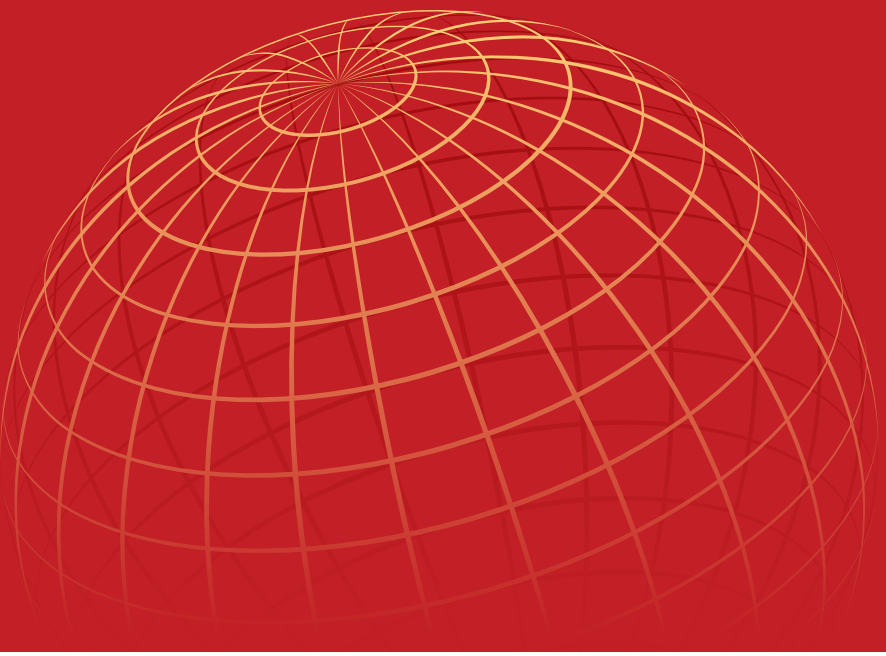


# SPECIAL FOCUS 2

## Education Demographics and Global Inequality

# Education Demographics and Global Inequality

*An expected shift in the skill composition of the global labor force will have important consequences for the future of global income inequality. Specifically, a more educated labor force from emerging market and developing economies will likely reduce inequality between countries. It would also diminish inequality within countries, especially in emerging market and developing economies.*

## Introduction

In the next two decades, new cohorts of more educated workers from developing countries will enter the global workforce with better skills. This change in educational demographics will likely have important consequences for global income inequality. Such formation of human capital will also enhance potential output and growth in the long run, a welcome development in light of the anticipated risks in the medium term (Chapter 3).

In the last two decades, global inequality was partly shaped by the rapid integration of rising working-age populations in emerging market and developing economies (EMDEs) into the world economy. The information and communications technology revolution, combined with cross-border increases in trade and financial flows, reduced the costs of communication and fragmented production by combining high-tech capital with best managerial practices and low-paid workers globally (Baldwin 2016). Between 1990 and 2015, the share of trade in global GDP rose by about 50 percent and the stock of international financial assets relative to GDP tripled (Figure SF2.1.A). Because of the convergence of income among countries, notably the rapid growth of large economies in Asia like China and India, global inequality fell from the late 1980s on. As average incomes across countries converged, the relative contribution of within-country inequality to global inequality rose (Figure SF2.1.B).[1]

Over the next two decades, the working-age population is expected to expand in EMDEs and shrink in advanced economies. This broad trend will be accompanied by a shifting skill composition, as the share of better-educated and more-skilled workers rises in EMDEs. These two factors will further change the income distribution between countries as well as within countries by 2030. Between-country distributional changes will continue to reflect an overall convergence in country-level per capita GDP whereas within-country distributional changes will be generated by improvements in household incomes led by younger, better-educated workers within each country.

In light of these changes and their likely impact, this Special Focus addresses the following questions:

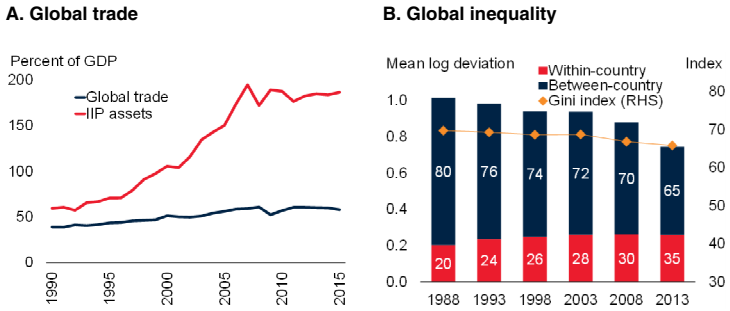
- How has global inequality evolved during the past three decades of rapid globalization?
- How will the next wave of demographic and educational trends shape the global labor market?
- What are the implications of these changes for global inequality?

