, somewhere between the extremes of the restricted growth and natural push levels. One such mixed case could be tertiary enrollment growth at the Base Case rate.

The USE2030 scenario has the natural push option built in. What does that imply, and how reasonable is it? In the Base Case, the 2015 tertiary enrollment rate for low-income countries grows from just under 8 percent in 2015 to 15 percent and 26 percent in 2030 and 2050, respectively. In the USE2030 scenario, enrollment rates grow to 32.8 and 53.7 percent in 2030 and 2050. In short, USE2030 pushes tertiary enrollment rates up by roughly a factor of 2 relative to the Base Case.

Are these numbers reasonable as a reflection of natural push? One way to answer that question is to ask what tertiary enrollment rates are in countries that have already reached universal secondary education. Figure 4.4 shows the tertiary enrollment rate as a function of the upper secondary graduation rate across all countries in 2014. Countries with secondary graduation rates above 80 percent tend to have tertiary enrollment rates above 50 percent. Thus, if low-income countries reached universal transition to upper secondary by 2030 with subsequent 100 percent survival, a climb toward 54 percent tertiary enrollment by 2050 seems quite reasonable.

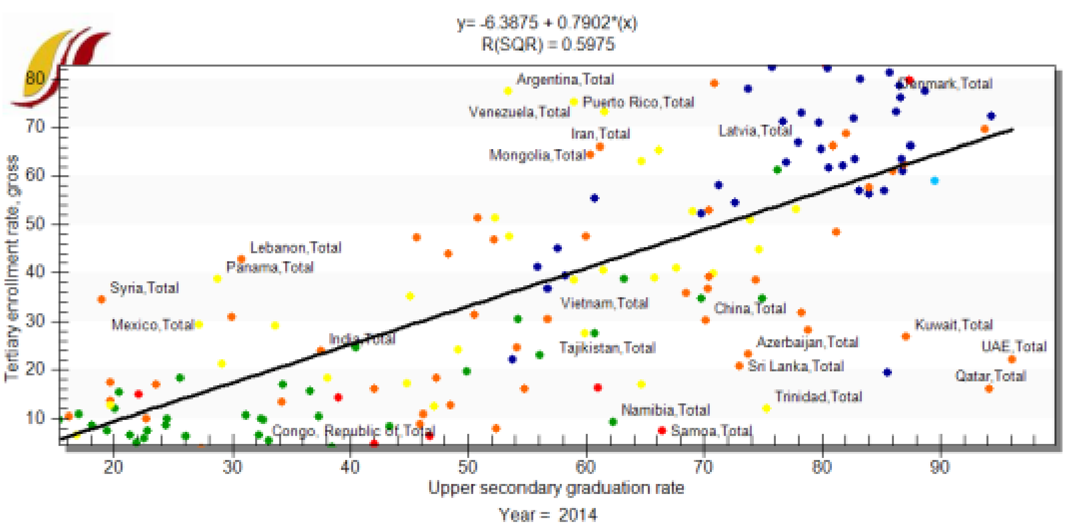

Figure 4.4 Cross-sectional relationship in 2014 of tertiary enrollment rate as function of secondary graduation rate

Because the tertiary expenditures per student are so high, the sensitivity of USE2030 analysis to them, as well as to tertiary student numbers, is large. Figure 4.5 shows a cross-sectional analysis of data that generates a pattern of tertiary expenditures per student very much like that of the USE forecast in Figure 4.3. The

GDP per capita at MER of low-income countries rises in the USE2030 scenario from $619 in 2015 to $2,822 in 2050 ($2011), and the GDP per capita at PPP rises from $1,579 to $4,906. These rises in GDPPC are in the range where the steepest decline is seen in tertiary per student expenditures and reinforce the pattern of Figure 4.3, but the importance of outliers in determining the height and slope of the curve in Figure 4.5 inevitably somewhat weakens our confidence about forecasts based on the relationship.

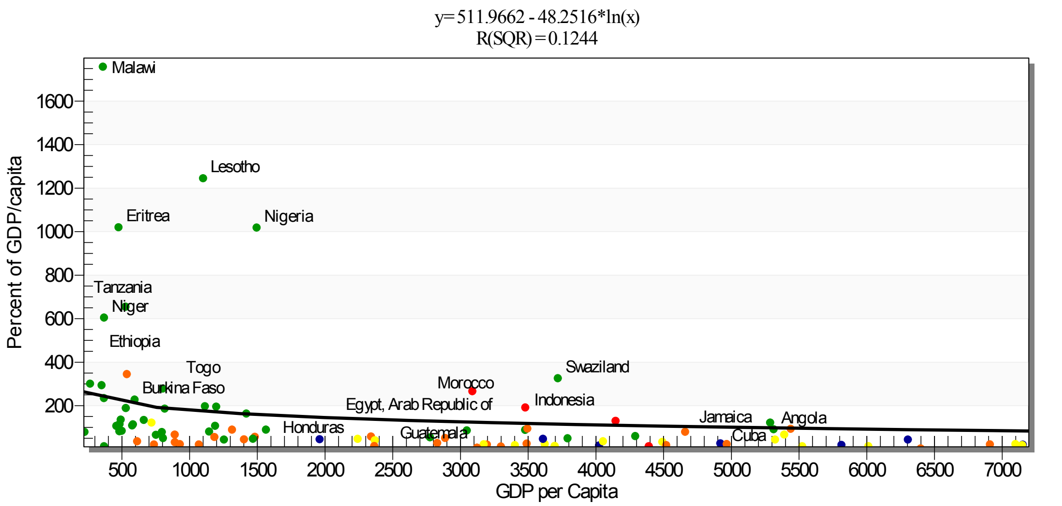

Figure 4.5 Per student tertiary education spending as percent of GDPPC, cross-sectional data analysis

In summary, we will carry the natural push tertiary enrollment growth pattern and the tertiary cost level and rate of decline that we have shown for the USE2030 scenario into our analysis of funding sources. We now know, however, the importance of those assumptions. For example, Table 4.7 has shown us that constraints on tertiary growth to Base Case levels (without going to restrictions to current levels) have the potential of reducing incremental spending needs by as much as 3.3 percent of GDP in the peak years of USE2030.

