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The Future of the Guatemalan Education System: A macro analysis of education quality and quantity's impact on development

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Acronyms List

CDCS	Country Development Cooperation Strategies
GDP	Gross Domestic Product
HEO	Health and Education Office
ICT	Information and Communication Technology
IFs	International Futures
IHME	Institute for Health and Metric Evaluation
INE	Instituto Nacional de Estadistica
ISCED	International Standard Classification of Education
MDG	Millennium Development Goal
MFP	Multifactor Productivity
NGO	Non-Governmental Organization
OECD	Organization for Economic Co-operation and Development
PID	Proportional Integral Derivative
PPP	Purchasing Power Parity
PRONADE	Programa Nacional de Autogestion para el Desarrollo Educativo
SDG	Sustainable Development Goal
TERCE	Third Regional Comparative and Explanatory Study
TFR	Total Fertility Rate
TIMSS	Trends in International Mathematics and Science Study
UAC	Unaccompanied Alien Children
USAID	United States Agency for International Development
UN	United Nations
UNDESA	United Nations Department of Economics and Social Affairs
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNHCR	United Nations High Commission for Refugees
UNICEF	United Nations Children's Fund
UNPD	United Nations Population Division

Abstract

This report models the impact of investments in education, with a goal of improving educational attainment (quantity) as well as test scores (quality), in Guatemala on economic activity, social violence, and migration by conducting quantitative modeling using International Futures. We created a scenario (the *Current Path*) that estimated the future trajectory of education in Guatemala based on a continuation of domestic investment and foreign aid allocation. We project that trends in Guatemalan education are expected to lag behind regional peers, but that these investments have broad and long-term impacts (through 2060) on increasing economic activity (by nearly $700 billion), reducing social violence (by 18 percent), and emigration (by over 70,000 non-seasonal migrants). We also explored alternative scenarios, such as a five-year push on increasing education investment with the goal of catching up to regional peers as well as a push to achieve the Sustainable Development Goals related to educational attainment by 2030. We found that both investment scenarios produce significant positive impacts on economic activity, reduce social violence, and reduce pressure for emigration. This report concludes that increasing investments in education in Guatemala has significant benefits by 2040, and are even larger through 2060.

Executive Summary

While Guatemala has made significant progress in improving the education system in the aftermath of its lengthy civil conflict, it remains one of the least effective education systems in Central America across both educational attainment (quantity) and test scores (quality). Improvements in Guatemalan education are expected continue, but the gap between the country and its peers is expected to remain and even widen. Guatemalan average adult educational attainment and average primary test scores are expected to remain lowest in the region and average secondary test scores are expected to fall to lowest in the region by 2040.

This report uses the International Futures (IFs) forecasting system to examine historical trends, outline the *Current Path* of development (to 2040), and explore scenarios that improve the Guatemalan education system. Specifically, it explores Guatemalan educational attainment and test scores across levels (and their drivers) and places them in a regional and global context. It then presents alternative futures (scenarios) in Guatemalan educational attainment and test scores, and explores the impacts of those scenarios on education and broader development indicators. The IFs platform uses data and a mix of different quantitative modeling approaches to provide an alternative way to think about tradeoffs in policymaking. Because education is modeled within IFS, as are the economy, violence and migration, we can shed light on the effects of education investments on these other outcomes. In the IFs model, education has direct (and indirect through other modules) effects on the economy (GDP and inequality) and labor. Education affects violence and migration indirectly through its impacts on the economy and labor. We believe that IFs provides a good way to help frame this work in the future, though we recognize that there is not a large literature documenting these relationships that affected the modeling choices made. In addition, the relationships, and findings, are affected by the quality of the data available for use in modeling. As more information is available on these variables and relationships, the modeling can be updated. Below are the key trends and takeaways from these various avenues of analysis.

Current education trends and challenges:

- Guatemalan education improved throughout the latter half of the 20th century, but progress has stalled in recent years.
- In 2017, average educational attainment in Guatemala was nearly 20 percent lower than any other country in Central America; Guatemalan gender parity is also well below Central American peers.
- Average test scores declined since 2000 and primary enrollment and survival rates fell over the last 10 years; the percent of the adult population that has completed secondary and tertiary education, has stagnated and declined, respectively. Guatemala's education bottleneck occurs between primary and secondary school. Many students fail to finish primary school or fail to acquire the skills that are needed to succeed in secondary school. This is evidenced in part by the fact that primary test scores (across reading, science, and math) are some of the lowest in the region.

- Guatemalan education spending, which stands at only 2.5 percent of Gross Domestic Product (GDP), is the lowest in the region and falls well short of global norms and the seven percent outline by the 1996 Peace Accords.

- Relatively high levels of corruption and low government effectiveness suggest that education funding is spent ineffectively.

Projected education trends and opportunities:

- Guatemalan education indicators are expected to continue to lag behind regional peers, but the value of continued progress is immense. Education improvements along the *Current Path* – which represents a continuation of current policy choices and environmental conditions across sectors – are forecast to contribute over $60 billion to overall GDP and pull nearly 800,000 people out of poverty over the next 22 years.

- Moreover, targeted policy interventions and the provision of additional resources to improve primary and secondary level enrollment, graduation, and test scores could help Guatemala catch up with regional peers and reap the benefits of a more educated populous.

- An *SDG Achievement* scenario - which is an ambitious push to provide quality education for all children through secondary school by the early 2030s (SDG 4.1) - would boost GDP by over $10 billion, reduce those living in poverty by more than 500,000, and reduce emigration by nearly 1,000 people compared to the *Current Path* in the year 2040.

- A *5-year education push* scenario - which represents a concerted effort by government and stakeholders to catch up with regional peers across primary and secondary education outcomes over the next five years - would boost GDP by over $30 billion, reduce the number of those living in poverty by more than 600,000, and reduce the number of emigrants by 1,500 compared to the *Current Path* in 2060.

- In the extreme long run, the impacts of these scenarios are even larger, as more students graduate with high skills and education. For example, by 2060, the *SDG Achievement* scenario increases GDP by over $70 billion, reduces poverty by more than 1.3 million, and reduces emigration by 3,000 individuals.

- Both scenarios are costly in the near to medium future, but the long terms gains are immense. By 2060, they each produce a four-fold return (in GDP terms) on overall minimum investment.

Purpose and process

This case study was produced in conjunction with a larger regional development report on Central America and the Caribbean for the USAID Bureau for Latin America and the Caribbean Regional Sustainable Development Office. The regional report explores trends in Central America and the Caribbean focusing on the education system to 2040. This Guatemala case study is supported by USAID Guatemala Health and Education Office (HEO) as well as the USAID Latin America and Caribbean Regional Office in Washington D.C., with consulting support from Mathematica Policy Research. The Pardee Center produced a similar case study on Honduras.

The Frederick S. Pardee Center for International Futures

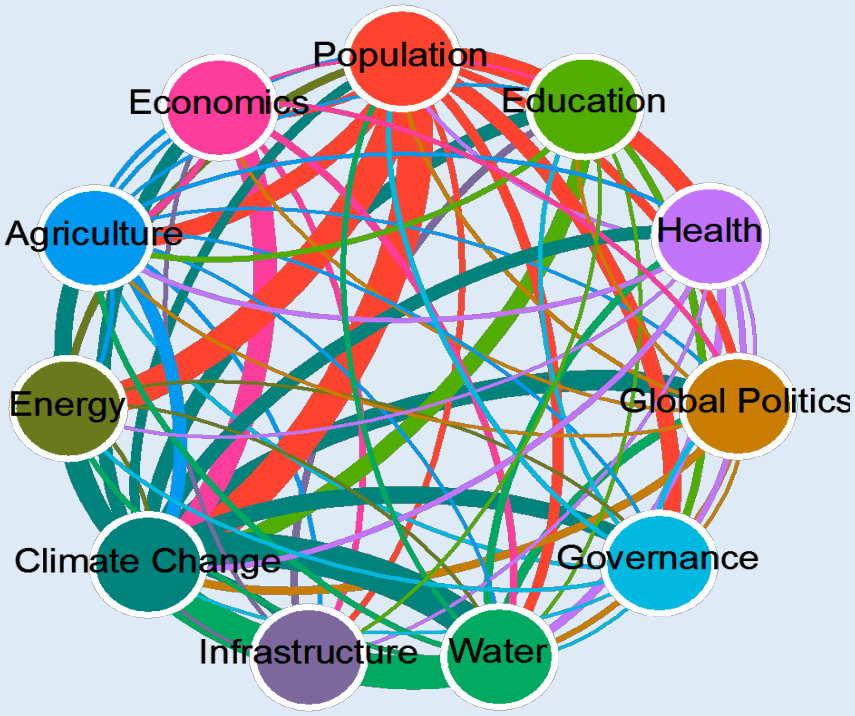
The Frederick S. Pardee Center for International Futures is based at the Josef Korbel School of International Studies at the University of Denver, USA. The Pardee Center specializes in helping governments, international organizations, and private sector organizations think strategically about the future. The Pardee Center focuses on exploring past development trends, understanding the inter-relationships that drive development outcomes, and shaping policies that achieve development outcomes.

International Futures (IFs) is a free and open-source quantitative tool for thinking about long-term futures. The platform helps users to understand dynamics within and across global systems, and to think systematically about potential trends, development goals and targets. While no software can reliably predict the future, IFs forecasts — which are calculated using data and a mix of quantitative modelling approaches — offer a broad and transparent way to think about the tradeoffs in policymaking.

There are three main avenues for analysis in IFs: historical data analysis (cross-sectional and longitudinal) of more than 4,000 series, Current Path analysis (how dynamic global systems seem to be developing), and alternative scenario development (exploring if-then statements about the future). To do this, IFs integrates relationships across 186 countries and 12 core systems, including: agriculture, demographics, economics, education, energy, environment, finance, governance, health, infrastructure, international politics, and technology. The sub-models for each system are dynamically connected, so IFs can simulate how changes in one system may lead to changes across all others. As a result, IFs endogenizes more variables and relationships from a wider range of key development systems than any other model in the world.

IFs is developed by The Frederick S. Pardee Center for International Futures. It was originally created by Professor Barry B. Hughes and is currently developed and maintained by a team of researchers. Learn more about IFs or download the tool for free at https://pardee.du.edu/.

Figure 1: Stylistic representation of IFs submodules



IFs modules added for this project

As part of this report, the Pardee Center added four separate models (or modules) to IFs in order to better represent some of the key issues facing Guatemala now and into the future. Below are brief descriptions of each model addition to the broader IFs platform – for more information or technical documentation please refer to the Pardee Center Wiki (https://pardee.du.edu/wiki/Main_Page). For more information on educational attainment and quality models, see Appendix 1. For a description of interventions for scenario analysis, see Appendix 2. For additional information on modeling documentation, see Appendix 3.

Education quality

The new modelling efforts from the Pardee Center use test scores as the main indicator of learning quality. Test scores offer a standardized, comparable indicator of student achievement across time and country, which is a crucial requirement for cross-country based modeling. IFs test scores projections are initialized from test scores from the World Bank Global Achievement database (Angrist et al, 2013). This database measures test scores (on a scale from 0 to 100) for 128 countries (from 1965 to 2010) at the primary and secondary level across three subjects - science, reading, and math. IFs uses the average overall score across all three subjects as the main indicator of education quality (by level).

Test score estimates and projections in IFs are driven by adult educational attainment (average years of education) and education spending per pupil.[1] This represents an 'intensive' approach to modeling education quality at the secondary and primary levels, which reflects the view that as individuals participate in higher levels of schooling, they tend to allocate more resources to higher quality schooling (Castelló-Climent & Hidalgo-Cabrillana, 2012:392).

Adult educational attainment also provides an indication of the family and home environment, and serves as a proxy for level of teacher education and level of development (GDP per capita).

In IFs, average test scores directly impact levels of multifactor productivity (MFP), and thus have fairly direct impacts on the economy. For more information and/or details of the education quality model please see the regional 'reference' report (The Pardee Center, 2018), Appendix 3 and/or the Pardee Center Wiki.

Social violence

Our model of social violence uses homicides across two main categories (political and interpersonal) and five sub categories (conflict and terror, police executions, and interpersonal homicides of men, women, and children) as the core indicators of social violence. While homicides are an imperfect proxy for social violence (which does not include other forms such as domestic abuse), homicide rates generally represent levels of overall violence and are a robust dataset.

The drivers of homicides across categories include the youth bulge (interpersonal), inequality (interpersonal), probability of civil conflict (conflict and terror), and corruption (police executions). The drivers of types of homicides are also interconnected and some types of homicide drive others: the total number of homicides is a driver of police executions and homicides against women drives suicide.

In IFs, homicides directly impact deaths by type and multifactor productivity (MFP) via the IFs Security Index, which is comprised of the IFs homicide index and government risk index. Because social violence impacts more than homicide rates, the government risk index provides a broader security context that measures drivers of state fragility from a multidimensional perspective. For more information and/or details of the education quality model please see the regional 'reference' report (The Pardee Center, 2018), Appendix 3 and/or the Pardee Center Wiki (https://pardee.du.edu/wiki/Main_Page).

Labor market dynamics

IFs models labor supply and demand by skill level across six economic sectors (agriculture, energy, mining, manufacture, services, and ICT). Labor supply is predominantly driven by demographics that determine the population and participation rate of working-aged individuals. Educational attainment determines the skill level of the workforce. Labor demand is largely driven by technological progress and potential economic output.

Supply and demand are equilibrated via wages, which can result in short- or medium-term fluctuations in unemployment. The model also forecasts the share of non-agricultural labor employed informally, driven primarily by level of development, educational attainment, and

[1] Spending per pupil impacts take effect only at values above/below the expected level. For example, countries that spend more than a typical country at that level of development will get a boost in the score projection. The spending-induced score boosts are reduced in proportion to the level of corruption and prevalence of insecurity in the society.

business regulation. For more information and/or details of the education quality model please see the regional 'reference' report (The Pardee Center, 2018), Appendix 3 and/or the Pardee Center Wiki (https://pardee.du.edu/wiki/Main_Page).

Bilateral migration

IFs forecasts total bilateral (country to country) migration through a "gravity model" using bilateral migration stock and flow data estimates from a number of sources. Migrant stock data is taken from the UN Department of Economic and Social Affairs migrant stock database (UNDESA, 2017) and migrant flow data is taken from Abel (2016), which estimates migrant flow data from the UNDESA stock data. Data on forced migration stocks is from the UN High Commission for Refugees (UNHCR, 2017); the Pardee Center has estimated annual flows of forced migrants using a methodology similar to that employed by Abel (2016).

Bilateral migration is forecast endogenously using a gravity model, which incorporates "push-pull" factors. Core push-pull factors are: distance (between two countries), size of the population (of the origin and destination countries), the size of migrant communities living in the destination country (as a percent of the destination country's population), the ratio of household income per capita (between two countries), the GDP per capita of the origin country, security (which includes levels of homicide in origin country), and risk of government instability in origin country. For a more complete discussion of the migration analysis in this report, see Appendix 3.

IFs Current Path/Scenarios

The IFs Current Path is a collection of interacting forecasts that, while dynamic, represent a continuation of current policy choices and environmental conditions. It represents a "most likely" future of development. Although the Current Path generally demonstrates continuity with historical patterns, it provides a structure that generates a wide range of non-linear forecasts rather than just a simple linear extrapolation of historical trends. The Current Path assumes no major paradigm shifts, seismic policy changes or impactful low-probability events. Given that the Current Path is built from initial conditions of historical variables and is analyzed in comparison to other forecasts of particular issue areas, it is a valuable starting point to carry out scenario analysis and construct alternative future scenarios. This report uses 2017 as the base year for reporting results; unless otherwise noted all 2017 values are model estimates.

In this report we compare the Current Path with two alternative scenarios. The first intervention, the *SDG Achievement* scenario ensures 'complete free, equitable and quality primary and secondary education' for all girls and boys (SDG 4.1). It does so by filling the education pipeline in the Honduran education system. It also boosts Honduran test scores across levels to Costa Rican levels. The Current Path is also compared to a scenario that simulates USAID's 5-year Country Development Cooperation Strategies (CDCS) planning periods. This scenario simulates a spending and policy push to improve Guatemalan education system indicators to the Central American average by 2023.

Introduction

Improvements in education are a core focus of political leadership in Guatemala, both at the executive level and within the foreign aid community. Current President Jimmy Morales promised "quality education for everyone" in his 2016 inauguration speech. The USAID Country Development Cooperation Strategy includes specific provisions for expanding education access and quality and acknowledges its important impact on income, health, and gender equity.

Education generates benefits for individuals and society as a whole. It improves skills and cognitive abilities while facilitating the acquisition of knowledge (Psacharopoulos & Patrinos, 2004). Dickson et al. (2010) explain that education improves communication skills and the ability to obtain information, promoting personal empowerment and the expansion of freedom. Furthermore, increases in education are tied to better health outcomes, higher life expectancy, greater earnings, and improved subjective well-being.

At the societal level, education correlates with lower crime rates, increased civic participation, and economic growth. This is especially important in Guatemala, where violence and suboptimal economic growth hamper societal progress. One study finds that higher levels of education are linked to lower levels of violence (Williams, 2016). Additional studies indicate that education-based interventions effectively curb violence amongst youth (UNESCO, 2012; Williams, 2016).