Note: This Special Focus was prepared by Marcio Cruz, Delfin S. Go, Franziska Lieselotte Ohnsorge, and Israel Osorio-Rodarte. Xinghao Gong provided valuable research assistance. The analysis in this Special Focus is mostly based on the background paper "Global Inequality in a More Educated World" by S. Amer Ahmed, Maurizio Bussolo, Marcio Cruz, Delfin S. Go, and Israel Osorio-Rodarte (2017).

[1] Two measures of inequality are used in the analysis – the Gini coefficient and the log mean deviation (also called Theil-L index or general entropy measure GE(0)). Although the Gini (1912) coefficient of inequality is intuitive and the most widely used single measure of inequality, it does not allow a decomposition into a between-country and within-country component since it is not additive across sub-groups. In contrast, the log mean deviation or Theil index as proposed by Theil (1967) allows a decomposition into between-country and within-country inequality (Bourguignon 1979). In Figure SF2.1.B, the relative importance of the two components add up to 100 percent. The fraction of global inequality accounted for by differences of average income across countries declined from 80 to 65 percent while the relative contribution of inequality within countries increased from 20 to 35 percent during 1988-2013. See the explanatory note of Figure SF2.1.B for details. See Annex for further discussion.

## FIGURE SF2.1 Globalization and inequality

*Two decades of rapid globalization resulted in increased trade and financial integration and have been accompanied by a decline in global inequality. This is mainly due to income convergence among countries. The relative importance of inequality within countries, however, has steadily increased.*




Sources: International Finance Statistics and World Economic Outlook, International Monetary Fund; World Bank (2016).
A. International investment position (IIP) assets are for countries with available data.
B. World Bank calculations based on data in Lakner and Milanović (2016) and Milanović (2016), using PovcalNet (online World Bank tool, http://iresearch.worldbank.org/PovcalNet/.) For each country, household income or consumption per capita is expressed in 2011 PPP exchange rates, and it is derived from household surveys that are represented by decile groups. The line (measured on the right axis) shows the Gini Index, which ranges from 0 (perfect equality) to 100 percent (perfect inequality). The height of the stacked bars shows an alternative measure of inequality, the GE(0) index which can be decomposed into within- and between-country inequality and increases from 0 (perfect equality) with growing inequality. The red bars show the population-weighted average of within-country inequality; and the blue bars show the average between-country inequality. The numbers in the bars denote the relative contributions (in percent shares) of these two sources to total global inequality.
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### Recent evolution of global inequality

**Emergence of a global labor market.** A "global labor market" emerged rapidly in the 1990s, when China, India, and the former Soviet bloc began to integrate into the global economy. This integration increased the global labor pool from 1.5 billion workers to 2.9 billion workers. This "great doubling" brought in workers who were mostly low-skilled and low-wage (Freeman 2008 and 2007; Jaumotte and Tytell 2007).

**Impact on inequality.** The immediate impact was to alter the global capital-labor ratio, favoring or increasing returns to capital relative to wages and raising concerns in some studies about linkages between globalization and inequality (Pitt 2017; Milanović 2016; Bourguignon 2015; Galbraith 2012; OECD 2011; Lall et al. 2007). The expansion of world trade and investment flows benefited low-skilled workers in China, India and, to some extent, the former Soviet bloc. Demand for the goods they produced rose, and so did their wages. Also, increased global economic integration accelerated diffusion and adoption of new technologies, which in turn supported rapid growth in EMDEs before the global financial crisis. These developments coincided with a decline in inequality in EMDEs, especially in the new millennium, and the country-specific Gini coefficients —a widely used measure of inequality—for EMDE regions, on average, fell from 41.1 in 1998 to 38.9 in 2013 (Figure SF2.2.A). Despite recent improvements, however, the average Gini coefficient in Latin America and the Caribbean and Sub-Saharan Africa were the highest and second highest in six EMDE regions, respectively.