4.3 Funding the Incremental Costs of USE2030

Recall that the maximum gap between the costs of the Base Case and USE2030 is nearly 6 percent of GDP from 2034 to 2038; the average annual gap is 2.1 percent of GDP between 2015 and 2030, and 3.8 percent for the full period between 2015 and 2050.[25] How, using domestic and/or external sources, might funds be mobilized to close such gaps?

We will explore multiple potential streams of financing that in various combinations could cover incremental USE2030 costs. None are without potentially complicating trade-offs.

[25] In 2050, the annual difference is 3.9 percent and it declines rapidly to below 1 percent by 2073.

Internal sources could include holding costs per student to Base Case levels (relative to GDP per capita); constraining tertiary enrollment growth; shifting funds to education from other categories of government expenditure; moving some of the cost from public to private pockets; and increasing government revenues as a share of GDP. External sources could include some combination of additional support from governments, intergovernmental organizations, and nongovernmental organizations.

We do not try to develop a recommendation for a mixture of these sources. Instead, we look across them to explore the potential magnitude of each, with an eye to understanding whether the sources even together would be adequate and how they compare individually. Table 4.8 summarizes the overall picture that the subsequent text will elaborate. The peak years (see Figure 4.1) of incremental costs relative to the Base Case differ in USE2030 (2034) and USEAbR (2044). In estimating the potential contributions to the gaps we rather arbitrarily look at 2035 for approximate estimates of potential savings of those incremental costs or contributions to meeting them. As we shall explain below, we do not anticipate a net positive contribution from Overseas Development Assistance (ODA) relative to 2015 levels, but rather an additional complication in terms of its availability to meet the financial needs.

	Percent of GDP
Needs Relative to Base Case	
USE2030 needs (peak year)	5.9 (2034)
USEAbR needs (peak year)	4.0 (2044)
Potential Contribution to USE Needs (in 2035)	
Holding costs/student to Base Case levels	1.6
Restricting/constraining tertiary rates (to 2015 levels; to Base Case levels)	4.1; 3.0
Changed/more effective use of domestic expenditures	2.0
ODA relative to 2015 contributions (as expected; if increased)	-1.0; -0.16
Domestic revenues to 30 percent of GDP (if dedicated; if proportional)	15.0; 2.5

Table 4.8 USE2030 and USEAbR costs relative to Base Case levels and possible streams of financial contribution to meeting them, low-income countries
Note: The sources of potential contribution to USE needs in 2035 are discussed in Sections 4.3.1, 4.3.2, 4.3.3, 4.3.4, and 4.3.5.

4.3.1 Holding costs per student to Base Case levels

We saw earlier that per student costs relative to GDP per capita rise in the USE2030 scenario relative to the Base Case (Table 4.5). In 2035, these run about 13 percent above the costs of the Base Case and contribute a very significant 1.6 percent of GDP to the extra costs of USE2030 relative to the Base Case.[26] If it were possible not only to hold per student costs to those of the Base Case but to generate still additional efficiency savings that actually lowered those costs below those of the Base Case, such savings would be contributions to USE financing on top of this reduction. We do not show that addition in the table—low-income countries already spend less of GDP per capita on students at lower educational levels than do high-income ones; an argument can be made that low-income countries do need efficiency gains but also need increases in per-student spending to bring up quality of education toward that of high-income countries.

4.3.2 Constraining or restricting tertiary enrollment

With respect to internal sources, we have already seen (Table 4.7) that constraining tertiary enrollment to Base Case levels could provide about 3.3 percent of GDP in 2035, with a general profile over time similar to that of the total incremental spending needs. Thus, tertiary spending is a very significant portion of the incremental costs and potential reduction in them.

We can calculate the extreme case of restricting or freezing tertiary enrollment at its 2015 gross enrollment rate of 7.8 percent. At a 7.8 tertiary enrollment rate in 2035, rather than the USE2030 push gross enrollment rate of 44.8 percent that year, the reduction of tertiary spending would be 4.1 percent of GDP[27], taking the funding gap from 6 percent to 1.9 percent. Making these calculations does not mean that such a restriction would be possible, much less desirable, but what we earlier termed "mixed cases" (e.g., constraining tertiary growth to Base Case rates) could be seriously considered. For example, holding tertiary enrollment in 2035 instead to that year's Base Case level of 17.9 percent would reduce spending by 3.0 percent of GDP.

The downsides of any restrictions on tertiary growth are, however, significant. In particular, as low-income countries become middle-income ones, they will confront the dreaded middle-income trap. Among the best ways to avoid a rapid slow-down in growth, and failure to advance to high-income levels, is via the development of a flexible, entrepreneurial, knowledge-based economy (Eichengreen, Park and Shin 2013; Kanchoochat and Intarakumnerd 2014). That requires tertiary education. Further, the social instability associated with young males without education and advancement opportunity is well-known. Recall too, that in our analysis in Section 3

[26] This represents in 2035 the USE2030 incremental per student cost at each educational level multiplied by total USE2030 costs at each level, summed across levels, and divided by GDP of the Base Case.

[27] The total tertiary costs of USE2030 in 2035 are $62 billion, meaning that the reduction would lower them by $51 billion relative to a GDP of $1,231 billion.

of positive impacts from acceleration to universal secondary education, the higher tertiary enrollment rates of the USE2030 scenario also contributed to the benefits shown.

4.3.3 Alternative use of public outflows

The second potential internal source is shifting funds from other categories of public expenditure. Because low-income-country data on public spending are both sparse and complicated, our confidence is limited with respect to numbers put on actual government revenues and spending patterns. In general, it appears that public revenues of low-income countries from domestic and international sources in combination are about 28 percent of GDP, or about 70 percent of the percentage in high-income countries (our forecast in 2035, however, discussed below, is 20 percent of GDP).

On the domestic expenditure side low-income countries have a low level of transfer payments. Most outlay is direct spending, including education (near 4.5 percent of GDP and 1/6 of total government revenues), infrastructure (roughly 6 percent of GDP), the military and security (about 3 percent), health (about 3 percent), and other categories, including administrative and a small amount of R&D. Many would point to military and security expenditures as a preferred choice for diversion; however, in today's world, leaders of few countries are likely to see the very successful Costa Rican or Japanese models as feasible or palatable. Other choices would almost certainly exacerbate other problems and the pursuit of SDG goals targeted at their amelioration (recall the analysis in Section 3.3.3 of years-of-life lost from diarrheal disease with the partial shift of funds from health spending).