Education is also a key driver of economic growth. It is linked to human capital generation, productivity, and the diffusion of knowledge and technology. In East Asia, for example, Kwack & Lee (2006) and Permani (2009) find that education predicted economic growth observed between 1960 and 2005. It was also linked to greater economic openness and increased foreign direct investment (Narayan & Smyth, 2006).

Education systems are measured by their ability to get students through the system (attainment) and the quality of education (test scores) at each step. Both elements impact productivity and human well-being in different ways, but they are also intrinsically interconnected. Further, education systems as a whole operate within systems of governance, economics, infrastructure, etc., which means that overarching trends and factors across each of those elements also impact educational outcomes.

While Guatemalan education outcomes have improved significantly since the end of the civil conflict in 1996, the country remains one of the poorest performing in Central America and lags behind other countries at similar levels of income. Both the stock of total education, as measured by the average educational attainment per adult, and the quality of learning, as measured by average test scores, are either the lowest or second lowest in Central America. Further, recent trends in enrollment and attainment show some backsliding in progress in the education system and a decline in the stock of highly educated individuals in Guatemala.

There are still significant bottlenecks in primary and secondary school that hinder long-term improvement in educational attainment. Over the past 10 years, Guatemalan primary enrollment and survival rates have declined and secondary enrollment and completion rates have stagnated. Furthermore, the portion of the population that has completed secondary and tertiary education

has shrunk since 2000. Primary and secondary average test scores (across reading, science, and math) are some of the lowest in the region and are significantly lower than global income peers. Less than half of all students who enter the 6th grade reach national standards across math and science and only a quarter of high school graduates achieve reading standards (Orozco & Valdivia, 2017).

Factors within the education system and external factors drive slow improvement in educational outcomes. First, while Guatemala has rapidly improved primary enrollment and completion, one in every four students who complete primary still fail to move on to secondary school, thereby narrowing the pool of students that can complete tertiary education. Further, secondary graduation rates are lowest in the region suggesting that many of those who begin secondary school do not make it through. Only 19 out of 100 students who start primary school today are expected to graduate secondary school.

Progress in overall attainment is also hindered by recent trends in enrollment and completion. Enrollment and graduation rates at the primary and secondary level have fallen or remained stagnant since 2008, a phenomenon that can be explained in part by inadequate public primary and lower secondary schooling, especially in rural areas. Further, the portion of the adult population that has completed secondary and tertiary education has stagnated or fallen over the past 10 to 15 years.

Part of the issue (in both quality and quantity) is that the Guatemalan government currently spends well below the regional average for Central America and Caribbean (three percent of Gross Domestic Product (GDP)[2] in Guatemala compared with five percent for the region). Further, Guatemala has high levels of corruption and low levels of government effectiveness (a measure developed by the World Bank Governance Matters project), which means that the funds allocated to education are likely not being fully utilized. Rural and indigenous communities in particular lack adequate learning materials and properly trained teachers. Moreover, external factors such as economic and labor growth, violence, and migration heavily impact the education system and education outcomes.

Recent attainment trends and test scores are also affected by larger contextual and development challenges. Guatemala's homicide rate increased significantly in the early- to mid-2000s and is among the highest in the world. It also suffered spillover effects from the global financial crisis in 2008 and has seen middling economic and job growth since. These persisting issues led many Guatemalans to migrate (largely to the U.S.) for security and economic reasons. All of these factors affect both schooling and incentives for educated individuals to remain in Guatemala.

Given the dual challenges of poor attainment and test scores in the current context, how can the government and development partners best improve long-term education outcomes? To help answer this question, we present two scenarios simulating alternative futures across educational

[2] In this report, we use GDP MER (market exchange rate), which indicates transaction values for goods that countries trade as opposed to goods produced for domestic use. They are influenced by supply and demand factors.

attainment and test scores and explore their impacts on education and development outcomes out to 2040.

The first scenario simulates a policy and spending intervention that pushes Guatemala to achieve Sustainable Development Goal (SDG) 4.1 by 2030, reaching 100 percent enrollment and graduation rates and improving test scores to the regional leader across both primary and secondary levels. The second scenario represents a concerted effort by government, local organizations, and international donors to bring Guatemala in line with regional peers across primary and secondary education outcomes over the next five years. Both education scenarios improve overall educational attainment and output, average incomes, poverty, and levels of violence, but improvements take a significant amount of time to fully materialize.

This report unfolds by first analyzing recent trends in educational attainment and the education pipeline. Second, it evaluates the current and future state of education quality (as measured by test scores). Third, it outlines trends and issues in government effectiveness and spending on education. Lastly, it introduces two scenarios that simulate improvements in educational attainment and test score outcomes across levels and explores the impacts of each on education and development outcomes.

Education quantity: attainment and completion

A starting point for examining the education system in Guatemala is to assess average adult educational attainment, which is a core measure of the stock of education in a given society. Average adult educational attainment is measured as the average years of education attained by individuals 15 and older. It serves as a main indicator of the success of the education system and the total amount of education in the productive portion of society from an education quantity standpoint.

Improving adult education attainment, or the "stock" of education in a country, requires expanding access to formal education and incentivizing children to remain in school and progress through the system. Education systems are a "pipeline" and can be modeled by tracking the progression of students through the formal education system at primary, secondary, and tertiary levels. IFs models enrollment, survival, and graduation rates at each level using data from UNESCO Institute for Statistics.[3] This approach helps identify bottlenecks in the education system; in Guatemala, bottlenecks begin to emerge between the primary and secondary level.

[3] For more information IFs education model see: Dickson et al, Patterns of Potential Human Progress: Advancing Global Education, 2010; and Irfan, IFs Education Model, 2015. IF's representations of progression at each level of education reflect the grade levels in primary and secondary defined by UNESCO.

Table 1: Education indicator definitions

Variable	UNESCO Definition
Gross enrollment rate	Number of students enrolled in a given level of education, regardless of age, expressed as a percentage of the official school-age population corresponding to the same level of education. For the tertiary level, the population used is the 5-year age group starting from the official secondary school graduation age.
Net enrollment rate	Total number of students in the theoretical age group for a given level of education enrolled in that level, expressed as a percentage of the total population in that age group.
Graduation rate (gross)	Number of graduates regardless of age in a given level or program, expressed as a percentage of the population at the theoretical graduation age for that level or program.
Completion rate	Percentage of a cohort of children or young people aged 3-5 years above the intended age for the last grade of each level of education who have completed that grade.
Transition rate	Number of students admitted to the first grade of a higher level of education in a given year, expressed as a percentage of the number of students enrolled in the final grade of the lower level of education in the previous year.
Survival rate by grade	Percentage of a cohort of students enrolled in the first grade of a given level or cycle of education in a given school year who are expected to reach a given grade, regardless of repetition.
Repetition rate by grade	Number of repeaters in a given grade in a given school year, expressed as a percentage of enrolment in that grade the previous school year.
Gender parity	Purely a numerical concept. Reaching gender parity in education implies that the same proportion of boys and girls - relative to their respective age groups - would enter the education system and participate in its different cycles.
Literacy rate	Total number of literate persons in a given age group, expressed as a percentage of the total population in that age group. The adult literacy rate measures literacy among persons aged 15 years and above, and the youth literacy rate measures literacy among persons aged 15 to 24 years.
Government expenditure per student (as % of GDP per capita)	Average total (current, capital and transfers) general government expenditure per student in the given level of education, expressed as a percentage of GDP per capita.
Government expenditure on education (as % of GDP)	Total general (local, regional and central) government expenditure on education (current, capital, and transfers), expressed as a percentage of GDP. It includes expenditure funded by transfers from international sources to government.

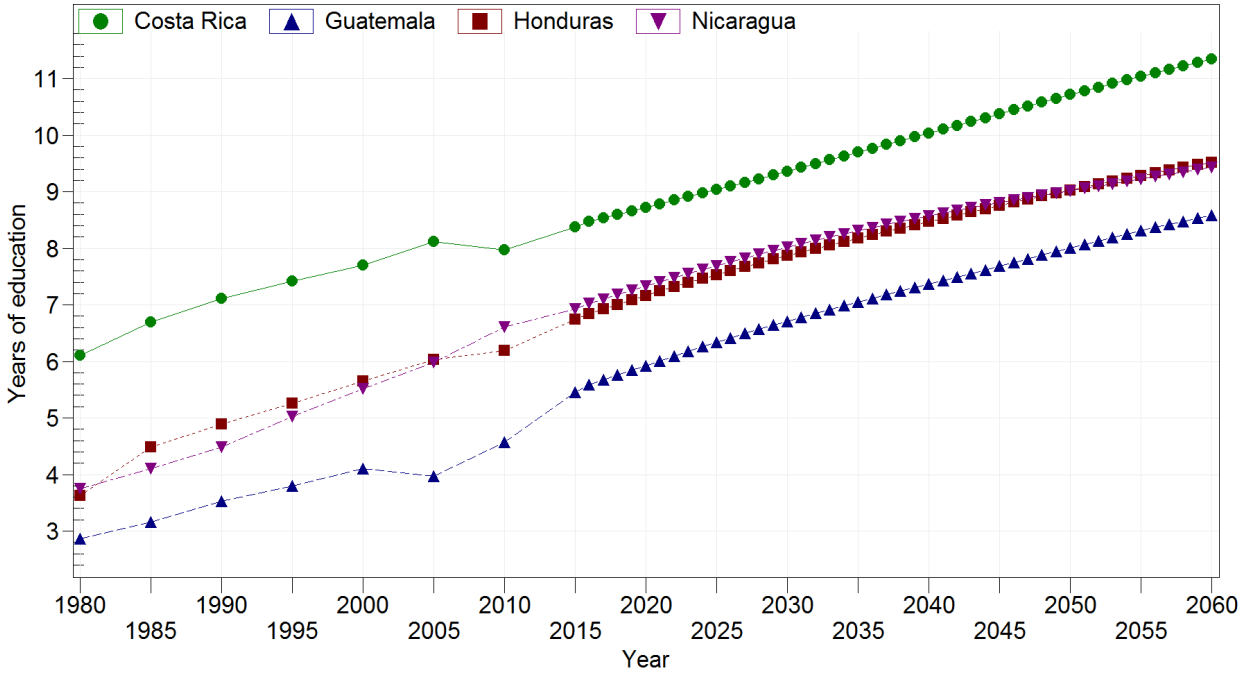
Adult attainment and completion

Guatemalan average adult educational attainment has grown steadily over the past 25 years but from a very low base compared to regional and income peers. The Guatemalan civil conflict, which lasted over 30 years from the mid-1960s to the signing of the Guatemalan Peace Accords in 1996, gutted an already-struggling education system by diverting education funds, destroying physical infrastructure, and displacing communities and families. An estimated one-third of education communities were in some way affected by the civil war (Marques & Bannon, 2003).

In 1995, near the end of the civil war, the population had an average of 3.8 years of education (4.2 male, 3.4 female). By 2017, average educational attainment had grown to 5.7 years (5.9 male, 5.5 female). Despite this improvement, Guatemalan average educational attainment falls short of regional and international peers (at similar levels of GDP per capita (PPP) in 2017).

In 2017, the average educational attainment in Guatemala was the lowest among countries in Central America, behind Honduras (6.9) and well behind Costa Rica (8.5) (Figure 2 below). It was also lowest among its international income peers, falling just below Morocco (5.9) and well below Bolivia (8.5) and Guyana (8.2).[4] Guatemala also lags behind regional peers in terms of gender equality in educational attainment. In Guatemala, women have an average of about five months less education than males; in the rest of Central America (except El Salvador), women average higher levels of education than males.

Figure 2: Average educational attainment, select Central American countries, 1980 to 2040



Source: Data from Barro-Lee, forecast from IFs 7.38.

[4] Income peers were chose based on current levels of GDP per capita. The group includes Morocco, Guyana, Bolivia, and Philippines, all of which have similar levels of GDP per capita to Guatemala.

Along the Current Path, IFs projects a significant improvement in average educational attainment in Guatemala, but the attainment gap between Guatemala and its peers will remain. In fact, IFs projects Guatemalan average attainment (7.5 years) in 2040 will still be lower than attainment in El Salvador today (7.6 years). The gender gap in education is projected to narrow, but women will still have about a month's less education than men in 2040.

Another way to assess overall adult educational attainment is to examine adult completion rates – which represent the portion of the adult population that has completed a given level of education - across levels (see Table 2). Guatemala rapidly increased the adult primary completion rate from 35.3 percent to 58.7 percent between 2000 and 2017. However, Guatemala started a lower point than many of its peers which means is still lags behind – the Guatemalan adult primary completion rate today is just below the adult primary rate seen in Honduras in 2000 (56.8).

Further, the adult secondary completion rate has stagnated and the tertiary adult completion rate has declined since 2000. The Guatemalan adult secondary completion rate has increased by only one percentage point and adult tertiary completion has declined by a percentage point since 2000. Stagnating or declining adult completion rates suggest that Guatemala may have a bottleneck between primary and secondary levels that constrains completion through tertiary school. However, it is it also likely that factors outside the education system are reducing adult completion rates.

Despite the 'bottleneck' between primary and secondary school and the slight decline in completion that has occurred since 2008, enrollment and graduation rates have actually increased overall over the past 20 years. This means that the stagnation/decline in adult completion is largely due to the emigration of educated individuals, which is often termed 'brain drain'.

Brain drain – the exodus of highly skilled workers from a country – occurs when inadequate opportunities and incentives exist for those who have attained high levels of schooling. In Guatemala, brain drain has been an ongoing problem for many years. A large share of Guatemala's most educated workers have migrated and continue to migrate to the U.S. (Adams, 2003). Approximately 30 percent of college-educated individuals from Guatemala (and other Central American countries such as El Salvador, Honduras, Nicaragua and Panama) reside in the United States (Ozden, 2006).

Table 2: Adult completion rates, selected Central American regions and countries, selected years

	Primary Completion			**Secondary Completion**			**Tertiary Completion**		
	2000	**2017**	**2040**	**2000**	**2017**	**2040**	**2000**	**2017**	**2040**
Guatemala	35.3	58.7	76.2	13.7	14.8	30.6	1.7	0.6	3.3
Honduras	56.8	69.3	84.1	16.7	22.8	37.1	2.4	2.2	9.4
Nicaragua	45.3	64.1	79.6	21.5	32.6	44.1	9.3	11.6	16.8
Central America	47.0	66.5	81.3	20.3	26.9	39.8	5.7	5.5	11.1

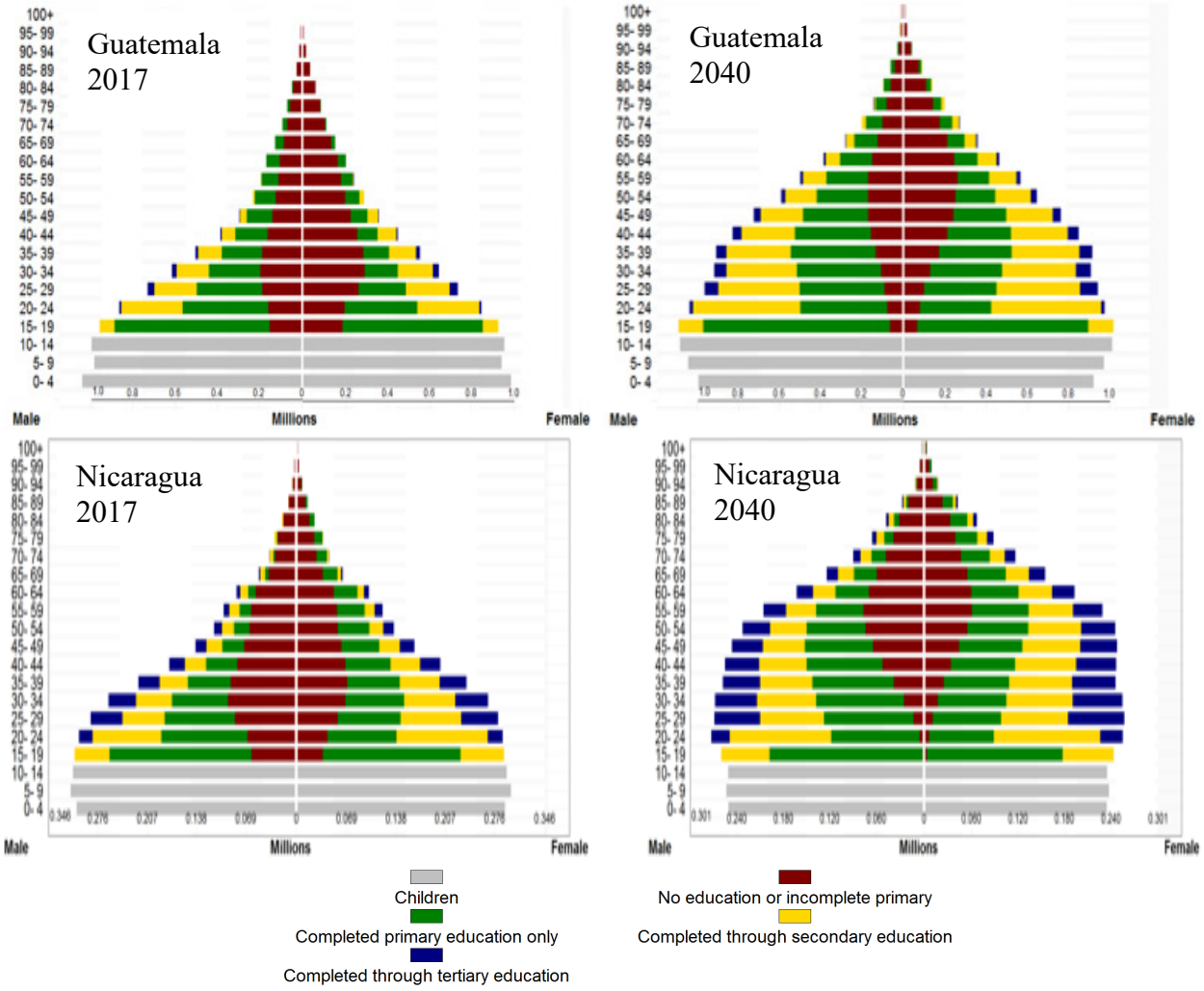
Source: Data from UNESCO, forecast from IFs 7.38.