The opposite occurred for low-skilled workers in advanced economies. The share of national income accounted for by wages declined (Stockhammer 2013). Physical and financial assets became more concentrated in the top income brackets, increasing inequality. A number of studies have called attention to the rising capital share of total value added and the concentration of income and wealth at the top-end of income distribution in advanced economies (Stiglitz 2012; Piketty 2014; Atkinson 2015; Bourguignon 2015). On average among advanced economies, country-specific Gini coefficients have increased from 29.8 in 1988 to 31.8 in 2013 (Figure SF2.2.A).

However, global income inequality declined, as demonstrated by a decline in the global Gini index from 69.7 in 1988 to 65.8 in 2013 (Figure SF2.1.B). This decline can largely be explained by the convergence of EMDEs towards advanced economy per capita incomes during the two decades of rapid growth, especially among the largest emerging markets. Even so, the share of within-country inequality to total global inequality has been steadily increasing from 20 percent in 1988 to 35 percent in 2013.

Reflecting the relatively broad progress that many countries made in the new millennium, the average unweighted country specific Gini in the world declined from 40.6 to 37.8 between 1998 and 2013, after rising during 1988-1998. In fact, this was the first decline in global inequality since the industrial revolution (Bourguignon 2015; World Bank 2016). However, the population weighted average, which captures the within-country inequality for the average person in the

world, follows a slightly different pattern. The population-weighted average Gini fell from 40.1 in 1998 to 39 in 2008 but rose very slightly after the financial crisis to 39.3 in 2013.

## Education wave and the global labor market

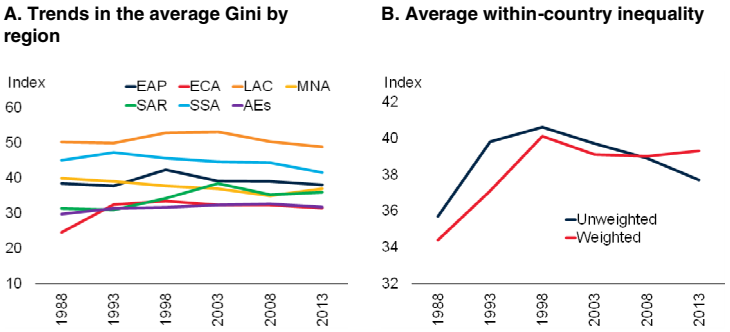
**Data and methodology.** The forward-looking analysis uses two World Bank global models that link economies across the world to derive the global repercussions of education demographics. The results of the analysis rely on income distributions from harmonized household surveys for over 100 countries (Ahmed et al. 2017; Annex).

**Future labor market trends.** Global demographic and educational projections foretell a second wave of substantial changes in the global labor market. Defining skilled workers as those having nine or more years of education, new entrants of better-educated workers will come mainly from developing countries (Figure SF2.3.A). Based on United Nations population projections and present rates of educational enrollment (conservatively kept constant into the future), the world will see the number of skilled workers rising from 1.66 billion in 2011 to 2.16 billion by 2040, an increase of about 500 million or 30 percent (Ahmed et al. 2017).

As in the case of the great doubling, the role of EMDEs is prominent. Due to their growing populations and investments in education, developing countries will contribute *all* of the additional workers to the world pool of educated workers. Because of aging, the overall number of skilled workers in advanced economies is projected to decline, from 603 million in 2011 to 601 million in 2030 and 594 million in 2050. Around 2012, one skilled worker from an advanced (OECD) economy was competing in the global labor market with two skilled workers from developing countries. In less than a generation, by 2030, that ratio will be 1 to 3. This "education wave" could constitute a shock to global labor markets and to the labor markets within EMDEs that may transform them once again, as the "great doubling" did in the first wave.

### FIGURE SF2.2 Evolution of inequality, 1988-2013

*In EMDEs, average inequality for most regions has declined in the new millennium. Despite broad-based improvement, the highest levels of inequality are observed in LAC and SSA. Average inequality in AEs, on the other hand, has been increasing since 1988. The average country-specific inequality as measured by the Gini index has declined since 1998.*