One philosophy in organizational budgeting is that it is always possible to squeeze some fat or waste. That may be particularly true in countries where significant corruption diverts substantial but not easily measurable revenues completely away from social expenditures. If we posit arbitrarily that 10 percent of total government revenues could be recovered or redirected to supplement those already flowing to education, that stream would be an important 2.0 percent of GDP in 2035.

4.3.4 Domestic revenues and ODA supplements

Turning to the potential for raising incremental domestic revenues and/or external funding, there are many interconnections between them, so it is useful to begin looking at them interactively. Table 4.9 provides a summary for low-income countries in the USE2030 scenario, showing us the bubble in education costs in the first column, total government revenues in the second, domestically generated revenues in the third, and inflows of ODA in the fourth, all as percentages of GDP for easier comparability across time.

Year	Education Costs Percent of GDP	Government Revenues (Total) Percent of GDP	Government Revenues (Domestic) Percent of GDP	ODA Percent of GDP
2015	4.54	28.00	15.90	12.10
2020	6.21	25.08	14.61	10.47
2025	7.91	23.22	14.19	9.04
2030	10.10	21.37	13.85	7.52
2035	11.00	19.88	13.81	6.07
2040	10.52	19.09	14.28	4.81
2045	9.84	18.96	15.15	3.81
2050	8.80	19.21	16.15	3.06

Table 4.9 Education costs compared to domestic and international revenues, USE2030, low-income countries
Source: IFs version 7.21

Let us begin with a look at ODA and then return to the interacting issue of domestically-generated revenues. Overall, the foreign aid revenue forecast in Table 4.6 depends on assumptions that:

- the net aid outflow from high-income countries will remain at roughly the current 0.22 percent of their GDP;
- the GDP growth of low-income countries will rise from the current 3.5-4 percent above that of high-income ones to about 5 percent greater in the late 2030s in the Base Case (USE2030 raises that differential by another percent or so);[28] and
- the distribution of aid to recipients will retain the current proportions across countries and, within countries, across target categories.[29]

Unfortunately, official development assistance (ODA) as a percentage of low-income country GDP has been declining. The rate of receipts peaked twice, once in 1994 at 18.2 percent of the GDP of low-income countries, in part due to the influence of post-Cold War enthusiasm, and again in 2003 at 18.8 percent, in part from the influence of support for the Millennium Development Goals. By 2013, ODA had fallen to just above 10 percent of low-income country GDP (there is some significant variation by year).

Two forces put ODA on a path for further decline in coming years, as suggested in Table 4.9. One is that since the turn of the century, low-income countries have experienced GDP growth rates significantly above those of high-income countries,

[28] This assumption of accelerating and very high low-income country growth is open to challenge, of course. It is not unlike the pattern of China in recent decades and what appears to be developing in India. Still, our expectations for low-income growth (see again Section 3) will fall below the SDG-related call for 7 percent annual growth in the Least Developed Countries.
[29] OECD statistical data suggest that foreign aid going directly to education in low-income countries has fallen from about 1 percent of GDP in 2006 (which would be more than 1/5 of total educational spending) to about 0.4 percent of GDP in 2014. The decline again represents the decreasing share that aid receipts constitute as a percentage of GDP. As important an insight is that a small fraction of aid, probably less than 5 percent, is being targeted for education.

changing a long-time pattern of more nearly comparable rates, even as middle-income country growth accelerated. Thus, if aid globally grew with the GDP growth patterns of high-income countries, its share of GDP for recipients would fall. Second, foreign aid transfers as a percent of high-income GDP have actually declined for several decades, reflecting a downward trend in donor dedication to foreign assistance. Unless either the new pattern of low-income country growth reverses, which would be very bad for almost all SDGs, or the pattern and trend of high-income country funds committed for aid reverses, increases in ODA are not likely to fill the funding gap associated with USE2030. In fact, the sad reality is that changes in ODA look less likely to fill the USE spending gap than to make filling it even more complicated.[30]

It is, of course, possible that commitments to the SDGs could potentially elicit at least a temporary increase in ODA as a percentage of donor country GDP. After all, the second target of Goal 17 does call for "Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of ODA/GNI to developing countries…" Based on the forecast values of Table 4.9, doubling the aid donations of donors to 0.44 of their GDP on average would provide more than 5 percent of low-income GDP in the middle of the 2030s at the time of peak need.

What are the implications for resources devoted to education? In the absence of other information, let us assume that all foreign aid goes to government revenues and that it is used proportionately across across all expenditure categories. Because education is about 1/6 of expenditures in low-income countries, a 6 percent reduction of aid receipts as a portion of GDP as foreseen in table 4.9 would imply a reduction in resources for education of 1 percent of GDP. If ODA contributions of high-income countries did rise to 0.44 percent of their GDP and that held decline in low-income-country receipts to 1 percent of GDP, the loss to education would be 1/6 of that or 0.16 percent of GDP.

4.3.5 Domestic revenues increases

Clearly then, the major potential source of incremental funding for USE will not be aid, but will need to be domestically-generated revenues. As we saw in Table 4.9, those are approximately 16 percent of GDP in low-income countries. It is important to note that, while the forecasting of demographics across our horizon is relatively simple and the forecasting of economic size is considerably more complicated, any forecasting of government revenues and expenditures is especially tentative. Nonetheless, we can undertake some estimates of rough magnitude of potential.

With respect to domestic revenues as a percent of GDP net of foreign aid receipts, our forecast in Table 4.9 shows falling values before they rise again to higher levels.

[30] UNESCO (2014: 111) also indicates that ODA for education has been falling and is more likely to decline than rise.

The reason for this is that IFs initialization data show relatively strong overall fiscal positions for the low-income countries (helped perhaps by commodity prices before their collapse and by significant foreign aid inflows)[31] that may weaken pressure for tax increases for some time. Obviously, the need for additional expenditures for education or other goals could quickly reverse that situation.