Looking forward, IFs projects that improvements in the education system will increase the number of people that complete education across all levels. As the education system continues to improve more students are expected to complete secondary and tertiary education. Meanwhile, continued economic growth and reductions in violence should reduce the impetus for educated individuals to leave, though uncertainties surrounding both economic opportunity and societal violence could easily lead to continued brain drain.

Another way to visualize and compare adult education completion is to overlay levels of completion over the total population. Figure 3 shows Guatemalan and Nicaraguan human capital distributions[5] by age and sex in 5-year cohorts in 2017 (left) and 2040 (right). The 2017 Guatemalan pyramid captures the story shared above – younger cohorts (especially the 15-19 cohort) have increasing portions of individuals who have completed primary school (higher levels of green and less red). It also shows how Guatemalan adult completion is expected to grow over the next 22 years – adult secondary (yellow bars) and tertiary (blue bars) completion both grow significantly by 2040.

[5] IFs population pyramids show population distribution in 5-year age-and-sex cohorts. This distribution reflects the country's population pyramid overlaid with education completion at each level of education in 2017 and 2040. Younger populations have a greater percentage of the population concentrated the bottom of the pyramid. As population ages, the middle and top of the pyramid begin to fill out.

Figure 3: Human capital distribution, Guatemala and Nicaragua, 2017 and 2040



Source: IFs 7.38.

The human capital pyramids also show the stark difference between Nicaragua and Guatemala both today and in 2040. In 2017, Nicaraguan secondary and tertiary adult completion are clearly much higher, as indicated by the larger yellow and blue bars across all cohorts. Guatemalan adult completion is but a small sliver of the population across most cohorts. By 2040, Guatemalan adult tertiary completion is expected to increase significantly, but still pales in comparison to Nicaraguan tertiary completion.

The general trends in the stock of education over the past 15 years show that Guatemala has been losing many of its most educated individuals, which has significant implications for economic growth and supply of skilled labor. That said, Guatemala has done well to improve overall attainment given that it started at a much lower base than many of its Central American peers. Further, it also shows that the Guatemalan education system has been able to increase the throughput of primary students, which means that younger generations have the opportunity to move through the education system.

Box 1: Regional and ethnic disparities in educational attainment

The IFs national level snapshot masks the variation in education access needed to understand the Guatemalan context. Due partially to data limitations and structural constraints, IFs does not forecast intra-country wealth quintiles or ethnic and religious groups. There are important disparities between these groups in Guatemala that deserve attention in the context of an assessment of national education, but are somewhat out of the scope of this study.

Adelman and Székely (2016) find stark differences in enrollment rates by income quintiles, between urban and rural populations, and among indigenous groups in Guatemala. Indigenous groups tend to live in rural, low-income areas, compounding the difficulty in providing equitable education to these populations. Further, the civil war had a disproportionate impact on vulnerable indigenous groups. According to one study on civil war and human capital in Guatemala, indigenous Mayan males and females completed 1.09 and 1.17 fewer years of schooling during the final period of the conflict (1985-1996) than non-indigenous populations (Chamarbagwala & Morán, 2011).

Attempts to improve service delivery to rural and marginalized populations resulted in the creation of community-managed schools across Guatemala. The *Programa Nacional de Autogestion para el Desarollo Educativo* (PRONADE) was launched by the Ministry of Education in 1994 and aimed to improve primary education access in rural areas inhabited by indigenous populations.[6] PRONADE increased access and completion in rural and indigenous areas - by 2006 over 4,000 PRONADE schools expanded educational access to more than 445,000 students (Moore, 2007) (Marshall, 2009).

While the PRONADE program did narrow attainment inequality, a report from the Inter-American Dialogue (2017) finds disparities across gender, indigenous groups, income levels, and urban and rural populations persist today. Illiteracy rates are higher for women than men, and are especially pronounced amongst indigenous women.

The education pipeline

According to UNESCO (2018), Guatemala has compulsory basic education which lasts 10 years, from ages six to 15, covering primary and lower secondary school. Students attend pre-primary school from ages four to six, primary school from ages seven to 12 (grades one through six), secondary school from ages 13 to 17 (lower secondary grades seven through nine, upper secondary grades 10 through 11), and tertiary education, typically from ages 18 to 22.

Most of the basic education in Guatemala is public, but private institutions (both for and not-for-profit) account for the majority of secondary enrollment. In 2016, 12.5 percent of primary students, 56.6 percent of lower secondary students, and 77 percent of upper secondary students

[6] The program ended after over a decade of protest by teachers unions and activists that it delivered substandard education to the most vulnerable populations and crowded out alternatives (Poppema, 2009).

were enrolled in private institutions (UNESCO, 2016).[7] Of those enrolled in upper secondary education in Guatemala, an estimated 70 percent attend vocational school, which is tied with Honduras for highest in the region (El Salvador is next closest at 46 percent).

Box 2: Population data and projections in Guatemala

Since 1950, Guatemala has conducted national censuses in accordance with the technical criteria and recommendations of the United Nations. However, the last census was conducted in 2002. Current population figures are estimates based on data from the 2002 census and projections of population growth rates. Due to a lack of recent data, there are concerns about the accuracy of population estimates in Guatemala.

To assess the accuracy of current population forecasts from the *Instituto Nacional de Estadistica Guatemala* (INE) we compared them to population forecasts in IFs. Guatemalan census figures are from *Características de la población y de los locales de habitación censados*, dated July 2003 (p. 13). Projections for 2008-2015 are downloaded from the INE website. IFs population data is from the UN Population Division (UNPD), which provides demographic and population estimates and forecasts for all countries.

The UNPD/IFs data and projections are largely in line, and even a little higher, than the current estimates from the INE. However, this does not confirm their accuracy as many factors could have altered population growth over the 16 years since the last census.

Table B.1: Comparisons of population data and projections

	Year	INE	IFs (UNPD)
Census	1950	2,790,868	3,115,000
	1964	4,287,997	4,731,000
	1973	5,160,221	6,105,000
	1981	6,054,227	7,467,000
	1994	8,331,874	10,170,000
	2002	11,237,196	12,210,000
Projection	2008	13,677,815	14,010,000
	2009	14,017,057	14,320,000
	2010	14,361,666	14,630,000
	2011	14,713,763	14,950,000
	2012	15,073,375	15,270,000
	2013	15,438,384	15,600,000
	2014	15,806,675	15,920,000
	2015	16,176,133	16,250,000

Source: INE, UNPD, and IFs version 7.38.

[7] This may reflect the disparities in educational attainment between low-income, rural, indigenous students, many of whom do not reach secondary school, and higher-income, urban, non-indigenous students who are more likely to attend private institutions. It may also reflect the emergence of private secondary institutions in response to demands for vocational training in areas like auto mechanics, information technology, administration, and tourism (Posner, 2017).

Outcomes by level

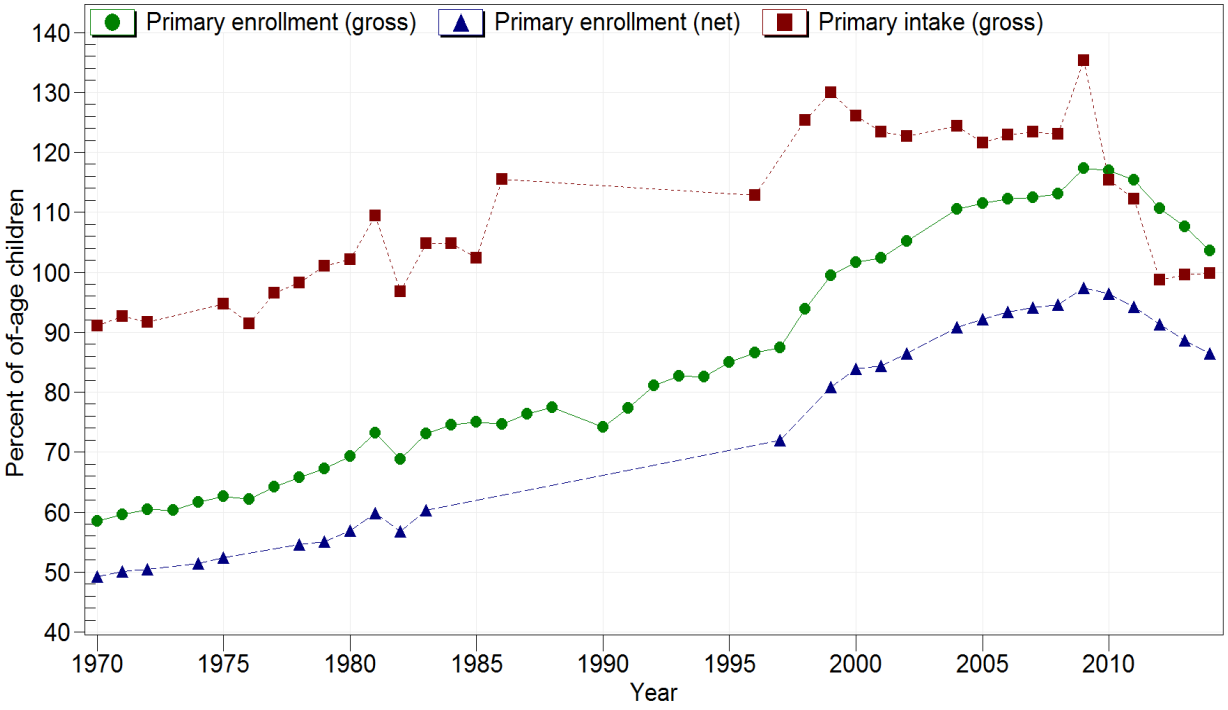
Guatemala has improved student retention and completion across primary, secondary, and tertiary levels over the past 20 years. However, significant challenges remain. Guatemalan enrollment and graduation rates across every level are either lowest or second lowest in the region. IFs estimates that there are just under 200,000 children missing from primary school and nearly 1.3 million students missing from secondary school today. Issues within the system start at, but are not limited to, primary level completion.

Driven in part by global momentum to expand primary access under the Millennium Development Goals (MDGs), Guatemala increased gross primary enrollment to 103.5 percent and net primary enrollment to approximately 92 percent in 2017. Net enrollment rates are on par with the region, however gross enrollment rates are still lower than the regional average (108.3 percent). Further, recent trends in Guatemalan primary enrollment data show declines in both gross and net primary enrollment over the past 10 years.[8]

Gross primary enrollment peaked in 2009 and then declined in more recent years (see Figure 4 below). Net primary enrollment and gross primary intake rates also peaked in 2009 and steadily declined until 2015. This trend is also seen, albeit less markedly, in primary survival rates and coincides with stagnation in growth in secondary enrollment and graduation rates.

[8] There are some discrepancies between Guatemalan national statistics from the *Instituto Nacional de Estadistica* (INE) and UNESCO data used in IFs. Prior to 2010, UNESCO data was consistently higher than that of the INE, but from 2010 onward, UNESCO net enrollment rates are consistently higher. Two possible sources for these issues are population estimation differences (i.e. differences in the estimates of total school-aged individuals and accounting issues in the Guatemalan education system (i.e. age appropriate kids in the INE estimates may not include 6-year-old children).

Figure 4: Primary enrollment indicators, Guatemala, 1970 to 2015



Source: Data from UNESCO, forecast from IFs 7.38.

The downward trend in gross primary enrollment rates (and stagnation in growth of secondary enrollment and graduation rates) over the past eight to ten years may have been driven by several factors. Typically, gross enrollment increases when the total stock of potential students who have not attended primary school becomes older and returns to school. It falls once these individuals have completed primary school. However, it is likely that other factors have also contributed to the decrease in enrollment rates. U.S. policies toward unaccompanied alien children (UAC) were relaxed in 2009 and economic growth in Guatemala declined significantly in 2008 and 2009 due the global financial crisis.

An examination of the education pipeline in Guatemala suggests that these trends have hindered progress throughout the education system (see Table 3). In 2017, Guatemala's primary survival rates (77.2 percent) were the second lowest in the region, higher only than Nicaragua (56.6 percent). This low primary survival rate limits the pool of students who are able to transition to secondary, thereby creating a bottleneck in the Guatemala education system.

Put another way, students at the primary level are dropping out at high rates - at the primary level, Guatemala had a dropout rate of 25.2 percent in 2014. Moreover, those that do make through to primary struggle to stay in school as well - dropout rate was 18.6 percent at the lower secondary level in 2015 (UNESCO, 2015). The combination of low rates of primary survival and high dropout rates constrain enrollment at the secondary level. Total net secondary enrollment is only 50 percent, which means that half of the children who are of secondary school age are currently not enrolled.

Gross enrollment, which includes 'of age' and all other current students, stands at 74.3 percent for lower secondary and 55.8 percent for upper secondary. When gross enrollment rates are significantly higher than net enrollment rates it signifies that significant number of adults or older students are returning or repeating. UNESCO (2015) data show that the primary repetition rate was 9.6 percent in 2014, while the lower secondary repetition rate was 2.9 percent in 2015.

Of the total students enrolled in lower secondary school, only 54.4 percent graduate and, of those enrolled in upper secondary, only 40.1 percent graduate. Guatemala had the lowest lower secondary graduation rate and second lowest upper secondary graduation rates in Central America in 2017. Only Honduras (40 percent) had a lower upper secondary graduation rate.

Table 3 shows that boys generally have significantly higher enrollment and completion rates through lower secondary, but that girls have higher enrollment and completion rates of upper secondary and tertiary. Because of the higher rates at early grades, gender parity in the education pipeline skill skews towards men.

Guatemala is expected to improve at each stage of the education pipeline by 2040, but will still lag behind most regional and income peers. By 2040, Guatemalan primary survival rates (89 percent) will still be lower than Honduran primary survival rates today (90 percent). Lower and upper secondary graduation rates are projected to be lowest in the region by 2040, remaining well below current graduation rates in El Salvador.

The number of dropouts across primary and secondary school is expected to decline, but there are projected to be 70,000 missing primary students and 850,000 missing secondary students in 2040. IFs projects that gender equality in the education pipeline will narrow by 2040; women's rates of primary and secondary enrollment will still lag behind men, but primary completion rates are projected to be nearly equal by 2040.

Table 3: Education pipeline indicators, Guatemala, 2017 and 2040

		Primary Enrollment (Gross)	Primary Survival	Lower Secondary Enrollment (Gross)	Lower Secondary Graduation (Net)	Upper Secondary Enrollment (Gross)	Upper Secondary Graduation (Net)	Tertiary Enrollment (Gross)	Tertiary Graduation (Net)
2017	Male	118.0	77.5	78.2	53.7	55.3	39.2	20.4	4.6
	Female	106.7	76.8	70.2	55.0	56.3	41.1	23.7	4.6
	Total	112.5	77.2	74.3	54.4	55.8	40.1	22.1	4.6
2040	Male	111.6	87.2	81.4	68.2	63.6	54.6	26.0	7.9
	Female	105.7	90.5	78.5	69.9	67.0	60.0	31.5	7.9
	Total	108.7	88.7	80.0	69.0	65.3	57.2	28.6	7.9

Source: IFs 7.38.

Notes: Primary survival rate is the percentage of entrants in grade one who persist to the last grade of primary school. All enrollment figures are gross enrollment, or the number of students enrolled regardless of age divided by the typical school age population. Graduation figures represent the total number of graduates (the graduates may be of any age) divided by the population at the typical graduation age of the specified level.

To put some of these rates and numbers in perspective and show how the pipeline moves over time, we can follow a cohort of individuals (100 students) enrolling in primary school today and moving through the system. Approximately 77 out of the 100 primary aged children who enroll in grade one today will make it to the end of primary school and only 67 out of those 77 children will move from primary to lower secondary. In other words, of 100 students who start primary in the same cohort, 33 drop out before even entering lower secondary school. Of those 77 students who enroll in lower secondary, only 38 will graduate from lower secondary school and move on to enroll in upper secondary school. Of those 40 who make it to upper secondary, only 19 will graduate upper secondary school.