Source: World Bank (2016).
Note: World Bank calculations based on data in Milanović (2014), using PovcalNet (online World Bank tool, http://iresearch.worldbank.org/PovcalNet/.)
A. The average within-country Gini by region are simple averages in the full sample without weighting countries by population. EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MNA = Middle East and North Africa; SSA = Sub-Saharan Africa; and AEs = Advanced Economies.
B. The lines show the trend in the average within-country Gini index with and without population weights in the full sample with an average 109 countries per benchmark year.
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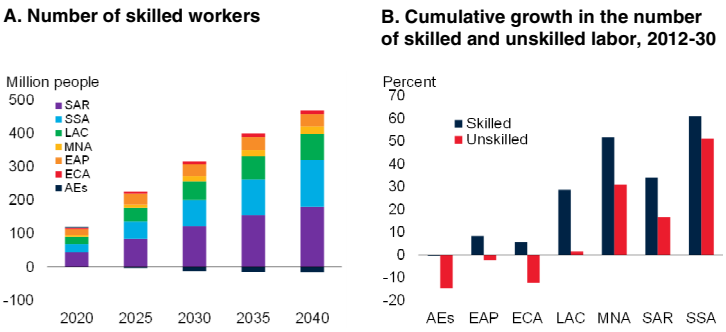
Large heterogeneity across regions will remain, as reflected in the growth rates of skilled versus unskilled workers. In most regions, the number of skilled workers is expected to grow faster—in some cases, much faster—than that of unskilled workers (Figure SF2.3.B). Within EMDEs, the regions of SSA, MNA, SAR, and LAC will have high growth in the supply of skilled workers.

**Factors analyzed for their impact on future inequality.** Changes in global inequality between 2012 and 2030 reflect not only the relative size of labor by skill among regions and countries but also their respective overall income growth, changes in sectoral employment, and income shifts between skilled and unskilled workers.

- By lifting the incomes of poor and non-poor alike, overall growth has long been identified as the main driver of poverty reduction (Dollar, Kleineberg and Kraay 2016). As long as per capita incomes grow faster in economies with many poor people than in economies with few poor people, aggregate growth will reduce global income inequality.

## FIGURE SF2.3 Future supply of skilled workers

*New skilled worker entrants will come mainly from EMDEs, and the number of skilled workers will generally grow faster than that of unskilled workers for most regions. Because of aging, however, the overall number of skilled workers in advanced economies is projected to decline by 2030.*




Source: Ahmed et al. (2017).

A. B. EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MNA = Middle East and North Africa; SSA = Sub-Saharan Africa; and AEs = Advanced Economies.

A. Skilled is defined as workers with more than nine years of education. Population projections are based on UN (2015). Education information is from harmonized household and labor surveys for 117 countries, keeping present rates of educational attainment in the calculation of the supply of skilled workers.

B. The growth rates are expressed as the cumulative growth for the period 2012-30.

Click here to download data and charts.

- A higher number of skilled workers (relative to unskilled workers) in 2030 compared with 2012 will, other things equal, reduce the skill premium in wages and, hence, within-country inequality, especially in EMDEs.

- As EMDEs urbanize, production, income, and the allocation of unskilled workers will likely shift towards non-agricultural, urban sectors. Since the agricultural sector uses unskilled labor more intensively than urban sectors, the process of urbanization is likely to release more unskilled agricultural workers to urban sectors. This development will put downward pressure on relative wages of unskilled workers in urban sectors and reduce the urban premium for unskilled workers.

The effect of these factors on inequality will depend on country-specific circumstances as the scenario analysis below documents.

### Education wave and global inequality

**Scenarios.** The simulation period is for about a 20-year span, from 2012 to 2030, comparable to the first wave of the "great doubling" of global labor supply. Two forward-looking simulations are defined:

- **Education-wave scenario.** The education-wave scenario is the baseline case. In this simulation, population projections are from the United Nations medium fertility scenario (UN 2015); economic growth projections are from World Bank (2015); and the share of skilled workers is projected to grow in line with population growth and assuming constant education attainment rates. Even with constant educational attainment rates (a conservative assumption),[2] the average schooling of the working-age population will increase as students move up from one educational grade to the next, while older, usually less educated ones leave the workforce—a pipeline effect or natural progression. The larger intergenerational education gap in developing countries, combined with the large size and growing pool of younger cohorts relative to the older ones in those countries, is the key driver of the education wave.

- **No-education-wave scenario.** The no-education-wave scenario is a counterfactual to the baseline scenario. It is the identical to the baseline case except for the assumption of a constant share of skilled workers in the working-age population (i.e., no pipeline effect from schooling). In contrast to the education-wave scenario, this assumes that the number of skilled and unskilled workers grows at the same rate as the working-age population for each country.