UNESCO (2014: 111; see also Wils 2015: 6) suggests a target after 2015 of countries spending at least 6 percent of GNP on education, directing 20 percent of public budgets to education.[32] This suggests public budgets at 30 percent of GNP (1/5 of 30 percent generates 6 percent).

Our analysis of recent data suggests that education currently receives about 17 percent of public revenues in low-income countries, not 20, and let us begin by assuming that to continue. If low-income countries raised domestically generated revenues from 15 to 30 percent of GDP, that proportion would generate an additional 2.5 percent of GDP.

Obviously, of course, if domestically generated revenues were to rise to that 30 percent target, more than 20 percent of the incremental domestic revenues could go to education. Directing 40 percent of the 15 percentage point increment to education would provide 6 percent of GDP, the entire incremental need of the USE2030 scenario (all of the newly generated domestic revenues would give education 15 percent more of GDP). And remember that the additional 6 percent of GDP is peak incremental need; the average annual gap is 2.1 percent of GDP between 2015 and 2030, and 3.8 percent for the full period between 2015 and 2050. Theoretically, front-end borrowing could help address the peaking character of incremental spending needs, although bonds for financing long-term educational spending might be a tough sell.

In short, there are combinations of tertiary education growth constraint, cutting waste and corruption, shifting expenditures across categories, mobilizing additional foreign resources, and raising domestic revenues that can meet the financial needs of low-income countries with USE2030. All are possible and all are challenging.

Unfortunately, we must put forward one major further caveat. So far, we have been talking about weighted average values for the low-income countries as a group, and averages are deceiving. The need for additional funds to achieve USE varies quite dramatically across countries in the low-income category. Looking at the year 2035, the incremental need varies from 16.6 percent of GDP in Niger, 10.4 percent in

[31] The surplus of revenues relative to expenditures is questionable. Yet still another part of the explanation is that there is sufficient corruption in low-income countries to account for at least some of the seeming and surprising surplus of revenues relative to expenditures.

[32] UNESCO shows low-income countries directing 4.1 percent of GNP to education from public spending in 2011 (nearly 1 percent less than our figure) and lower-middle-income countries directing 5.1 percent.

Afghanistan, and 10.2 percent in Tanzania to "only" 0.2 percent in Nepal, 1.1 percent in Cambodia, and 2.0 percent in the Gambia.[33] Government revenues as a percent of GDP (net of foreign aid inflow) also vary greatly across low-income countries. In Zimbabwe, they are already in 2015 near 30 percent, leaving limited headroom for rise. Liberia, Mozambique, and Malawi all fall into the 23-27 percent range. At the other extreme, 14 countries are at 15 percent or below, including Niger and Afghanistan, where education-spending increases appear especially needed.

One of the potential advantages of the USEAbR scenario is that it would at least somewhat reduce the peak incremental needs. For Niger those would fall to 6.5 percent and in Tanzania they would drop to 4.4 percent. Yet they would still be an almost assuredly prohibitive 9.5 percent of GDP in Afghanistan—even the USEAbR scenario, defined by rapid rates of progress rather than absolute goals, can still sometimes look out of reach.

4.4 Synopsis and Commentary

For low-income countries especially, but of course also for the lower-middle income group, mobilizing even an additional one percent of GDP for any purpose poses challenges. We have, nonetheless, seen that at least the theoretical possibility exists for mobilizing even the full amounts needed (on average) for low-income countries to achieve USE2030. The problem is always trade-offs.

A potentially significant share of the spending deficit for USE could be raised (actually, extra costs averted) by limiting the growth of per student costs as a portion of GDP per capita to something more like that of our Base Case forecast. Even more cost could be averted by holding tertiary education closer to Base Case levels. The cost especially of the latter would be the loss of potential benefit from education that ultimately will be needed in those countries as they move into and through the middle-income transition. Yet, it remains a potential action course, if only because without the push for universal secondary education by 2030 what we have called the "natural push" into tertiary would not occur.

Additional funds could come from diverting from other expenditures. Taking from needs such as health, infrastructure, or R&D seems very questionable. Unfortunately, corruption levels in these country groups are frequently high, and even the reduction of fund diversion to private pockets could provide an unknown but certainly significant stream of funding.

Additional ODA (and transfers from IGOs and INGOs) is an obvious potential resource, but we have argued that developing countries will almost certainly find that to be a diminishing source of resources. Movement toward the 0.70 percent of donor GDP urged by many over decades now, or to other official targets, is badly

[33] The country grouping calculation can gloss over or potentially average out a great deal of bad data; national figures like these must be considered cautiously.

needed, but is more likely to limit decreases in inflows as percentages of recipient GDPs than to provide increases in them.

Finally, there is the mobilization of additional domestic resources. The current relatively low level of those resources as portions of GDP, and the need for additional spending on other public needs, not just education, makes increasing revenue-raising capacity an attractive key element for financing. Obviously, such a rise would affect taxes, household consumption, poverty, growth and much more. Exploring these additional impacts of higher revenues or alternative scenarios is beyond the scope of the current project.

In closing, if determining the sources of needed incremental education funding is challenging, reiterating the value of doing so is not. We have seen that it may well take 25 years before the rate of return on investment in education turns positive in terms of higher GDP (discounted or not). Thereafter, however, the positive gap that we would expect between the GDP of the USE2030 scenario compared to the Base Case could continue to grow rapidly as far into the future as we can reasonably forecast.

5 Conclusion

As noted at the beginning of this report, its motivation has been exploration of the potential for, and consequences of, pursuing the first target of the new Sustainable Development Goal 4: "By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes."