While Guatemala is projected to improve enrollment and completion rates across the education pipeline, students who enter school in 2040 will still be more likely to dropout than finish secondary school. Of a cohort 100 students starting primary school in 2040, only 32 are expected to graduate upper secondary school.

When put in a cohort perspective, the impact of the bottlenecks in the Guatemalan education system is powerful. Low survival rates at the primary level and low transition and graduation rates at secondary level mean that the pool of students that can move to higher levels of education narrows at each step. The pipeline should continue to improve, but education systems are slow moving. Improvements in primary survival rates over the next couple years will only be noticeable in 10 years (at the earliest).

Meanwhile, recent downward trends in Guatemalan enrollment and graduation rates coincide with broader trends in violence, economic growth and migration policies. As with overall improvements in the system, these recent trends may not manifest until more recent cohorts finish primary school and move on to secondary school. Further, the consistent downward trajectory of these indicators over the past 10 years may mean that the IFs education system projections are a bit too optimistic.

While trends and outcomes in the education pipeline and overall attainment are important indicators of overall education levels in Guatemala, they only part of the education story. Attainment and graduation rates do not fully capture the level of skills and quality of education provided across the system.

Education quality and learning achievement

Education quality is increasingly highlighted as an important aspect of economic growth and development, both across and within countries (Hanushek, Ruhose, & Woessmann, 2015). Recent studies have even suggested that improving education quality contributes more to growth performance than simply expanding attainment with the same quality (OECD, Hanushek, & Woessmann, 2015).

However, measuring and modeling education quality is an inherently challenging exercise. Global standardized data on education quality is difficult to obtain and education quality is influenced by a number of factors both inside and outside the education system.

Student achievement (as measured by test scores) across national, regional, and international exams is commonly measured at multiple grade levels, years, and subjects, making

comparability across countries and time particularly challenging. For example, the TERCE regional exam measures achievement level for 3rd and 6th graders in 2010, while the international TIMSS exam measures achievement for 4th and 8th graders in 2012. Many countries administer their own national, curriculum-specific exams to measure student achievement. However, given that these exams are prepared for the national education context, they are often not comparable across countries.

Further, modeling education quality is challenging because drivers of quality originate both within and outside the school. UNICEF (2000:3) states that education quality includes health and nutrition of students, safe, protective, and inclusive learning environments, relevant content and materials, appropriate student-centered teaching approaches, and appropriate methods to evaluate knowledge, outcomes, and skills. Systemic factors (drivers inside the school) include teacher quality and pedagogy, school infrastructure, access to books, materials and resources for learning, and spending on education. Structural factors (drivers outside the school) include household income, student health and nutrition, parental expectations, and child labor rates.

Measuring and modeling education quality

The education model in IFs uses average test scores at the primary and secondary level as the main indicators of education quality. IFs test score estimates are initialized from the World Bank Global Achievement database (Angrist et al, 2013). This database measures cognitive achievement for 128 countries around the world from 1965 to 2010 at the primary and secondary level and across three subjects – science, reading, and math – on scale from zero to 100.[9] IFs calculates and forecasts the overall score averaged across the three subjects for primary and secondary.

Test score forecasts by level are driven by adult educational attainment (average years of education) and education spending per pupil (relative to income).[10] Adult educational attainment provides an indication of the family and home environment, and serves as a proxy for teacher education and overall level of development (GDP per capita). Education spending per pupil (relative to GDP per capita) provides a proxy for overall education system resources such as school infrastructure and teacher pay.

Guatemalan test scores: a global perspective

Before analyzing Guatemalan test scores, it is important to place IFs estimated test scores in perspective. First, the scale ranges from 0 to 100 for each subject and for the overall average,

[9] The data are constructed from regional and global achievement tests, such as the Programme for International Student Assessment (PIRLS), Trends in International Mathematics and Science Study (TIMSS), and the regional tests, like SACMEQ, the Programme d'Analyse des Systemes Educatifs de la Confemen (PASEC), and the Laboratorio Latinoamericano de Evaluacion de la Calidad de la Educacion (LLECE), among others. Where data is unavailable, IFs estimates test scores by level and subject based on levels of average adult educational attainment and spending per pupil (relative to income).

[10] Spending per pupil (relative to income) is calculated as the percent of average per capita income spent on each student in each level. The impacts of this driver take effect only at values above/below expected level and are further adjusted for level of corruption and security/violence.

though all countries register scores between 20 and 60 across all levels and subjects. Globally, Montenegro scores the highest at the primary level (55) and Singapore scores the highest at the secondary (59.1) level. Burkina Faso has the lower primary scores (22), while Niger scores the lowest in secondary (31.9).

In 2017, Guatemalan primary average test scores (average of reading, science, math) were estimated at 30.1, the lowest average score among countries in Central America. Belize has the highest estimated score at 43. Including Caribbean countries, Guatemala's average primary test score is higher than only Haiti (28.5). Secondary achievement scores are similarly low. Guatemala's average secondary test score is estimated to be 39.3, which is among the lowest scores in the region –ahead of only Honduras (38.2), Haiti (38.8), Dominican Republic (39.2).

Guatemala's primary and secondary test scores fall below expectations for a country at its current level of development. IFs ranks Guatemala as 145th out of 186 countries for average primary test score, immediately behind Mozambique and ahead of Zambia; Guatemala's average secondary test scores ranks 137th, just behind Tanzania. To put that in perspective, Guatemala's estimated scores are the same as countries that register half or even a third of Guatemala's GDP per capita.

Table 4: Overall primary (left) and secondary (right) test scores by gender, selected years

		Primary			Secondary		
		Male	**Female**	**Total**	**Male**	**Female**	**Total**
Math	**2017**	32.2	32.2	32.2	42.1	41.8	42.0
	2040	37.0	37.1	37.0	45.8	45.6	45.7
Reading	**2017**	29.0	29.0	29.0	38.7	39.3	39.0
	2040	33.6	34.0	33.8	42.3	43.2	42.8
Science	**2017**	28.9	29.4	29.2	36.7	36.9	36.8
	2040	33.7	34.2	34.0	40.4	40.7	40.5
All	**2017**	30.1	30.2	30.1	39.2	39.4	39.3
	2040	34.8	35.1	34.9	42.8	43.1	43.0

Source: IFs 7.38.

The Current Path projects that scores at each level (and in each subject) will improve across the horizon, but Guatemala's progress will struggle to keep pace with gains observed in other countries. Guatemala's average primary and secondary test scores are projected to reach 34.9 and 43, respectively, by 2040. This would place Guatemala 146th in the world for primary average test scores and 147th for secondary average tests scores (both lower rank in 2040 than in 2017).

Guatemalan test scores: national and regional estimates and factors

Due to differences in testing methods and questions, national test scores and results from regional tests often cannot be easily compared across countries.[11] But, the takeaways from national and regional tests and analysis can shed some light on country- or region-specific trends and issues in educational quality.

According to the Guatemalan Ministry of Education, only 40 percent of sixth graders met national education standards in reading, and only 44 percent of sixth graders met standards in mathematics. Achievement is even lower among graduating high school students, of whom 26 percent achieved national standards in reading and just eight percent in math (Orozco & Valdivia, 2017).

According to the Third Regional Comparative and Explanatory Study (TERCE), a 15-country study of learning achievement administered to third and sixth grade students across Latin America and the Caribbean, students in Guatemala perform below the regional average across grades and most disciplines (Flotts et al., 2015). A follow-on report on TERCE scores goes on to say that Guatemala's relatively low rates of pre-primary enrollment (under 50 percent net enrollment), relatively high repeater rates (approximately 10 percent of primary students) and fairly low attendance scores (as measured by those who miss school twice or more per month) are all key contributors to low test scores (Trevino et al., 2015). But, the causes of these low indicators are difficult to isolate because they are often due to multiple interrelated systems and external factors.

The TERCE analysis of test scores suggests that socioeconomic status is the strongest indicator of academic performance – this effect is particularly strong in Guatemala. TERCE data also show that many children are forced to work while attending school, even in third and sixth grade. Regionally, Guatemala has one of the highest rates of child labor in third grade, with an estimated 8.9 percent of students also working (Trevino et al., 2015). The study finds that child workers perform worse academically, even when controlling for socioeconomic status.

Family expectations of performance also play a role in shaping conditions for student test score achievement. TERCE results estimated that 53 percent of families in the region expect their children to pursue tertiary education, but Guatemalan families surveyed were much less likely to hold these expectations (Trevino et al, 2015).

[11] The World Bank Global Achievement dataset does use some regional test scores to estimate and produce standardized test scores. The standardization process includes rigorous qualitative and quantitative comparison of scores produced by regional and global tests.

Box 3: Regional and ethnic disparities in education quality

The legacy of the PRONADE program also has had a lasting effect on ethnic and regional inequalities. Teachers in the PRONADE program were less experienced, had lower pay and benefits, and higher rates of turnover than public schools. Administrators often lacked resources, capacity, or capability to perform their duties (Meade, 2012).

Many schools still fail to deliver a curriculum tailored to the needs of rural and indigenous students (Posner, 2017). In general, students in the program had lower test scores, with indigenous students still performing worse than their ladino counterparts (Marshall, 2009; Meade, 2012). Among 9th graders, the percentage of non-indigenous students achieving national standards in math (30 percent) was more than double that of indigenous students (14 percent). Disparities were even greater for reading, where 31 percent of non-indigenous students met national standards, compared to nine percent of indigenous students (Orozco & Valdivia, 2017).

These inequalities also overlap with urban/rural disparities. Data from the Ministry of Education on student achievements finds students educated in the capital city score significantly higher (50 percentage points in 2014) on mathematics and reading than do those educated in more remote areas of the country (Orozco & Valdivia, 2017).

Pupil-teacher ratios, quality of the teachers, and education infrastructure also impact test scores. Despite being the most populous country in Central America, Guatemala's pupil-teacher ratios have improved over the past decade and a half, particularly at the primary level. Ratios at the primary level have fallen from 33 students per teacher in 2000 to 20 in 2015, and from 14 (in 2000) to 11 (in 2015) per teacher at the secondary level.

Today, Guatemala's average pupil-teacher ratio is on par with the average for upper-middle income countries. However, teachers in Guatemala tend to have lower-than-average levels of formal education. In fact, Guatemalan teachers have some of the lowest educational attainments in the region (along with Honduras and Nicaragua) (Trevino et al, 2015).

Further, less than 60 percent of students have the required textbooks in grade six and a lack of access to public secondary education prevents rural and poorer urban students from continuing education. As noted in the attainment section, over 50 percent of all secondary students attend private institutions.

Guatemala's average teacher educational attainment largely reflects the general lack of education attainment in the country. Improving overall attainment will take time, but expanding teacher training, access to school supplies, and public education infrastructure could be an avenue through which the government improves the education system in the short and long term.

Education spending and effectiveness

Spending on education is a key lever for governments and NGOs to improve attainment and quality, but equally important is spending effectiveness. Overall education spending (as a percent of GDP) and spending per pupil (both absolute and relative to income) in Guatemala lag

far behind regional and income peers. Further, poor government capacity and widespread corruption undermine spending effectiveness.

There are three key measures that can help assess levels of spending on education: total spending on education (as a percent of GDP), total per pupil spending on education by level (as a portion of GDP), and total per pupil spending by level (in absolute terms). Each of these measures tells us something different about how much is being spent on education in a given region or country.

According to data from World Development Indicators and UNESCO Institute for Statistics, public spending on education in Guatemala was around 2.9 percent of GDP in 2015. Guatemala spends less on education than every country in the region except El Salvador, behind Costa Rica (7.5 percent), Belize (6.6 percent), and Honduras (5.9 percent). Guatemala's level of public spending is also well below widely accepted targets (4 to 6 percent of GDP by 2030) for education spending defined by the UNESCO Global Education for All Muscat Agreement (2014). Along the forecast horizon, total education spending is forecast to remain between three and 3.5 percent of GDP, well below the UNESCO targets.

However, overall education spending as a percent of GDP fails to capture the whole spending story. Guatemala is a very young country – the median age is just under 22 years old and 34 percent of the population is under the age of 15 – whereas, in the OECD, only 18 percent of the population is under 15. This means that Guatemala must provide for more students (relative to the total population) than many OECD and more developed countries.

Spending per pupil, in both absolute and relative terms, serves as important measures because it takes demographics and student numbers into account. Per pupil spending (relative to GDP per capita)[12] in Guatemala is well below the Central American average. At the primary level, Guatemala spends 30 percent less than the regional average. At the secondary level this shortfall is even more pronounced; Guatemala's lower secondary spending per pupil (relative to GDP per capita) is half the regional average and upper secondary spending per pupil is one-third the regional average.

Per pupil spending (absolute) also paints a dire picture of education spending in Guatemala. Guatemala spends about half as much per primary pupil (absolute) than the Central America average. Central American average per pupil spending (absolute) is 2.5 times higher than the Guatemalan per pupil spending (absolute) at the lower secondary level and 4.5 times higher at the upper secondary level. Some of this discrepancy in absolute per pupil spending can be attributed to lower overall levels of income (GDP per capita), but it can also be traced to Guatemala's extreme low levels of overall government revenue.

Part of the current gap in education spending specifically may be due to the legacy of the PRONADE program and the prevalence of private institutions at the secondary level. The

[12] This measure refers to per pupil spending per GDP per capita, which is a measure of spending per student based on GDP per capita. It serves as a key benchmark for per pupil education spending relative to income levels, i.e. the portion of income that is devoted to education spending per student.

PRONADE program effectively devolved education provision from the national government to local communities in rural areas, after PRONADE programs ended in the 2000s total government spending on education (as a percent of GDP) increased significantly, but not enough to bring Guatemala on par with peers.

The Guatemalan government does not generate enough total revenue to meet education (and other) spending needs. Guatemalan government revenues stood at 12.5 percent of GDP in 2017, which is over seven percentage points less than the next lowest in the region (El Salvador). In fact, Guatemalan government revenue (as a percent of GDP) is one of the lowest in the world – it ranks 183 out of 186 countries in government revenue (as a percent of GDP).

Moreover, Guatemala registers one of the more corrupt and least effective governments in the region (above only Honduras and Nicaragua), which means that the little revenue that is collected is likely either diverted or is not used effectively. Currently, Guatemala ranks 3rd lowest in the region on government effectiveness, as measured by the World Bank and in transparency, as measured by Transparency International. Globally, Guatemala ranks 126th in transparency and 136th in government effectiveness, just below Mali and Gabon, respectively.

For education spending to have a positive impact on educational outcomes (both attainment and test scores), the Guatemalan government must improve its ability to both generate revenue and to effectively distribute that revenue where it is needed. That said, the Guatemalan education system has improved attainment despite tremendously low levels of education spending and government effectiveness.

The value of Current Path improvements in education

The Current Path projects improvement in the overall stock of education quality and quantity in Guatemala. But what is the impact of this continued progress? What are the possible impacts of stagnation in education outcomes? To try and demonstrate the value of education in Guatemala moving into the future, we simulated a world in which improvements in educational attainment and quality completely stall and compared it to the Current Path.[13] Below we explore the Current Path education gains (and their effects on other sectors) to demonstrate the importance of projected progress across the education system.

The Current Path education system improvements in Guatemala will have significant impacts on the future development of the country. As the stock and quality of education in the region improves, those who enter the labor force are more skillful and are able increase overall productivity in the economy. We estimate that projected improvements in educational attainment and quality will contribute $61.5 billion in overall GDP between 2018 and 2040, which is slightly more than the total GDP output of Guatemala today.

[13] In the stalled education world, average educational attainment remains the same out to the 2030's in both Central America and the Caribbean, before declining slightly out to 2060. Average attainment begins to fall in each region as older educated individuals begin to die, but younger individuals lack the education necessary to increase the overall stock of education in society.

Current Path improvements in education also contribute to slight reductions in inequality, as education access and quality expands so too do the gains across the population. Current Path educational progress reduces the number of people living in poverty by nearly 800,000 people by 2040. Further, the additional reductions in inequality and acceleration of population ageing from improved education outcomes contribute to a 5.5 percent decline in homicides by 2040.

Lastly, the economic gains and reductions in societal violence from continued investment in education reduce migration out of Guatemala. Increased economic output increases economic opportunity and reduced violence lowers the impetus for individuals to flee the country. As such, Current Path improvements in education reduce emigration by a total of 9,000 individuals between 2018 and 2040.[14]

Because education systems are slow moving - children must move through levels of education sequentially to get to the next step and eventually the workforce - the gains from Current Path improvements in education are even more pronounced in the extreme long-run.

Educational improvement along the Current Path scenario will contribute a total of $697 billion (11 times current GDP) between 2018 and 2060. Further, Current Path improvements are expected to reduce the number of those in poverty by nearly 2.7 million and reduce the number of homicides by 18 percent (1,500 homicides) in 2060. Finally, total emigration from Guatemala is expected to be reduced by 71,000 individuals between 2018 and 2060 due to gains from educational improvements along the Current Path.

Comparing the Current Path to a world in which education improvements cease helps to show the importance of continued gains in education for overall development. These projected education gains have significant impacts of overall economic output, poverty reduction, societal violence, and migration. Moreover, if Guatemala can improve upon this Current Path, the country could see additional benefits across the education system and overall development.

Exploring alternative futures

The previous sections outline the historical trends, presented the Current Path of key education indicators and the value of Current Path investment, and identified challenges and bottlenecks in educational attainment and quality in Guatemala. The next step is to construct scenarios that simulate changes in key indicators and leverage points identified by this analysis.

Scenario construction and analysis is one of the key uses of the IFs tool and can help policymakers better understand the effects of interventions in and across key sectors. The

[14] Using this metric, IFs forecasts the annual flow of Guatemalan migrants. Projected migration numbers differ from the total stock of migrants residing outside of Guatemala. The model used to make projections relies on understandings of stocks and flows. Abel (2016) uses the stock of foreign-born population living in each country on a bilateral basis (provided by the United Nations Population Division) to estimate the flows of people moving from one country to another (not those moving temporarily). The data include adjustments for undocumented workers but not those who move seasonally or who traverse the border multiple times in a given year (or who are caught and returned by border patrol). For more information see the 'IFs Modules added for this project' section.

following section will present a number of different scenarios that simulate improvements in the drivers of educational attainment and test scores. Each scenario presented here is a compilation of key interventions across a number of education indicators over time.

Each scenario is built upon and compared to the Current Path of development across indicators – the Current Path provides a baseline of assessment that is grounded in the current trajectory of trends and dynamics in Guatemala. Further, because education systems change slowly and effects of interventions in the education system do not fully manifest until far into the future, we show results in both 2040 and 2060.

Below we present two scenarios that aim to tackle different questions and present different futures for the education system in Guatemala. The first scenario rapidly improves the Guatemalan education system to 'fill' the education pipeline with carefully sequenced interventions. This is meant to simulate a push to 'ensure that all girls and boys complete free, equitable and quality primary and secondary education' (SDG 4.1). This scenario is an extremely ambitious scenario that aims to explore benefits and costs of a huge policy and spending push to give every child an education.

The second scenario aims to show the effect of targeted interventions at different levels of the education pipeline over the next five years (to coincide with the USAID CDCS five year planning periods). This scenario simulates a spending and policy push to reach ambitious but reasonable targets for improving the Guatemalan education system through 2023. It explores the benefits and costs of the scenario out to 2040 and 2060.

SDG achievement scenario

This scenario simulates a sequenced push to achieve SDG goal 4.1 which aims to ensure 'that all girls and boys complete free, equitable and quality primary and secondary education'. It represents a very ambitious scenario to get Guatemala to 'full' enrollment and graduation across primary, lower secondary, and upper secondary levels by 2030. Concurrently, it boosts Guatemalan test scores across levels to Costa Rican levels. This scenario is meant to showcase the immense benefits (and costs) of educating every child in Guatemala.

Table 5: SDG achievement scenario details

Variable(s)	Intervention	Time period
Full primary school	Increases the primary survival rate and transition rate between primary and secondary to 100%.	By 2026
Full lower secondary school	Increases lower secondary graduation and primary to lower secondary transition rates to 100%.	By 2028
Full upper secondary school	Increases upper secondary graduation and lower to upper secondary transition rates to 100%	By 2030
Improved test scores	Improves primary and secondary test scores to Costa Rican levels.	By 2030

The *SDG achievement* scenario improves average adult education attainment and adult average test scores by seven percent by 2040 and, by 2060, it improves average adult attainment by 12 percent and average adult test scores by 13 percent. In this scenario, over 730,000

additional adults will have completed primary school and 2.1 million additional adults will have completed secondary school by 2040.

By 2060, the number of additional adults who have completed primary school is projected to remain fairly similar, but the number of additional adults who complete secondary school will increase to nearly five million. Further, primary tests scores are projected to reach levels seen in Cyprus today and secondary test scores are projected to reach levels currently seen in the Netherlands, both of which currently rank amongst the top 10 globally.

This increase in educational attainment and quality also produces benefits across other development systems. Table 6 below shows the impact of the *SDG achievement* scenario across key indicators.

Table 6: Various outcome indicators, Guatemala, 2040 and 2060

	GDP (billion $)	GDP per capita (thousand $)	Informal labor (millions)	Skilled labor (millions)	Emigration (thousands)	Poverty (millions)	Homicide (per 100,000)
In 2040							
Current Path	146.9	6.20	4.22	2.92	28.74	3.81	33.7
SDG Achievement	157.5	6.71	3.98	3.02	27.81	3.26	32.9
Difference	10.6	0.51	-0.25	0.10	-0.93	-0.55	-0.8
In 2060							
Current Path	261.8	9.55	3.47	3.85	30.26	3.41	27.4
SDG Achievement	335.8	12.36	2.85	4.03	27.26	2.08	25.2
Difference	74.0	2.81	-0.62	0.18	-3.00	-1.33	-2.2

Source: IFs 7.38.

The increases in the total stock and quality of education under *SDG achievement* scenario significantly increases economic potential and output (total and per person) over the forecast horizon. Under this scenario the number of skilled workers is 100,000 (3.4 percent) higher and the number of informal workers is 248,000 (5.8 percent) lower than under the Current Path in 2040. This, in turn, improves productivity of the economy as whole; by 2040, total GDP is $10.6 billion (7.2 percent) higher and GDP per capita is $514 (8.3 percent) higher than along the Current Path. Put another way, total additional economic output (GDP) amounts to $60.3 billion (cumulative) between 2019 and 2040.

These enormous gains in economic output, paired with a slight reduction in inequality, pull 550,000 people out of poverty (those living on less than $3.10 per day) by 2040. However, the *SDG Achievement* does not get at the core issues that sustain long term economic inequality. Increasing education access does not necessarily change the government's ability to provide other services to vulnerable populations and, even in 2040, much of the population remains in the in the informal sector, which has little to no institutional social safety net. Nonetheless, the slight reduction in inequality, along with slight reductions in the relative size of the youth population, does reduce the homicide rate by about 2.3 percent (280 homicides) by 2040.

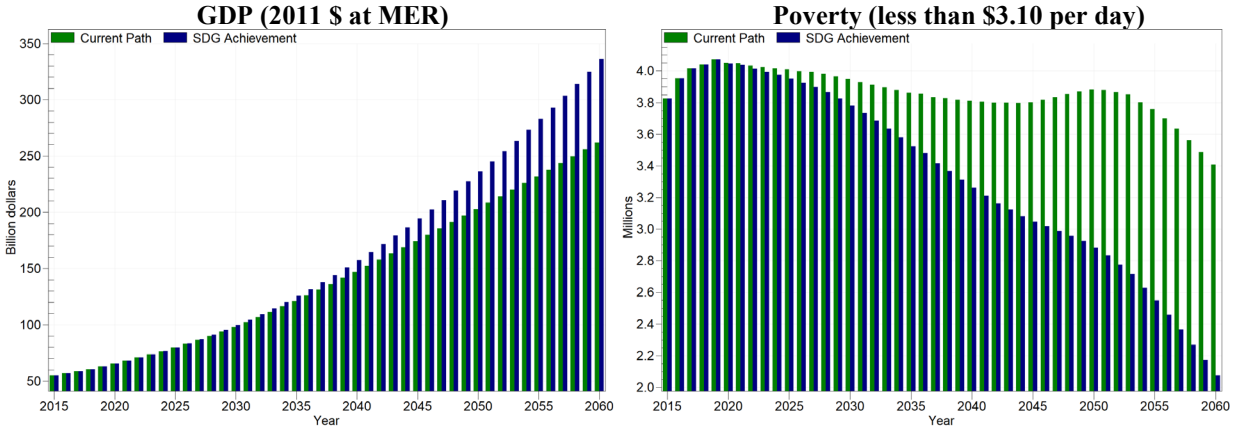
Finally, the increase in economic growth and wider provision of quality education reduces the impetus for Guatemalans to emigrate. By 2040, emigration from Guatemala is reduced by 3.2 percent and a cumulative 7,000 fewer Guatemalans emigrate between 2019 and 2040.

While the effects of the *SDG Achievement* scenario are significant in 2040, they do not capture the full impact of this type of scenario. Even by 2040 the students who entered primary school in 2030 will not be in the workforce for at least another two years. However, by 2060, those who benefitted from the scenario will all be in the workforce.

By 2060, the compounding positive effects of the *SDG Achievement* scenario further improve Guatemalan development across the indicators above. In the year 2060, total GDP is $74 billion (28 percent) higher and GDP per capita is $2,807 (29 percent) higher. The scenario also reduces the homicide rate by eight percent (673 homicides) and results in a 10 percent (3000 people) reduction in emigration in 2060.

All in all, the *SDG Achievement* scenario generates a cumulative increase in GDP of $820 billion (13.5 times current GDP). This gain is represented in Figure 5 (left) by the total difference (added across years) between the blue and green bars out to 2060. Further, 1.33 million (39 percent) fewer people live on less than $3.10 per day in 2060, represented in Figure 5 (right) by the gap between the green and blue bars in 2060. Lastly, these gains in growth and reductions in poverty result in a cumulative decrease of 47,000 (0.27 percent of total current population) emigrants from Guatemala between 2019 and 2060.

Figure 5: GDP and poverty (Current Path and SDG Achievement scenario), Guatemala, 2015 to 2060



Source: IFs 7.38.

Costs of the SDG Achievement scenario

Ensuring that all children in Guatemala receive a quality education through secondary school clearly has immense benefits, but it also requires significant political will and mobilization of resources. As such, we calculated an estimated minimum cost of achieving SDG 4.1 by 2030 for Guatemala.

To calculate the cost of this intervention we estimated the additional per pupil cost (relative to income) needed to improve test scores to Costa Rican levels by 2030 and applied that cost to

all students entering the system in the *SDG Achievement* scenario out to 2060. We then subtracted the cost of the Current Path scenario (calculated using the same method) to arrive at a minimum additional cost for the *SDG Achievement* scenario.

As outlined in the sections above, Guatemalan education spending is one of the lowest in the region and the world, which means that the country must increase spending across all levels by a significant amount to reach full enrollment/graduation and test score levels commensurate with Costa Rica. If Guatemala increases spending per pupil to levels seen in Costa Rica to achieve full enrollment and increase test scores across primary and secondary, the total additional cost amounts to $190 billion by 2060.

This cost could be reduced if Guatemala improves government efficiency and reduces corruption alongside increases in education spending. If Guatemala is able to increase the efficiency of spending per pupil by 15 percent, the additional cost of an SDG Achievement scenario could be reduced to $162 billion by 2060, which represents $28 billion in cost savings by 2060.

Without improvements in government efficiency of spending effectiveness, the returns of the investment in the *SDG Achievement* scenario are more than four-fold by 2060. If the Guatemalan government increases the efficiency of education spending by 15 percent by 2030, the return on the investment in the *SDG Achievement* scenario could be five-fold by 2060.

A push to achieve SDG 4.1 by 2030 would cost a significant amount on the front end (2019 through 2030) either way. Guatemala would need to spend an additional $26 billion (43 percent of current GDP) on education by 2030 if spending efficiency does not improve and $20 billion (33 percent of current GDP) if spending efficiency is improved by 15 percent over the same time horizon. Both of which are far higher than the $4.9 billion cumulative GDP gains from the *SDG Achievement* scenario by 2030.

In fact, Guatemala's investment in achieving SDG 4.1 would not 'pay off' until the mid to late 2030's under either cost scenario. As the students who received a quality education through secondary school begin to move into the workforce, gains from improved skills and education begin to manifest and the economy sees large boosts every year through the 2060 time horizon.

The *SDG Achievement* scenario is a very ambitious one, but it illustrates the immense societal benefits of getting every child a quality education through secondary school. It also helps to illustrate the need from long-term thinking in education. The costs of the SDG Achievement scenario are large and the benefits to society take a long time to materialize. This type of scenario requires a huge amount of policy will and spending over a long period of time to achieve, but the long-term benefits do far outweigh the costs.

5-year education push

The *5-year education push* scenario is meant to represent a scenario that simulates a world in which authorities and donors improve key areas in the Guatemala education system over the next 5 years. This scenario represents a shorter policy timeline that aligns with USAID 5-year CDCS planning periods and is an attempt to provide an ambitious, but reasonable set of interventions to improve the Guatemalan education system to the Central American average.

This scenario simulates an increase in primary and secondary enrollment, transition, and graduation rates to move students through the education system and increase overall educational attainment and quality over the next five years. It assumes an increase anywhere between five to 15 percent over the Current Path projection for primary and secondary test scores and survival, transition, and graduation rates from 2018 to 2023 (and maintains that effort/difference out to 2060).[15] This increase pushes Guatemalan primary survival, and secondary enrollment, transition, and graduation rates to or slightly below the Central American average for each by 2023.

Table 7: 5-year education push scenario details

Variable	Intervention	Explanation/Benchmarking
Primary survival rate	Increases primary survival rate from 77% today to 90% by 2023. This represents a 12.5% increase compared to the Current Path (80%) in 2023.	Guatemala has seen similar increases in primary survival rates in the past - from 2011 to 2016 primary survival increased by 15%. This intervention brings Guatemala in line with the Central American average in primary survival.
Primary test scores	Increases average primary test scores from 30 today to 35 in 2023. This represents a 12% increase compared to the Current Path (31.4) in 2023.	Given the dearth of data in globally comparable estimates of test scores, it is difficult to benchmark this historically. This intervention brings Guatemala in line with the Central American average in primary test scores in 2023.
Primary to lower secondary transition rate	Increases primary to lower secondary transition rate from 85.5% today to 96% by 2023. This represents an 11% increase compared to the Current Path (86.6%) in 2023.	This increase in the transition rate is double the rate of increase seen in the 1980's and a fourth of the rate of increase seen in the late 1970s. It brings Guatemala to the Central American average by 2023.
Lower secondary graduation rate	Increase lower secondary graduation rates from 55% today to 67% in 2023. This represents a 15% increase compared to the Current Path (58%) in 2023.	This intervention brings Guatemala to just below the Central American average in 2023.
Lower to upper secondary transition rate	Increases secondary transition rates from 93% today to 98% in 2023. This represents a 5% increase compared to the Current Path in 2023.	This brings Guatemala just below Costa Rican and Honduran secondary transition rates by 2023.

[15] See Appendix B for intervention details.

Variable	Intervention	Explanation/Benchmarking
Upper secondary graduation rate	Increases upper secondary graduation rates from 40.5% today to 51.5% in 2023. This represents a 15% increase compared to the Current Path (44.5%) in 2023	This intervention brings Guatemala to just below the Central American average in 2023.
Secondary test scores	Increases average secondary test scores from 39.5 today to 42 in 2023. This represents a 5% increase compared to the Current Path (40) in 2023	Given the dearth of data in globally comparable estimates of test scores, it is difficult to benchmark this historically. This intervention bring Guatemala in line with the Central American average in primary test scores in 2023.

The *5-year education push* improves average adult educational attainment and average adult test scores by four percent by 2040 and, by 2060, it improves average adult attainment by 5.5 percent and average adult test scores by 6.7 percent. In this scenario, 670,000 more people will have completed primary school and 860,000 more have completed secondary school by 2040.

By 2060, the number of additional adults who complete primary remains similar, but the number of adults who complete secondary school jumps to 1.7 million. Further, by 2060, primary test scores reach levels seen in Belgium today (ranked 40th in the world), and secondary test scores reach levels seen in Puerto Rico today (ranked 49th in the world).

As with the *SDG Achievement* scenario, this increase in educational attainment and quality positively impacts other key development systems. Table 8 below shows the impact of the *5-year education push* across key indicators.

Table 8: Various outcome indicators, Guatemala, 2040 and 2060

	GDP (billion $)	GDP per capita (thousand $)	Informal labor (millions)	Skilled labor (millions)	Emigration (thousands)	Poverty (millions)	Homicide (per 100,000)
In 2040							
Current Path	146.9	6.20	4.22	2.92	28.74	3.81	33.7
5-year push	152.5	6.45	4.15	2.96	28.28	3.57	33.4
Difference	5.6	0.26	-0.08	0.04	-0.46	-0.25	-0.3
In 2060							
Current Path	261.8	9.55	3.47	3.85	30.26	3.41	27.4
5-year push	295.1	10.80	3.24	3.94	28.81	2.75	26.6
Difference	33.3	1.25	-0.23	0.08	-1.46	-0.66	-0.8

Source: IFs 7.38.

The increases in the total stock and quality of education under *5-year education push* scenario significantly increases economic potential and output (total and per person) over the forecast horizon. Under this scenario the number of skilled workers is 40,000 (1.3 percent) higher and the number of those working informally is 80,000 (1.8 percent) less than under the

Current Path in 2040. This, in turn improves productivity of economy as whole; by 2040, total GDP is $5.6 billion (3.8 percent) higher and GDP per capita is $260 (4.1 percent) higher. Total additional economic output (GDP) amounts $34 billion (cumulative) between 2019 and 2040.