We have used the International Futures (IFs) integrated multi-issue forecasting system in this analysis, allowing us to break some new ground with respect to analyzing the broader development impact of USE2030, as well as its costs and possible funding. For low-income countries, and to a lesser degree lower-middle-income countries, we have found that:

(1) The consequences of reaching the USE2030 target for broader human and social development are major and widespread across issue areas. Education has, of course, great value in and of itself. Already by 2030, USE could add nearly 1 full year to the average years of education attained by adults in low-income countries, and by 2050, that increment would rise to 2.7 years (1.8 years in lower-middle-income countries). Although there are significant lags in the forward impacts of such advancing education (students must enter the work force and begin to make their marks across the society), by 2050 USE can add 25.0 percent or $980 (2011 USD) to GDP per capita (PPP) of low-income countries and 8.4 percent or $1,200 to that of lower-middle-income countries. And the benefits of USE are much wider than income, including by 2050 adding 2.2 years of life expectancy and saving 120 million people from extreme poverty in low-income countries, and adding 1.7 years of life and saving 81 million from poverty in middle-income countries.

(2) The economic returns to investment in USE2030 solely in terms of GDP increase are very great in the longer run. Although a positive return might not materialize until about 2040, it would grow indefinitely. Even by 2050, the cumulative net discounted return to low-income countries could be $1.6 trillion and for lower-middle income countries (with a much higher base) it could be $5.4 trillion. By 2060, those numbers could balloon to $8.9 and $25.9 trillion. The expenditures on education are a flow; but the education attainments they support are a very long-lasting and self-supporting stock.

(3) Reaching USE requires a phased ramping up across levels of education and time. Thus, the cost of pursuing the USE target rises over time, relative to both current spending and the Base Case trajectory as portions of GDP. The differential peaks in the early to mid-2030s, at nearly 6 percent of GDP for low-income countries on average and 1.7 percent for

lower-middle-income countries. Variation across countries within each set is great. Concerning the payment of those increments, restriction of growth in tertiary enrollment within low-income countries to that of the Base Case, not an insignificant rise, could reduce that net cost by 3.0 percent. Although we did not explore this with modeling, shifting other expenditures to education could almost certainly generate 1-2 percent without significant negative consequences for other social goals, and where substantial corruption exists, its reduction might well generate amounts of that magnitude with no costs. Receipts of Overseas Development Assistance (ODA) as a portion of GDP are unfortunately likely to fall rather than rise, simply because economic growth in developing countries now outstrips that in high-income ones. Yet, doubling ODA from a current average of 0.22 percent of donor GDP could largely prevent such decline in contribution to education. Because low-income country revenues raised domestically are only about 15-16 percent of GDP, even increasing domestic revenues to 20 percent could proportionally generate an additional 1 percent of GDP for education; raising revenues to 30 percent of GDP and directing 20 percent of that to education could generate 3 percent more for education. Challenges and potential trade-offs accompany each potential source of additional revenue.

(4) We also found that aggressive but reasonable variations of the USE2030 scenario generally had scaled-down benefits, but ones with the same general patterns and potentially with much the same broader impact by mid-century.

Where might this research go from here? There are always possibilities for improvement in the quality of any analysis, and models inevitably suffer from limitations due to data and formulation inadequacies. Although the IFs system has evolved and presumably improved over more than three decades, the scale and complexity of it add not just to its utility, but to the possibilities for errors of both omission and commission. In fact, throughout the preparation of this report as a team we have commented on the likelihood that a number of forward linkages are either missing or understated, the inclusion of which would more probably increase rather than diminish the positive impact of the interventions examined.

The SDGs are a complex and very much interrelated set of goals. Each target calls out for analysis of the broad systemic implications of its pursuit. Together, they call out for analysis of broad interaction effects, both trade-offs (often in terms of the cost of implementation, as well as the forward effects of them) and complementarities. That is an analysis we have only begun to explore; we hope to build on the report provided here and extend that analysis in future IFs work.

Appendix A: The Models and Applications of IFs

A.1 The IFs Education Model in Brief

The International Futures education model represents the year-by-year progression of students, by sex, through primary, lower secondary, upper secondary and tertiary levels, with some representation also of vocational education and the portion of tertiary students in science and engineering. Key dynamic elements include student entry (or transition) rates to the various levels and subsequent student persistence or survival year-by-year. The model also dynamically computes costs per student, influenced heavily by GDP per capita. Government spending on education per student and overall (number of students times cost per student) is also a key component and connects the education model to the broader representation in IFs of government finance. The UNESCO Institute for Statistics is the primary source for our historical data on these student flow variables. We look to it and to the World Development Indicators for data on public spending in total and by student.

The student flows through education levels feed the model's representation of education attainment stocks by age and sex, which then overlay on the cohort-component model of population in IFs, so that they are carried forward over time. Data from Barro and Lee (2015), spread across adult ages, initialize those stocks.

For more documentation on the IFs education model and its use, see Irfan 2008; Dickson, Hughes, and Irfan (2010); and Irfan and Margolese-Malin 2012; see also ongoing model documentation on the Pardee Center website (Pardee.du.edu).

A.2 Other Models within the IFs System

Figure A. 2.1 identifies the major models within the International Futures (IFs) system. The Pardee Center web site (http://pardee.du.edu/working-papers) contains working papers with technical documentation of each model.