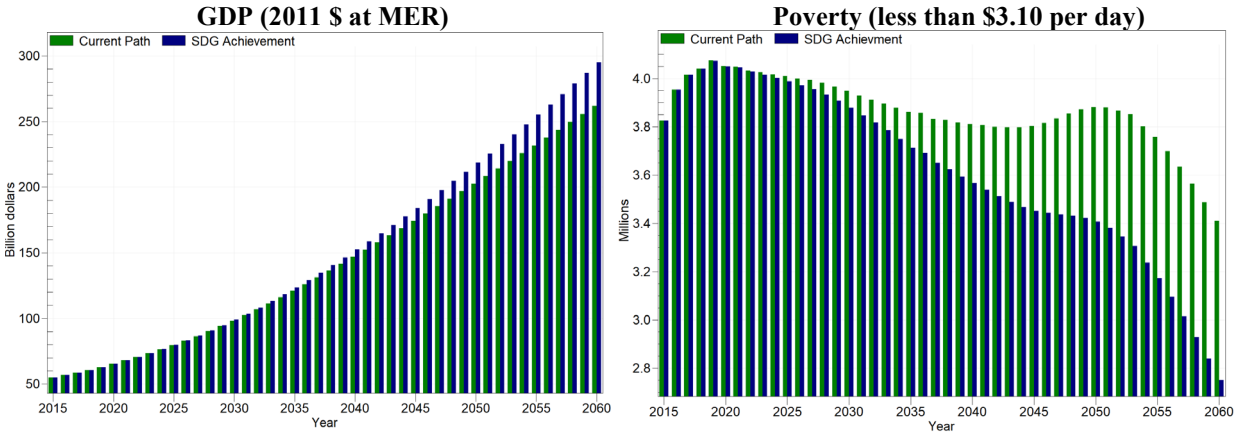
The *5-year education push* scenario also reduces inequality by providing education to all populations, but, as with the *SDG Achievement* scenario, it does not get at the core issues that sustain long term economic inequality. Nonetheless, the slight reduction in inequality, paired with the enormous gains in economic output, pull 245,000 people out of poverty (those living on less than $3.10 per day) by 2040. Further, the slight reduction in inequality, along with slight reductions in the relative size of the youth population, reduces the homicide rate by about 0.9 percent (88 homicides) by 2040.

Finally, the increase in economic growth and wider provision of quality education reduces the impetus for Guatemalans to emigrate. By 2040, emigration from Guatemala is reduced by 1.6 percent and a cumulative 3,600 fewer Guatemalans emigrate between 2019 and 2040.

As with the *SDG Achievement* scenario, full impact of the *5-year education push* scenario does not manifest until further down the line. By 2060, the compounding positive effects of the *5-year education push* scenario further improve Guatemalan development across the indicators above. In the year 2060, total GDP is $33.3 billion (12.7 percent) higher and GDP per capita is $1,250 (13 percent) higher. The scenario also reduces the homicide rate by 2.9 percent (262 homicides) and results in a nearly 4.8 percent (nearly 1,500 people) reduction in emigration in 2060.

All in all, the *5-year education push* generates a cumulative increase in GDP of $390 billion (6.4 times current GDP). These cumulative gains are represented in Figure 6 (left) by the sum of the difference between the blue and green bars (across all years). Further, 660,000 (19 percent) fewer people are living on less than $3.10 per day in 2060, represented in Figure 6 (right) above as the difference between the green and blue bars in the year 2060. Finally, these economic and poverty gains result in a cumulative decrease of 23,000 (0.13 percent of total current population) emigrants from Guatemala between 2019 and 2060.

Figure 6: GDP and poverty (Current Path and 5-year push scenario), Guatemala, 2015 to 2060



Source: IFs 7.38.

Costs of the 5-year education push scenario

Because Guatemala spends so little on education currently, it would be difficult for the country to achieve the *5-year education push* without additional spending. To estimate the cost of this intervention we estimated the additional per pupil cost (relative to GDP per capita) needed to improve test scores to Central American averages by 2030 and applied that cost increasing to all students entering the system in the *5-year education push* scenario out to 2060. We then subtracted the cost of the Current Path scenario (calculated using the same method) to arrive at a minimum additional cost for the *5-year education push* scenario.

If Guatemala increases per pupil spending (relative to GDP per capita) to the Central American average by 2030, the cost of the *5-year education push* reaches $100 billion (160 percent of current GDP) by 2060. This represents nearly a four-fold return on investment over the long-run.

However, as with the *SDG Achievement* scenario, the costs of *5-year education push* scenario out weight the benefits over the near to medium term. The students who fully benefit from the *5-year education push* scenario won't enter the workforce until at least 2030, which means that full benefit from the additional skills those students gain won't be realized for at least 12 years. In fact, the cost of the *5-year education push* outweighs the benefits until the mid-2040's, after which the cumulative benefits to the economy begin to push far above the total costs.

If Guatemala is able to increase per pupil spending (relative to GDP) to the Central American average by 2030 and increase the efficiency of that spending by 15 percent by 2030, the cost of the *5-year education push* falls to $77 billion (128 percent of current GDP) by 2060. This would increase the return on investment to over five-fold over the long-run. The costs of the scenario would still outweigh the benefits in the near to medium term, but the cumulative benefits of would surpass the costs by the late 2030s rather than the mid-2040s.

Conclusion and policy recommendations

The Guatemalan education system has improved overall since the middle of the 20th century, however the country started from a very low base across education indicators and still lags far behind regional peers. Further, education indicators suggest that progress across the system has stalled in recent years. Primary enrollment and survival rates have dropped and the percent of the population with secondary and tertiary schooling has declined. Guatemalan primary test scores are the lowest in Central America, while its secondary test scores are second lowest. Furthermore, average adult educational attainment lags far behind all other countries in Central America.

IFs projects that Guatemalan education will gradually improve over the next 40 years. The Current Path forecasts that scores at each level (and in each subject) will improve and that primary survival, secondary enrollment, and secondary graduation rates will increase as overall development and economic growth persist. These continued improvements in education outcomes are expected to contribute over $60 billion in overall output and pull nearly 800,000 people out of poverty over the next 22 years. That said, Guatemala is expected to struggle to keep pace with other countries and the gap between the Guatemala education system and peers is expected to widen.

Several factors explain the current shortcomings and modest forecasts across the Guatemalan education system, most of which relate to education spending and effectiveness. Guatemala's per pupil spending (both absolute and relative to GDP per capita) and total spending (as a percent of GDP) on education lag far behind regional and income peers. Further, limited government capacity and extensive corruption exacerbate the spending issue by reducing the effectiveness of the funding that does go towards education. In other words, the first step in improving the education system in Guatemala is to increase resources allocated to education and to improve the effectiveness and reach of those resources.

Specifically, resources should be directed toward improving primary school outcomes and secondary school access. Our assessment of the education sector in Guatemala shows that the largest bottleneck in the education system exists in the transition from primary to lower secondary school. Many students do not make it to the final grade of primary school and even less are able to move on and succeed in secondary school. Targeted interventions to improve test scores and completion rates in primary school and improve access to secondary school would be important steps in a strategy to improve the education system overall.

This report proposes two education scenarios that accelerate education system progress in Guatemala, both of which boost the country's relative performance across primary and secondary school and generate gains across several development indicators. The first is an *SDG Achievement* scenario, which simulates the achievement of Sustainable Development Goal (SDG) 4.1 by 2030. The second is the *5-year education push* scenario, which represents a push to meet primary and secondary education outcomes of regional peers by 2030.

Both scenarios produce immense gains across the education system and key development indicators, but the full benefits of each education scenario take a long time to manifest. The costs outweigh the overall output gains until the mid-2030s in both scenarios, but, by 2060, both scenarios produce a four-fold return on the minimum investment needed to achieve improved education outcomes. The ambitious *SDG Achievement* scenario adds over $800 billion in total GDP output, reduces poverty by nearly 40 percent, and reduces emigration from Guatemala by a total of 47,000 individuals by 2060 (compared to the Current Path). Meanwhile, the *5-year education push* adds over $390 billion in total GDP, reduces poverty by 19 percent, and reduces emigration by a total of 23,000 individuals by 2060 (compared to the Current Path).

These results highlight both the need for long term thinking and planning in the education sector and the immense benefits of investing in the education system. Education should be a foundational element of the human development strategy in Guatemala and these scenarios show the substantial positive effects of investing in students. The country has some of the poorest education outcomes in Central America and will continue to underperform unless more resources are allocated toward the education system.

The findings in this report are based on analysis conducted using the IFs platform, a quantitative modeling tool, to develop scenarios that can be used to assess the impacts of education investments. IFs uses data and a mix of different quantitative modeling approaches to provide an alternative way to think about tradeoffs in policymaking. Because education is modeled within IFS, as are the economy, violence and migration, we can shed light on the effects of education investments on these other outcomes. In the IFs model, education has direct (and

indirect through other modules) effects on the economy (GDP and inequality) and labor. Education affects violence and migration indirectly through its impacts on the economy and labor. We believe that IFs provides a good way to help frame this work in the future, though we recognize that there is not a large literature documenting these relationships that affected the modeling choices made, and the relationship and findings are affected by the quality of the data. As more information is available on these relationships, modeling can be updated.

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Appendix 1: Educational attainment and quality model in IFs

The education model of IFs simulates patterns of educational participation and attainment in 186 countries over a long time horizon under alternative assumptions about uncertainties and interventions (Irfan 2008). Its purpose is to serve as a generalized thinking and analysis tool for educational futures within a broader human development context.

Educational attainment model

The model forecasts gender- and country-specific access, participation and progression rates at levels of formal education starting from elementary through lower and upper secondary to tertiary. The model also forecasts costs and public spending by level of education. Dropout, completion and transition to the next level of schooling are all mapped onto corresponding age cohorts thus allowing the model to forecast educational attainment for the entire population at any point in time within the forecast horizon.

From simple accounting of the grade progressions to complex budget balancing and budget impact algorithm, the model draws upon the extant understanding and standards (e.g., UNESCO's ISCED classification explained later) about national systems of education around the world. One difference between other attempts at forecasting educational participation and attainment (e.g, McMahon 1999; Bruns, Mingat and Rakotomalala 2003; Wils and O'Connor 2003; Delamonica, Mehrotra and Vandemoortele. 2001; Cuaresma and Lutz 2007) and our forecasting, is the embedding of education within an integrated model in which demographic and economic variables interact with education, in both directions, as the model runs.

We emphasize the inter-connectedness of the components and their relationship to the broader human development system. For example, during each year of simulation, the IFs cohort-specific demographic model provides the school age population to the education model. In turn, the education model feeds its calculations of education attainment to the population model's determination of women's fertility. Similarly, the broader economic and socio-political systems provide funding for education, and levels of educational attainment affect economic productivity and growth, and therefore also education spending.

Educational quality model

Education quality is a recent addition to the International Futures (IFs) education model. This part of the model compares and forecasts quality of learning at the educational levels of primary and secondary for 186 model countries. To initialize the quality variables IFs model pre-processor uses the World Bank Global Achievement database of country scores in international achievement tests or regional equivalent of such tests in the test areas of reading, science and math. There is a total of eight new variables, four for primary and four for secondary. At each level, there are three subject area scores – science, math and reading – and an overall score. The scores will be further disaggregated by sex of the student depending on the availability of necessary data.

Test score forecasts in our model are driven by average educational attainment of the adults as an aggregate indicator of family environment and expenditure per student as an indicator of the quality of the school system. Each of the subject area scores are regressed against these

variables using data for the base year or the most recent year with data. The regression relationships compute the scores in the forecast-years using values for the independent variables obtained from other IFs models. Any difference in scores obtained from historical database with those obtained from regression is considered as a country-specific situation. The base-year country shifts in the scores, added to the regression output in the subsequent years, decrease gradually as the country merge towards the general relationship.

Some researchers have discovered that the quality of education is an important determinant of economic growth and productivity. The education quality model contains a forward linkage from learning quality to economic productivity. This linkage is implemented through the introduction of an elasticity of productivity to learning quality.

Data for education quality are initialized in the model using the global education dataset from the world bank. This dataset does not provide education quality disaggregated by gender. 8 variables are initialized namely education quality at the primary level (Math, Science, Reading, Total) and at the secondary level (Math, Science, Reading, Total).

Appendix 2: Details of scenario interventions

Scenario name	Parameter name	Parameter description	Base value	Changed value	Justification for intervention
Stalled Education	edyrsagm	Years of Education Multiplier	1	0.55	Simulates a decrease of years of education attained by 45%
5- year push	edprisurm	Education, primary, survival rate, Multiplier	1	1.125	Simulates a 12.5% increase in survival rate in primary education in Guatemala over a 5 year period
5- year push	edqualpriallm	Education, quality, multipler on primary	1	1.125	Simulates a 12.5% increase in education quality in primary education in Guatemala over a 5 year period
5- year push	edseclowrtranm	Education, Lower Secondary, transition rate, Multiplier	1	1.1	Simulates a 10% increase in transition rate in lower secondary education in Guatemala over a 5 year period
5- year push	edseclowrgram	Education, Lower Secondary, Graduation rate, Multiplier	1	1.15	Simulates a 15% increase in graduation rate in lower secondary education in Guatemala over a 5 year period
5- year push	edqualsecallm	Education, quality, multipler on secondary	1	1.05	Simulates a 5% increase in education quality in secondary education in Guatemala over a 5 year period
5- year push	edsecupprtranm	Education, Upper Secondary, transition rate, Multiplier	1	1.05	Simulates a 5% increase in transition rate in upper secondary education in Guatemala over a 5 year period
5- year push	edsecupprgram	Education, Upper Secondary, Graduation rate, Multiplier	1	1.15	Simulates a 15% increase in graduation rate in upper secondary education in Guatemala over a 5 year period
SDG Achievement	edpriintntrgtyr	Education, Primary, Net Intake Rate, Target Year	0	11	Simulates an increase of net intake at the primary rate to 100% by 2030, thus achieving SDG
SDG Achievement	edprisurtrgtyr	Education, Primary, Survival Rate, Target Year	0	11	Simulates an increase of survival at the primary rate to 100% by 2030, thus achieving SDG
SDG Achievement	edseclowrtrantrgtyr	Education, Sec Lower, Transition Rate, Target Year	0	13	Simulates an increase of transition at the lower secondary rate to 100% by 2030, thus achieving SDG

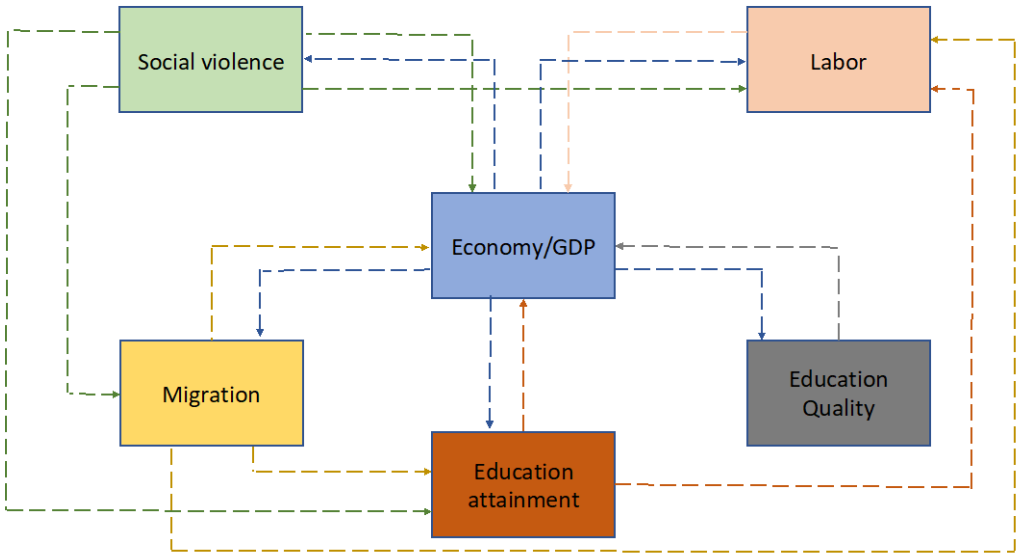
Scenario name	Parameter name	Parameter description	Base value	Changed value	Justification for intervention
SDG Achievement	edseclowrgratrgtyr	Education, Sec Lower, Graduation Rate, Target Year	0	13	Simulates an increase of graduation at the lower secondary rate to 100% by 2030, thus achieving SDG
SDG Achievement	edsecupprtrantrgtyr	Education, Sec Upper, Transition Rate, Target Year	0	14	Simulates an increase of transition at the upper secondary rate to 100% by 2030, thus achieving SDG
SDG Achievement	edsecupprgratrgtyr	Education, Sec Upper, Graduation Rate, Target Year	0	14	Simulates an increase of graduation at the upper secondary rate to 100% by 2030, thus achieving SDG
SDG Achievement	edtergradgr	Education, tertiary, graduation rate, annual growth	0	0.8	Simulates a 20% decrease in tertiary graduation rate
SDG Achievement	edqualpriallm	Education, quality, multipler on primary	1	1.185	Simulates an increase in primary education quality by 18.5%
SDG Achievement	edqualsecallm	Education, quality, multipler on secondary	1	1.135	Simulates an increase in primary education quality by 13.5%

Appendix 3: Modelling documentation

IFs integrates variables across 186 countries and 12 core systems, including: agriculture, demographics, economics, education, energy, environment, finance, governance, health, infrastructure, international politics, and technology (see Figure 1 in the Methodology section of the report). The sub-models for each system are dynamically connected, so IFs can simulate how changes in one system may lead to changes across all others. As a result, IFs endogenizes more variables and relationships from a wider range of key development systems than any other model in the world.