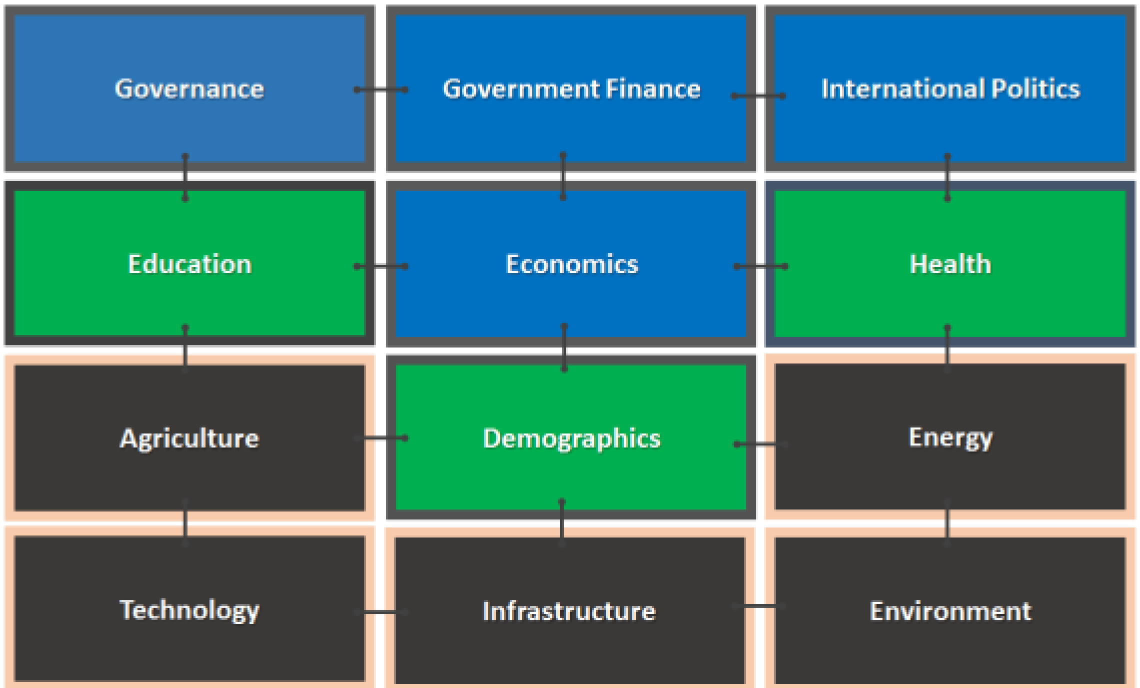

Figure A. 2.1. The models of the International Futures (IFs) forecasting system
Note: Green indicates models in IFs primarily focused on human development, blue represents socio-economic development, and black shows models especially important to sustainable development.

The color coding of Figure A.2.1 corresponds roughly to three sets of issue arenas and questions that the IFs system helps address. The models in green at the center of the diagram are central to the representation of human development. Those in blue link clearly to social structures and change, and those in black link the model to biophysical sustainability. A quick survey of the models other than education (briefly described above) follows:

> The demographic model uses a standard cohort-component representation, portraying demographics in 5-year categories (adequate for most users), but building on underlying 1-year categories to be consistent with its computational time steps. Unlike most demographic forecasting systems, both fertility and mortality are computed endogenously (migration is specified exogenously, currently using forecasts from IIASA[34]). The

[34] As a result of project work connected to the Shared Socio-economic Pathways initiative discussed later the IFs system includes in its database IIASA forecasts on migration and education, Organization for Cooperation and Development and Potsdam Institute for Climate Impact Research forecasts of

availability in the IFs system of both education and health models greatly facilitates such endogenous treatment. Data come from the United Nations Population Division's latest revision updates every two years.

The 6-sector economic model structure is general equilibrium-seeking, in which a Cobb-Douglas formulation drives production and in which multifactor productivity is substantially an endogenous function of human capital, social capital/governance, physical capita (infrastructure and energy), and knowledge capital. Although capital and labor accumulations are very important in long-term forecasting, the formulations around productivity most heavily shape dynamics within the economic model and its interaction with other models. There is also a foundational representation of global technology development and diffusion that facilitates further representation of productivity dynamics and inter-country convergence or lack thereof. A linear expenditure system determines household demand. A social accounting matrix structures flows across sectors and agent categories, assuring full financial flow consistency. Data come heavily from the World Bank and the Global Trade Analysis Project. The project has also built a treatment of the informal economy using data from the International Labor Organization and others.

The IFs global health model represents a hybrid and integrated approach to forecasting health outcomes. It is hybrid because it uses drivers at both distal (i.e., income, education, and technology) and proximate (e.g., risk factors such as smoking rates and undernutrition levels) levels to produce outcomes, and it is integrated because both drivers and outcomes are situated within the greater IFs system, allowing for the incorporation of forward linkages and feedback loops. (The Mathers and Loncar 2006 model of the World Health Organization, upon which IFs built with the support of Mathers, treats only distal drivers.) The IFs hybrid and integrated approach enables users to explore dynamic age, sex, and country-specific health outcomes related to 15 individual and clustered causes of mortality out to the year 2100.

IFs energy and agricultural models are partial equilibrium with a physical basis that is translated to monetary terms for interface with the economic model. The energy model represents resources and reserves on the production side, which differentiates oil, gas, coal, hydroelectric, nuclear, and other renewable sources. The dynamics around the stocks of fossil resources and their use and those around the development of renewable forms are critical. The agricultural model represents land usage on the production side, which differentiates crops, meat and fish. As in the economic model, production-side representations are key to long-term dynamics. Trade in the

GDP, and National Center for Atmospheric Research forecasts of urbanization. The system also includes forecasts on its key variables from many other sources, allowing systematic comparison of those with each other and with the forecasts of IFs.

energy, agricultural, and broader economic models uses a pool approach rather than bilateral flows.

The IFs energy model is driven on the demand side by the size of economies and populations, representing also the continued reduction of energy intensities in most countries. On the supply side, production requires not only resource bases, but also the accumulation of capital stock via investment in competition with other sectors. Trade is responsive to differential cost and price structures across countries. Interventions by the user can represent geopolitically based constraint in the growth of production, as well as decisions to restrain exports. Global prices are normally calculated so as to clear the market, but user interventions can override market prices. Most data are from the International Energy Agency. A recent update of the model added data on, and forecasting of, contributions from unconventional fossil resources (aggregating shale oil and gas, tight oil, coal-bed methane, etc.).

The agricultural model in IFs is similar to the energy model in general structure. Demand is very responsive to population and income levels; assumptions about future meat demand of emerging countries are very important to long-term dynamics. On the supply side, crop yield per hectare is critical. Trade and price equilibration are similar to those in energy. Most data are from the UN Food and Agriculture Organization. The project is now substantially extending its treatment of aquaculture and wild fisheries.

The infrastructure model addresses selected forms for transportation (roads and paved percentage of them), electricity generation and access, water and sanitation, and information and communications technology (land-lines, mobile telephones and broadband connectivity by mobile phone or line). Demand and supply are related through the interaction of financial requirements and availability of private and public funds. Many parameters for setting and pursuing targets of access are available, and data are drawn from many specialized sources such as the International Telecommunications Union.

The environmental model is closely tied to energy and agriculture, because both demands from those systems (for fossil fuels, land, fish, and water) and outputs from them (especially carbon dioxide) are key drivers of the model. The model represents atmospheric carbon as a stock and feeds its level forward to temperature and precipitation changes that, in turn, affect agriculture.