Education attainment and the new model additions - education quality, labor market dynamics (with updated data), societal violence, and bilateral migration – are fully integrated within the broader IFs platform (see Figure 1). These additions are endogenized within the broader modeling framework and have been developed using a combination of literature and statistical analysis. While there are "hard links", or connections in which one variable impacts another through (potentially) multiple separate links within the model, between each of these model additions (discussed in more detail below), Figure 1 captures the effects observed if changes are made to the module included in a scenario. [16]

Figure 1: Model connections



Education quality and attainment, variables on which this report focuses, have hard links in the model to the other variables of interest in this report, namely the economy/GDP, labor, societal violence, and migration. Education has direct (and indirect through other modules) effects on the economy (GDP and inequality) and labor. Education affects violence and migration indirectly through its impacts on the economy and labor.

[16] Note: The economy/GDP and labor are all connected to migration, violence, and education in the IFs model, but the effects may not be observed in the particular scenario. This figure is not exhaustive of all connections between variables in IFs.

Specifically, education quality impacts human capital, which affects multifactor productivity (MFP), which drives GDP. Economic factors influence other variables in the model, including emigration and violence. This is because voluntary emigration is driven in part by the ratio of household income between the home and destination countries. Also, the youth bulge and inequality (GINI co-efficient), which are affected by demographics and the economy (both of which are affected by education), drive homicides.

Also, educational attainment influences the total fertility rate (TFR), which affects the population size, influencing GDP per capita (providing another channel through which education can impact the economy). Attainment also impacts the skill profile of workers, which influences labor dynamics. By pushing cohorts through the education system, the SDG achievement scenario generates a more highly educated workforce. A change in the labor force can influence the GINI, impacting societal violence.

Labor impacts the economy through its effect on economic output. Further, there is a hard link between labor and violence whereby labor impacts the GINI coefficient, which influences societal violence. Labor's effects on the economy also impact migration and education.

Societal violence also has hard links to the additions in this report. Homicides and government risk and instability impact forced migration. Further, violence impacts education via the security index. Violence can affect labor through homicides, which contribute to total deaths, affecting the population size, and thus the size of the labor force. Finally, violence affects MFP via the security index.

Migration impacts education attainment, labor and the economy, all of which impact other variables in the model. Migration impacts educational attainment and labor because it changes the population in the country, thereby changing those in school, the labor supply and the size of the informal labor market. Migration impacts the economy through its effects on remittances from the foreign population and the link between household consumption and migration. Migration can impact household consumption by influencing the population growth rate.

Each of these modules is discussed in more depth in the sections that follow.

Economy

The population model provides forecasts of cohorts within the population and the economic model provides forecasts of spending in accordance with the GDP of regions. These two models become the basis for the education model. Thus the education model is able to produce forecasts of the pipeline of education at different levels (primary, secondary and tertiary) and by genders (male, female, total). This model generates a number of final outcome variables, the most important of which are average years of education for the population aged 15+ (and 25+), and quality of education (overall and at each level of education).

Education can impact other variables in the IFs system through impacts on multifactor productivity (MFP). This is because average years of education amongst adults ages 15+ impacts human capital, which (along with social capital, physical capital, and knowledge) affects MFP. Then, MFP has forward linkages to economic growth, which is tied to health, violence, migration, and other aspects of development.

There is a multitude of other ways in which the economy is tied to variables explored in this report. For example, education attainment impacts the skill level of workers, which affects labor dynamics. Labor is tied to the GINI coefficient, which influences societal violence. Furthermore, attainment impacts the fertility rate, which impacts the population size, a driver of GDP per capita.

Demographics

As mentioned above, the population model provides forecasts of cohorts within the population and serves as a basis for the education model. The dominant population equation is a simple addition of births at the bottom of the cohort distribution, subtraction of deaths from each population cohort, and advance of people to the next cohort over time.

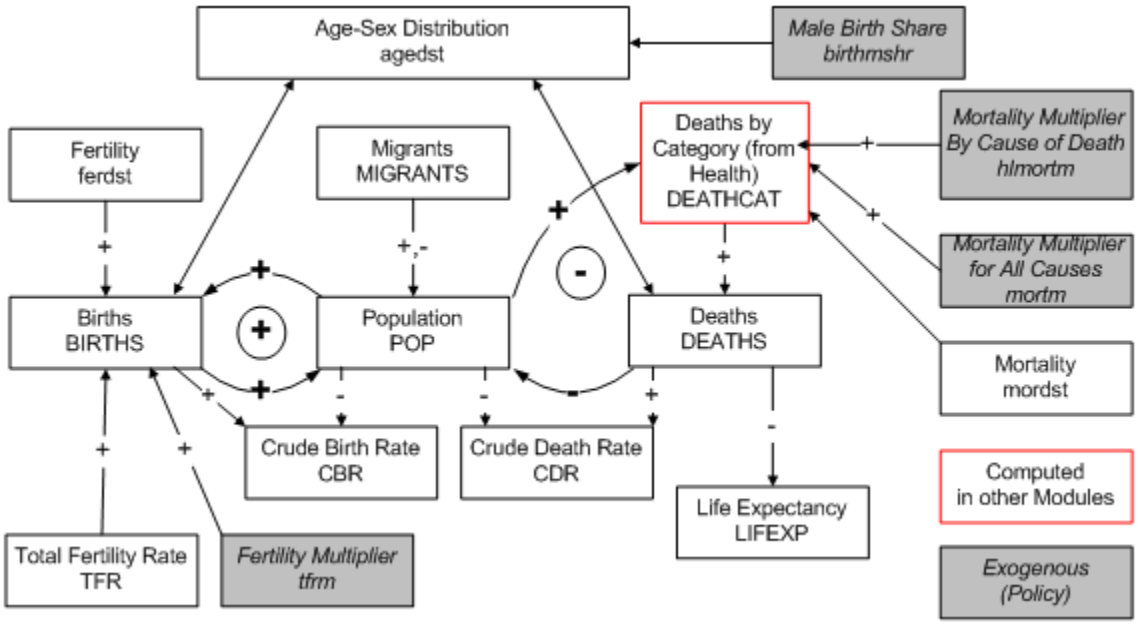
The following key dynamics are directly linked to the Dominant Relations:

- Births are primarily a function of the total fertility rate, which in the longer term responds especially to education level of the adult population. The model user has direct control over TFR with a multiplier, but also much control for low fertility countries with a parameter specifying long-term stabilization level and lower boundary for fertility. There is also a secular trend reduction in fertility.

- Deaths are primarily a function of life expectancy, itself computed within the IFs health model where, like fertility, it responds in the long run to adult education and also to GDP per capita and technology change. The model user has direct control over all deaths with a mortality multiplier and over those specific to a cause of health with an alternative multiplier. There is also a secular trend reduction in mortality.

The larger demographic model (Figure 2) in combination with the health model provides representation of and control over migration; the fertility impact of infant mortality and contraception use rates; and the mortality impact of many factors including undernutrition, smoking rates, and indoor air pollution from open burning of solid fuels.

Figure 2: Representation of demographic model



Migration

This project has supported expansion of the IFs tool to include a representation of international bilateral migration forecasts (see Figure 3). Forecasts are disaggregated by motivation, being voluntary (i.e. seeking better economic opportunity, education, or reuniting with family) or forced (i.e. seeking asylum from the threat of violence or persecution).

The bilateral migration model has four major procedures (1) initialization of migration stock and flow forecasts with data, (2) distribute country-level outflows among all partner-countries using a gravity equation, (3) balancing of bilateral migration flows with gross, country-level forecasts of outward and inward flows, and (4) options for scenario analysis.

The initialization process draws migration stock and flow data from multiple sources to provide first-year values for forecasts of bilateral and country-level migration stocks and flows (inward and outward) for total migration and forced migration.[17] Voluntary migration is calculated as the annual residual between these two values.[18] In the current Base Case, outflows and inflows are adjusted so that they are equal to forecasts of country-level net migration from the UNPD (2017). Forced migration is currently forecast as a function of IFs' existing forecast of domestic instability (SFINTLWARMAG) divided by population (POP). The goal is for this

[17] Total migration stock data comes from UNDP 2017. Abel (2016) estimated migration flow data from an earlier version of UNDP 2017. Forced migration stock data comes from UNHCR (2017). Forced migration flow data has been estimated by the Pardee Center using a methodology similar to that of Abel (2016).

[18] This method can sometimes lead to negative voluntary flows given discrepancies in the primary data sources. In such cases, we assume voluntary migration flows to be equal to 5 percent of forced migration flows and adjust total migration accordingly.

driver to be replaced by one measuring broad societal violence, which is currently under development as part of this project.

The bilateral distribution of inward and outward migration flows is determined by the initial data and evolved according to a gravity model which includes a set of push and pull drivers such as physical distance between origin and destination countries, origin country population size, the ratio of household income per capita between origin and destination countries, and the size of origin-country population living in the destination country. The resulting bilateral migration flow pattern is then adjusted through an iterative process until the sum of all inward (outward) flows to a country is equal to the country-level forecast value of inward (outward) migration.

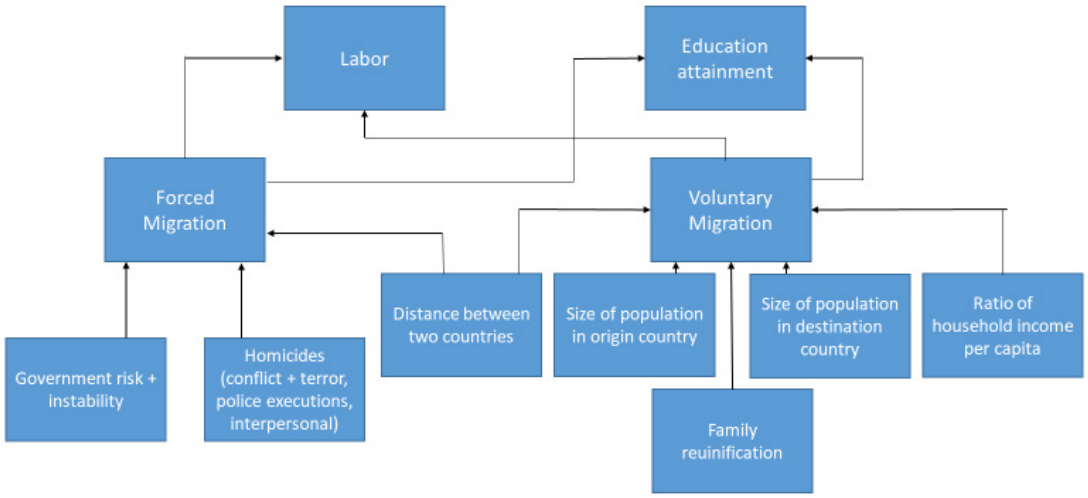
Bilateral migration flows directly augment bilateral stocks. Stocks decrease with deaths and return migration.[19] In the case of forced migration stocks, it is assumed that annually a portion of forced migrants make the decision to voluntarily remain in the country.[20] If forced migration flows are lower than voluntary flows, forced migrants are assumed to return to their country of birth over a period of 5 years.

Through scenario analysis, users have the flexibility to change many of the assumptions around country-level flows, bilateral patterns, death rates, return rates, as well as relax the exogenous specification of net migration using UNPD forecasts. Doing so results in forecasts which are determined to a greater extent by the gravity equations.

[19] The death rate of migrant stocks is assumed to be equal to the weighted average of death rates in the countries of origin and destination, with parameterized weights of 0.2 and 0.8 respectively. The share of return migrant flows in any bilateral flow is assumed to be equal to the ratio of bilateral migrant stocks between the origin and destination countries. This assumption is also a parameter and can be modified through scenario analysis.

[20] This conversion of forced migrant stocks to voluntary migrant stocks occurs at a similar rate as the expected voluntary flows from country of origin to country of destination.

Figure 3: Representation of Bilateral Migration



Education attainment

The education model of IFs (Figure 4) simulates patterns of educational participation and attainment in 186 countries over a long time horizon under alternative assumptions about uncertainties and interventions (Irfan 2008). Its purpose is to serve as a generalized thinking and analysis tool for educational futures within a broader human development context.

Educational attainment of the adult is obtained through an accounting system that splits population into five-year cohorts starting from the age of fifteen. Each of the cohorts are initialized with an average level of educational quality (EDQUALAG15) and quantity (EDYRSAG15). The cohort averages change as people join or leave the cohorts bringing in or taking away their education with them. The computation of the educational attributes of the youngest couple of cohorts uses the high school and college graduation rates from the enrollment model.

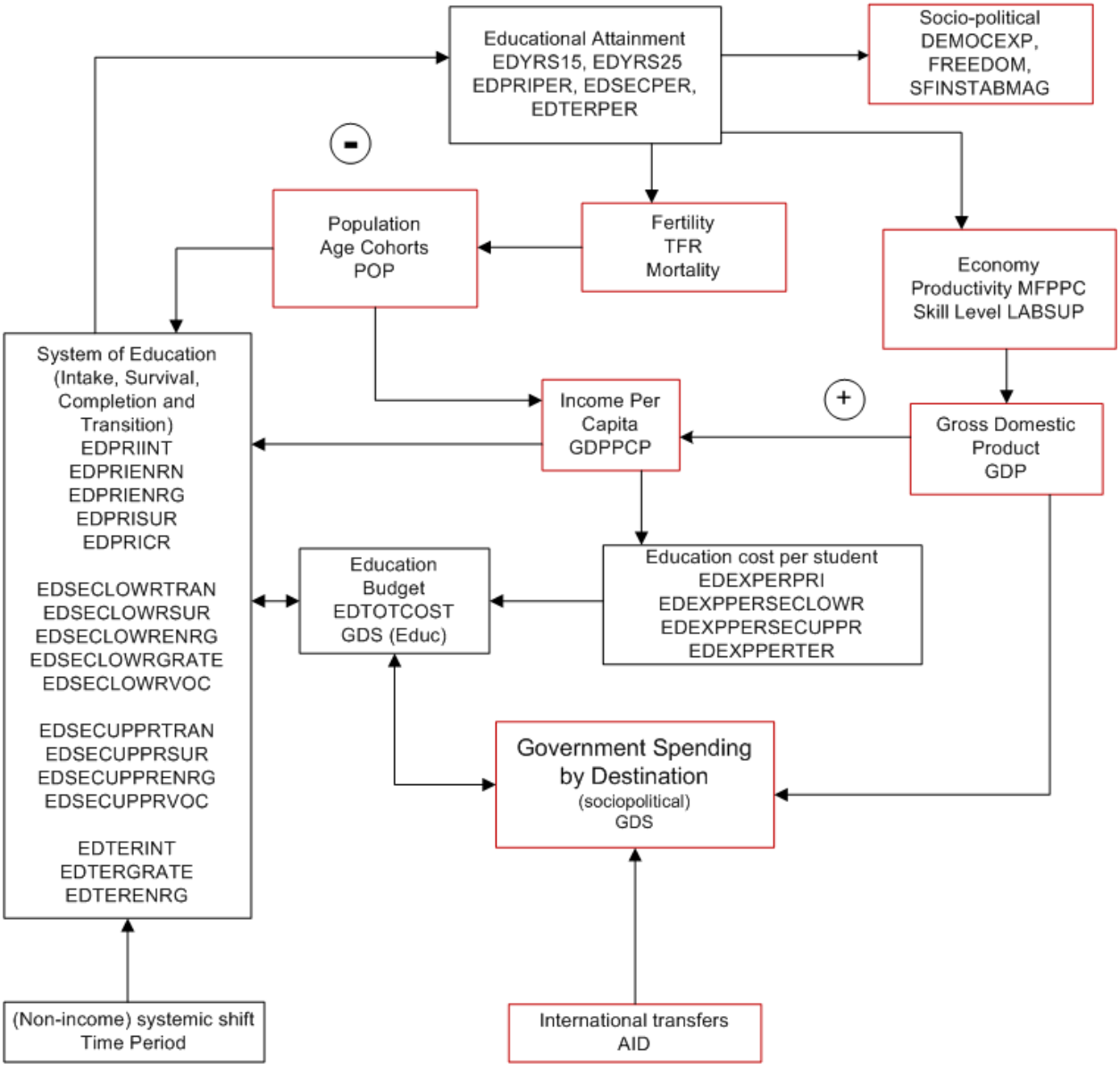
The model forecasts gender- and country-specific access, participation and progression rates at levels of formal education starting from elementary through lower and upper secondary to tertiary. The model also forecasts costs and public spending by level of education. Dropout, completion and transition to the next level of schooling are all mapped onto corresponding age cohorts thus allowing the model to forecast educational attainment for the entire population at any point in time within the forecast horizon.

From simple accounting of the grade progressions to complex budget balancing and budget impact algorithm, the model draws upon the extant understanding and standards (e.g., UNESCO's ISCED classification explained later) about national systems of education around the world. One difference between other attempts at forecasting educational participation and attainment (e.g, McMahon 1999; Bruns, Mingat and Rakotomalala 2003; Wils and O'Connor 2003; Delamonica, Mehrotra and Vandemoortele. 2001; Cuaresma and Lutz 2007)

and our forecasting, is the embedding of education within an integrated model in which demographic and economic variables interact with education, in both directions, as the model runs.