Technology is not a separate model in the IFs system. Rather, technology is represented across and within all the other models—for instance, in changing cost structures for energy forms and rates of progress in raising agricultural yields.

The domestic governance model represents governance in terms of three dimensions—security, capacity, and inclusion—each of which involves two or more elaborating variables. Variables connected to the dimensions include risk of domestic conflict, corruption, government effectiveness, democracy, and gender empowerment. Change in these variables is driven by variables across the other models, and especially by income and educational levels. Change in the three governance dimensions, in turn, drives other aspects of the integrated system, including economic productivity growth. Data sources are disparate and include the World Governance Indicators project at the World Bank and the Polity Project of the Center for Systemic Peace.

Revenues and expenditures are another critical element of governance represented in the IFs system. Revenues involve streams from firms, households, and in the case of foreign aid, from other governments. Expenditures involve streams to transfer payments and to direct expenditure on the military, education, health, infrastructure, R&D and a residual other category. Government revenues and expenditures are fully integrated within the larger social accounting matrix system with much data from the World Development Indicators.

There are some additional important sociopolitical elements integrated with the governance and other models. These include components of the Human Development Index (income, life expectancy, and literacy) developed at the United Nations Human Development Office and the basic dimensions of the World Values Survey (traditional vs. secular rational and material vs. self-expression).

The IFs international political model calculates national material power (from inputs such as economic output, population, military spending, and a proxy for technological advance), but also allows the user flexibility around including and weighting these and other elements. Whether countries pose a threat to each other is a complex function of such power and of a number of other variables, including level of democratization and trade relationships. The variables of the international political model are primarily satellites to the rest of the IFs system, but power dynamics do affect military spending levels directly and therefore all government finance indirectly. The IFs project has a major data-making project underway to enhance existing series on international relationships, such as those from the Correlates of War project, and to build new ones, including those often considered to represent soft power.

In development of the models within the IFs system, we have examined approaches in many other projects. Table A.2.2 shows a small sample of the projects of importance in some of the key issue areas.

Model	Related Projects
Demographic	UNPD 2014; IIASA/Wittgenstein Centre (Lutz, Butz, and KC 2014); Lutz and Skirbekk 2014; Fuchs and Goujon 2014
Education	IIASA/Wittgenstein Centre (Lutz, Butz, and KC 2014); see also Wils and O'Connor (2003) and work with both IIASA and the Education Policy Data Center
Health	WHO and Global Burden of Disease project (Murray and Lopez 1996; Mathers and Loncar 2005, 2006); GISMO project of the Netherlands Environmental Assessment Agency (Hilderink and Lucas 2008); also work of Ezzati, Lopez, Rodgers and Murray, 2004)on Comparative Risk Assessment
Governance and Government Finance	U.S. Political Instability Task Force (Goldstone et al. 2010); on democracy the Polity Project (Marshall and Cole 2014); on social accounting again work rooted in the Netherlands (Vos 1989)
Economics	WorldScan from the Netherlands (CPB 1999); LINKAGE and related models from the World Bank (van der Mensbrugghe 2011); OECD forecasting (OECD 2012)

Table A.2.1. Selected projects and models looked to in development of the International Futures (IFs) forecasting system

The integration within IFs of a large database, including series for all key model variables since 1960, allows comparison of model performance with historical series, and serves as one aspect of verification, validation, and accreditation efforts. The database also allows analysis of forecasts as an extension of historical patterns. The interface further facilitates the structuring of interventions, singly and in combination, for the purpose of scenario development.

In summary, IFs is a hybrid system, and as such does not fall neatly into econometric, systems dynamics, or other model categories. It is a structure-based, agent-class driven, dynamic modeling system. Households, governments, and firms are major agent-classes. Still, the system draws upon standard approaches to modeling specific issue areas whenever possible, extending those as necessary and integrating them across issue areas. Among the important reasons for a hybrid approach is that it allows the combination of close attention to stocks and flows (and differentiation among them, as in systems dynamics) and to data and estimation of relationships. IFs further combines these traditions with a heavy use of algorithmic or rule-based elements and even, when it comes to equilibration, with some elements of control theory. Maintenance of accounting structures is very important in the overall system, including the use of them to track aging populations (cohort component structure), financial flows among agent classes (social accounting), energy resources and production/demand, land use, and carbon stocks and flows. The overall system is recursive with single-year time steps with a current forecast horizon to 2100.

A.3 Users and Uses of the IFs Model

IFs has supported a wide range of scientific analyses and policy-oriented projects. An overview of these analyses and projects is included in Hughes 2016; general descriptions appear in Hughes 1999 and Hughes and Hillebrand 2006 and in other publications noted below.

With respect to project applications in association with international organizations, IFs was a core component of two projects exploring the New Economy sponsored by the European Commission (Johnston and Hughes 2004; Moyer and Hughes 2012). IFs provided forecasts for the fourth Global Environment Outlook of the United Nations Environment Program (UNEP 2007). It was also used in forecasts of two United Nations Development Programme Reports (UNDP HDR 2011 and 2013; see, Hughes, et al. 2011 and 2012; and Hughes 2013 for supporting policy research papers). The United States Institute of Peace commissioned a study of work with IFs and other projects on fragile or vulnerable states (Hughes, Moyer, and Sisk 2011). The World Bank supported a study of the prospects for eradicating poverty by 2010 in fragile and conflict-afflicted states (Burt, Hughes, and Milante 2014 and forthcoming 2016).

Most recently, the Pardee Center produced a report for the New Partnership for Africa's Development (NEPAD), the planning and coordinating technical body of the African Union, on the prospects for eradicating hunger in Africa by 2025 (Hedden, Hughes, and Rothman 2016). The Center is currently collaborating with the Atlantic Council on a project with the Inter-American Development Bank. On the environmental side, the IFs project has begun to connect with the Shared Socio-economic Pathways (SSP) initiative (O'Neill et al. 2014) that in turn connects to the work of the Intergovernmental Panel on Climate Change. The IFs project work is focused on analyzing the internal coherence of the five SSP scenarios, given that issue-specific forecasts for them have come from different modeling groups with largely unconnected models (Rothman, Siraj, and Hughes 2016).