We emphasize the inter-connectedness of the components and their relationship to the broader human development system. For example, during each year of simulation, the IFs cohort-specific demographic model provides the school age population to the education model. In turn, the education model feeds its calculations of education attainment to the population model's determination of women's fertility. Similarly, the broader economic and socio-political systems provide funding for education, and levels of educational attainment affect economic productivity and growth, and therefore also education spending.

Figure 4: Representation of the education model



Education quality

Education quality is a recent addition to the IFs education model. This part of the model compares and forecasts quality of learning at the educational levels of primary and secondary for 186 model countries. To initialize the quality variables IFs model pre-processor uses the World Bank Global Achievement database of country scores in international achievement tests or regional equivalent of such tests in the test areas of reading, science and math.

Test score forecasts in our model are driven by three factors representing three different areas – society, family and school system. Variables that represent these three areas are – income per capita as a proxy for the level of development of the society, average educational attainment of the adults as an aggregate indicator of family environment and expenditure per student as an indicator of the quality of the school system. Each of the subject area scores are regressed against these three variables using data for the base year or the most recent year with data. The regression relationships compute the scores in the forecast-years using values for the independent variables obtained from other IFs models. Any difference in scores obtained from historical database with those obtained from regression is considered as a country-specific situation. The base-year country shifts in the scores, added to the regression output in the subsequent years, decrease gradually as the country merge towards the general relationship.

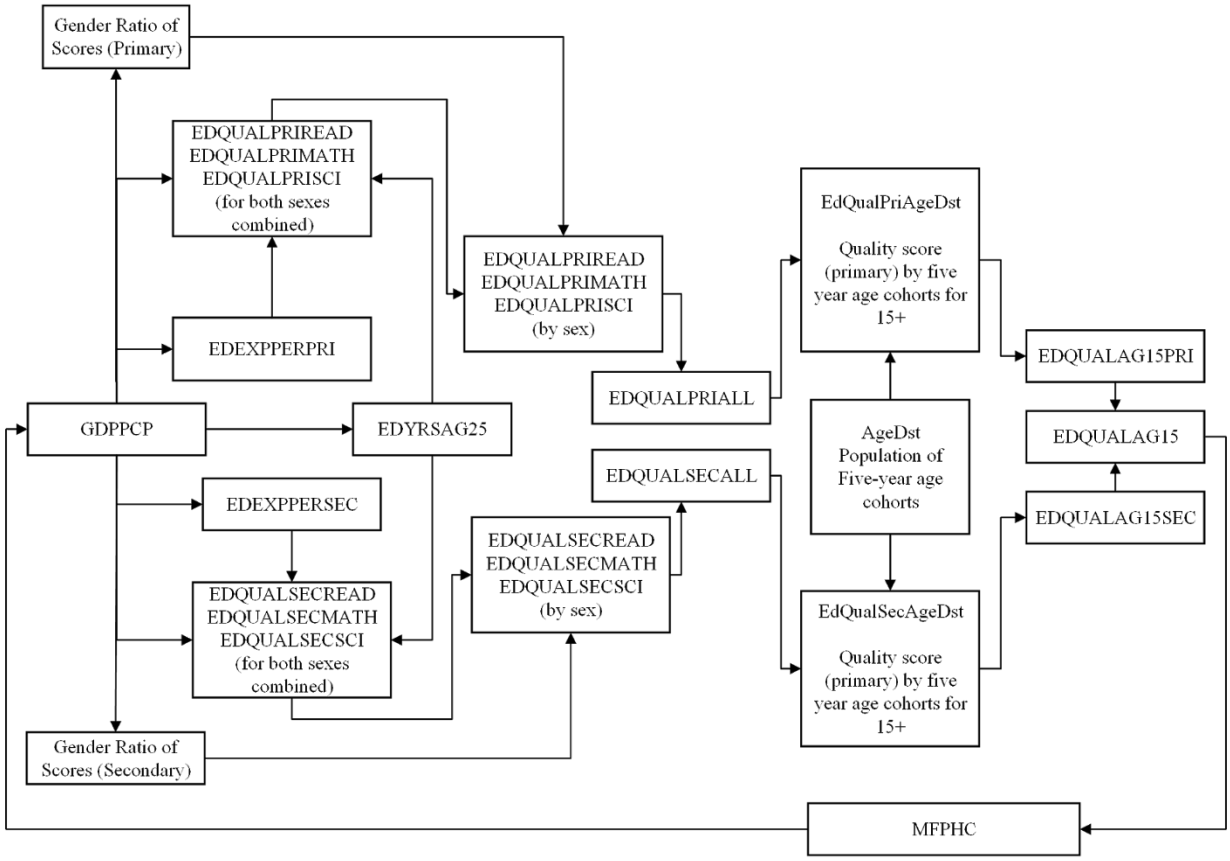
Learning quality indicators for primary and secondary education (EDQUALPRI, EDQUALSEC) are driven by level of development, parental education and spending in the corresponding level of education.

We have used test score data from twenty-five years back as an average measure for the learning quality of the adults in the model base year. Historical quality scores for primary and secondary, for all subjects combined, are used in this way to initialize adult quality scores. This is not a very accurate way of measuring adult education quality. It incorporates several crude assumptions, for example, the quality score of adults of a certain age are same as the quality score when these adults were in school. This is the best we could do given the availability of data.

The model starts with spreading these quality scores into scores for each of the five-year age-sex cohorts. As the model runs, students age and join the youngest of the adult cohorts carrying their quality score with them. Also, as the model runs, each year each of the five-year cohorts is joined by some from the younger cohorts and left by others who move to the older cohort. The scores of the cohort are re-aggregated each year to reflect the score changes from these entry and exit. Population weighted average of all five-year age-sex cohorts gives two quality scores (EDQUALAG15PRI and EDQUALAG15SEC) for the adults, 15 years and older. An overall adult score (EDQUALAG15) is obtained by averaging these two. This score drives multi-factor productivity in the economic model of IFs.

Figure 5 is a diagrammatic representation of the education quality model in IFs.

Figure 5: Representation of the education quality model

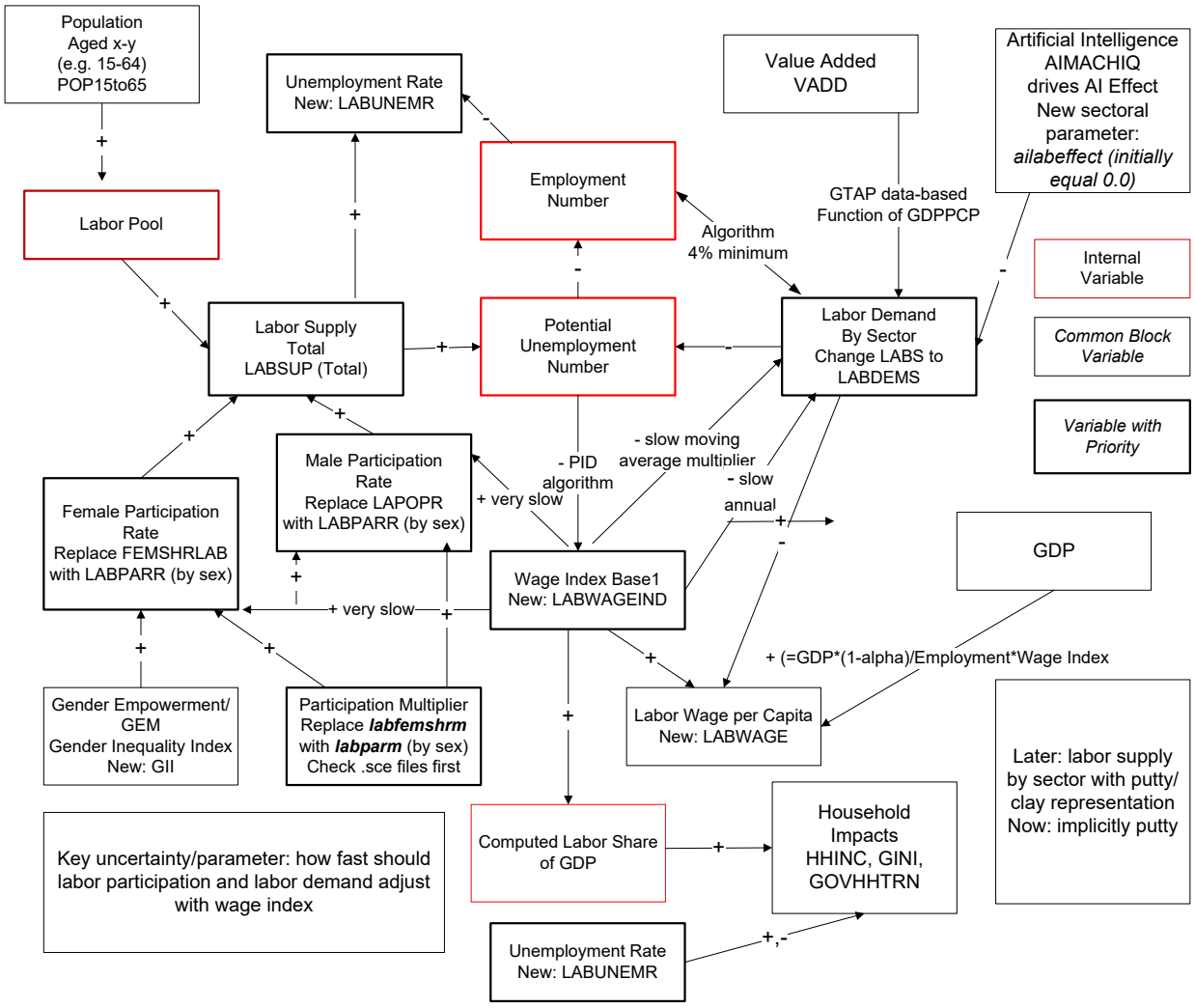


Labor

The labor model in IFs (Figure 6) was modified by incorporating unemployment through this contract. Labor supply is determined by the working age population and the share of that population who are willing to work. The labor supply is relatively stable. It is the demand instability that gives rise to most of the imbalances in the labor market. Economists generally use a demand curve of labor which shows the quantity of labor the employers are willing to hire at a given wage. These demand curves are helpful in studying the short-term demand fluctuations, for example, those that result from the business cycle. In the longer-term labor demand is driven by technological progress. The advent of new technology in a particular sector usually reduces the demand for labor in that sector, more so for the labor with less or no skills.

Neoclassical assumptions are used to balance the market. The higher the wage the more willing are the workers to work. Firms, in contrast, prefer to hire when the wage is low. The imbalance shows up first in the rate of unemployment. Shifts in the rates of unemployment beyond what is usual impacts wage, the price of labor. For example, wages drop in the event of rising unemployment as there are more people to hire from. Wage adjustments feed back to the demand for labor thus bringing the system back to the equilibrium.

Figure 6: Representation of labor model



Description of initial labor market modelling in IFs:

IFs model follows the notion of an equilibrium market. However, instead of computing an analytical solution at each point in time, as is usually done in comparative statics models, we balance the market through an equilibrium seeking algorithm. We use an algorithm borrowed from the control systems engineering.

This PID controller algorithm, described also in the IFs economic model documentation, works basically by computing corrective signals for equilibrating variables using a buffer variable, for example wage, as the buffer moves towards or away from a target value. The signal is computed from two quantities, the distance of the buffer from the target and the current rate of change of the buffer, and scaled to a suitable base. The computed signal is then applied on the variable/s which need to be balanced, demand and supply of labor in our case, thus getting closer to a balance at each step of simulation. The target value for the buffer variable and the parameters of the control algorithm are obtained through expert judgment and model calibration.

IFs labor model uses two PID controllers to balance the demand and supply of labor. One of the controllers use unemployment (LABUNEMPR) as a buffer variable and the other uses wage (LABWAGEIND) as a buffer. The model assumes labor to be perfectly substitutable across all sectors of the economy with an overall wage and unemployment rate for the entire labor market. This assumption is rather simplistic but this is the best we can do with the data we have at our hand.

Violence

The IFs system includes a representation of mortality from different types of societal violence. The types of violence represented are homicides, police violence, violence from conflict, self-harm and violence against vulnerable populations (women & children). Total violence is calculated using a weighted average of mortality rates for each of the above and using population of the respective age-cohorts as a weight. The different types of violence are then fed into the security index in IFs (GOVINDSECUR) which has forward linkages to multifactor productivity, forced migration and educational enrollment.

In the first year of the model, data for the different types of violence are initialized using mortality data from the Institute for Health and Metric Evaluation (IHME). Note that we currently do not forecast prevalence of any kind of violence due to a lack of data related to the same. There is a switch that a user can activate to normalize violence related mortality to violence related to intentional injuries (based on data from UNPD) in the first year of the model.

Levels of homicide deaths and levels of deaths of vulnerable populations are determined in the forecast years using the youth bulge and inequality (GINI co-efficient) as drivers. Conflict deaths are driven using the probability of internal war, police violence is driven by levels of homicides and corruption and self-harm is driven using deaths from mental health and levels of homicides.

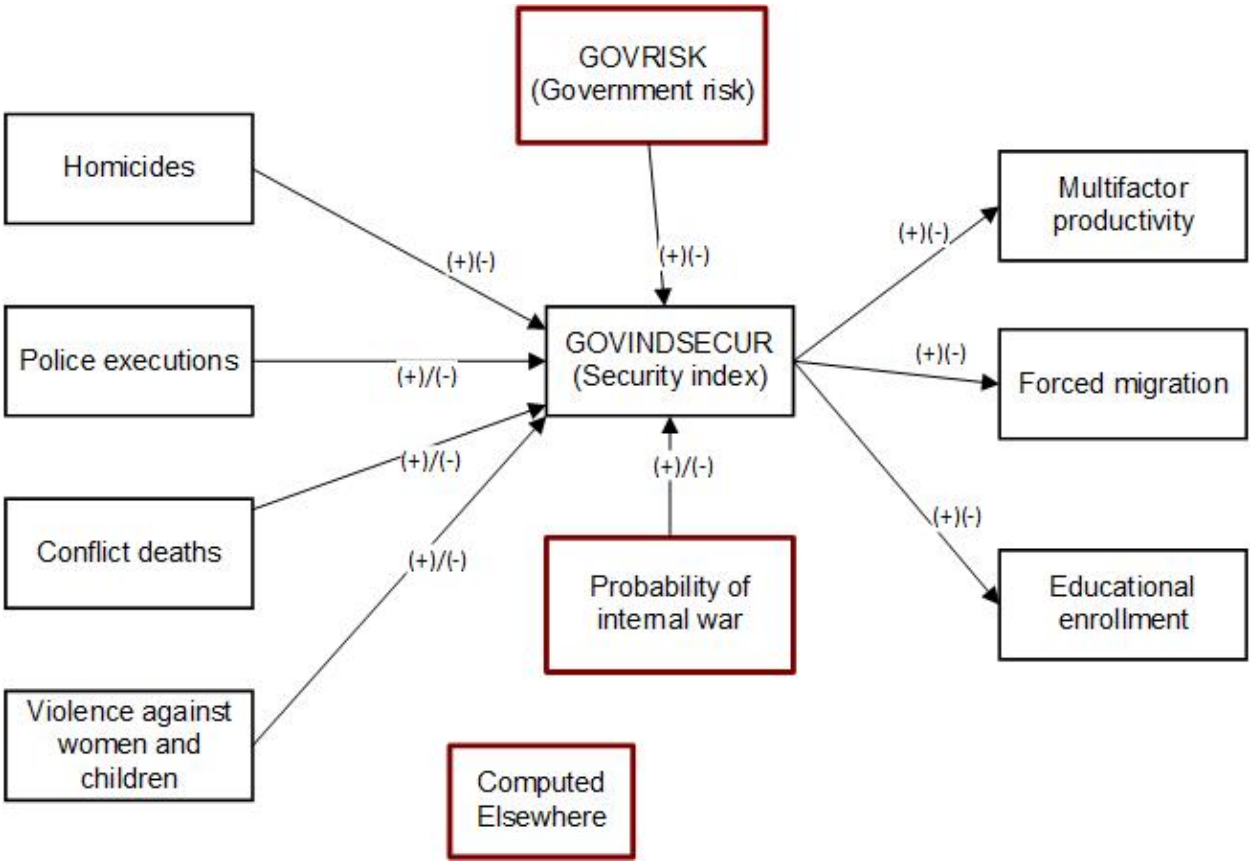
In addition to the variables themselves, there are multiplicative and additive parameters available to the user to simulate an increase or decrease in levels of violence.

Finally, the different types of violence are used in the calculation of a violence term which is one of three terms used in the computation of the government security index (GOVINDSECUR). The other two terms used are a term for government risk and a term for probability of war.

The security index has a forward linkage to multifactor productivity, a forward linkage to forced migration and a forward linkage to educational enrollment. All forward linkages are represented through elasticities in the model. In addition to these, the violence model itself has a linkage to the demographic model since it contributes to the death rate.

The flowchart in Figure 7 provides a diagrammatic representation of the violence model along with relevant forward linkages

Figure 7: Representation of the violence model



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