Turning to national and subnational analyses, forecasts from IFs heavily supported the Global Trends 2020, 2025, and 2030 reports to the President by the U.S. National Intelligence Council (US NIC 2004, 2008, and 2012). The Pardee Center has also supported US intelligence and the army in extensive database development projects. Further, IFs supported a study of the future of education in the southern Africa region (Irfan and Margolese-Malin 2012). The Pardee Center worked with the government of the Western Cape province of South Africa on a series of policy briefs and on embedding use of the IFs system in the government's policy-making processes. The Center has similarly collaborated with the National Center for Strategic Planning (CEPLAN) in the government of Peru (see CEPLAN 2014 for its own description of the IFs model and its use in their work).

Moving to international non-governmental organizations, the Overseas Development Institute has used IFs forecasts and scenarios on global poverty in two major reports

(Shepherd et al. 2013 and 2014) as well as in other work, including a project for Save the Children.[35] In partnership with the Institute for Security Studies (ISS), a pan-African think tank based in South Africa, the IFs project has produced a series of policy briefs on African Issues (available at http://pardee.du.edu/policy-briefs and on the ISS website). These cover topics ranging from the future of water and sanitation (Eshbaugh et al. 2011) through attaining food security (Moyer and Firnhaber 2012) to eradicating malaria and gas fracking in South Africa (Hedden, Moyer and Rettig 2013). IFs also serves as the primary analytic tool for the African Futures 2050 project based at the ISS (Cilliers, Hughes, and Moyer 2011), including its support of the South African government in a variety of projects. The Pardee Center supported Population Services International on a study of the health impact of moving from solid-fuel to modern cookstoves in households (Kuhn et al. 2016), and it is similarly working with Water for People to explore the impact of providing safe water and sanitation. Further, we collaborated with Action Against Hunger in a study of the ability to eliminate and/or treat severe acute malnutrition (wasting).

The Center has not kept track of the numbers of students, scholars, policy analysts and others who have, over the years, used or at least perused the IFs system, but there is little question that many thousands have. Some of that use has led to published third-party research and analysis that relied heavily on the system. See, for example, Casetti 2003; Chadwick 2006; Hillebrand 2008; Cave et al. 2009; Hillebrand 2010; Cantore 2011; Cantore 2012; Pearson 2012; Birkmann et al. 2013; Cilliers and Schúnemann 2013; Cilliers and Sisk 2013; McCauley 2014; Hillebrand and Closson 2014; West et al. 2014, and Cantore and Cali 2015.

The most substantial use of the International Futures (IFs) system in recent years, however, has been the publication by the Pardee Center of its five-volume flagship series, called Patterns of Potential Human Progress, on the global issues of poverty, education, health, infrastructure, and governance. Paradigm Publishers in Boulder, Colorado, and Oxford University Press in New Delhi, India, co-published the volumes (in sequence the citations are Hughes et al. 2009; Dickson, Hughes, and Irfan 2010; Hughes et al. 2011; Rothman et al. 2013; and Hughes et al. 2014). The production of this series served two major purposes: (1) motivating the development of entirely new models within the forecasting system, several of them (like health, infrastructure, and governance) fundamentally unique; and (2) generating substantial exposure of the system to other users for their own analyses (as indicated above).

[35] Private correspondence with Amanda Lenhardt.

Appendix B: IFs Education Trajectories, Base Case vs. USE2030

	2015	2030		2050	
Gross enrollment rates	Estimate	Base Case	USE 2030	Base Case	USE 2030
Low-income countries					
Primary	107.6	102.3	109.1	102.5	102.2
Lower secondary	53.6	65.9	112.0	84.3	102.4
Upper secondary	33.0	45.1	122.8	64.1	112.9
Tertiary	7.6	15.9	33.5	28.6	55.5
Lower-middle-income countries					
Primary	108.8	111.3	111.9	101.5	101.5
Lower secondary	85.5	104.9	117.3	109.6	103.5
Upper secondary	58.1	75.1	110.2	90.7	102.8
Tertiary	23.1	38.8	48.1	60.6	69.8
Number of students (millions)					
Low-income countries					
Primary	111.7	149.7	160.1	184.0	163.8
Lower secondary	26.5	46.2	79.6	79.9	90.3
Upper secondary	13.5	24.9	68.4	48.9	84.7
Tertiary	4.6	14.0	29.7	37.5	71.6
Lower-middle-income countries					
Primary	344.1	381.6	384.9	344.0	333.6
Lower secondary	150.2	201.8	228.8	206.6	192.9
Upper secondary	108.6	157.6	235.5	187.2	212.4
Tertiary	60.3	113.7	142.1	178.2	208.2
Per student costs as % of GDP per capita					
Low-income countries					
Primary	11.35	10.18	11.17	12.13	14.51
Lower secondary	20.56	16.91	18.75	17.25	20.33
Upper secondary	39.44	30.97	34.69	28.43	33.28
Tertiary	180.50	111.80	126.00	65.13	76.69
Tottal	251.85	169.86	190.61	122.94	144.81
Lower-middle-income countries					
Primary	12.09	12.52	13.04	16.62	17.45
Lower secondary	16.48	15.71	16.57	19.83	20.98
Upper secondary	26.00	24.08	25.36	28.13	29.75
Tertiary	65.09	46.39	49.56	38.15	41.23
Tottal	119.66	98.70	104.53	102.73	109.41
Total cost by level as % of GDP					
Low-income countries					
Primary	1.98	1.61	1.90	1.59	1.77
Lower secondary	0.85	0.83	1.59	0.98	1.36
Upper secondary	0.84	0.82	2.52	0.99	2.10
Tertiary	1.31	1.66	3.98	1.74	4.09
Tottal	4.98	4.92	9.99	5.31	9.32
Lower-middle-income countries					
Primary	1.43	1.35	1.42	1.36	1.40
Lower secondary	0.85	0.90	1.07	0.97	0.97
Upper secondary	0.97	1.07	1.69	1.25	1.51
Tertiary	1.34	1.49	1.99	1.62	2.06
Tottal	4.58	4.81	6.17	5.21	5.94

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