At the global level, the share of skilled workers in the total workforce was about 42.7 in 2012. In the no-wave scenario, despite keeping a constant share of skilled workers in the working-age population of each country, the global share of skilled workers is expected to fall slightly to 40.1 in 2030. This is due to differences in the demographic transition between countries attributable to changes in the size of the population and compositional effects as countries with less skilled workers increase their share of the global working-age population. In the

[2] Lutz and KC (2014) provide alternative projections with higher improvements in the enrollment rates from the International Institute for Applied System Analysis (IIASA). The beneficial effects of education on inequality have been documented in some country cases, such as Mexico (Lopez-Acevedo 2006) and Brazil (Blom et al. 2001). See the section on "Other factors" for further discussion.

education-wave scenario, the share of skilled workers is projected to rise to 45.5 in 2030.

**Education-wave scenario.** Since better skills are associated with higher income, the world under the baseline scenario will continue to become more equal by 2030 as EMDE per capita incomes catch up with advanced-economy per capita incomes. The global Gini coefficient is expected to decline from 65.8 in 2012 to 62.6 in 2030 (Figures SF2.4.A). This 3.2 percentage point decline in the global Gini coefficient as a result of assumed education demographics compares with the 7.2 percentage point decline in the global Gini coefficient during the slightly longer period 1988-2013, that was the outcome of a wide range of global and local developments (World Bank 2016).[3]

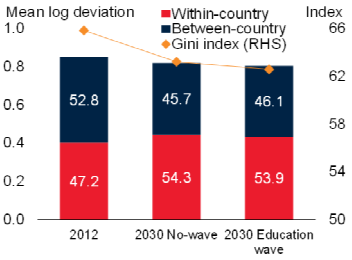
This expected decline in global inequality by 2030 in the baseline scenario mainly reflects a continuing convergence in average per capita incomes in EMDEs towards advanced economy levels (Figure SF2.4.B). Hence, fast-growing EMDEs with a large number of poor, such as India, which accounts for 28 percent of the world's poor in 2013, will continue to contribute to the reduction of global inequality. Within this declining trend in global inequality, the relative contribution of average within-country inequality rises from 47.2 percent share in 2012 to 53.9 percent by 2030.[4]

**No-education-wave scenario.** In the no-education-wave scenario, removing the additional influx of skilled workers from the pipeline effects of schooling and population aging into the global labor market would enhance the skill premium compared to the baseline or education-wave scenario and, hence, increase inequality. Compared with the baseline scenario, the global Gini coefficient would be slightly higher at 63.2 in 2030 while the GE(0) index would also rise to 0.82. The relative contribution of average within-country inequality at the world level would account for 54.3 percent by 2030. Compared to the baseline, the relative shares of between- and within-country inequality would change only marginally. This is because the education wave would improve both between-country inequality

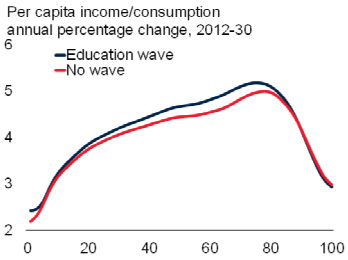
## FIGURE SF2.4 Global inequality in 2012 and 2030

*Global inequality is expected to fall further by 2030, largely reflecting a continuing convergence of EMDE per capita incomes to advanced-economy levels and the sectoral employment shifts due to economic transformation. Although within-country inequality will rise in importance at the global level, the education wave will nudge down within-country inequality, especially in EMDEs.*

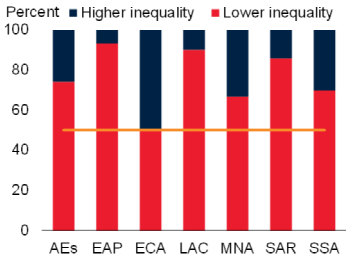
**A. Gini coefficient**



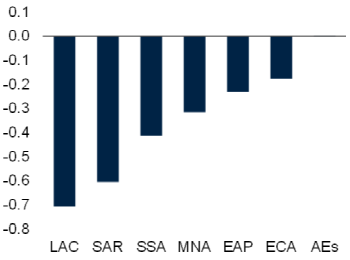

**B. Global growth incidence, 2012-30**




**C. Economies with higher or lower within-country inequality in the education-wave scenario compared to the no-wave scenario**




**D. Population-weighted average of difference in the Gini index between education and no-wave scenario**




Source: Ahmed et al. (2017).

A. The quantitative levels of inequality and particularly the decomposition between and within-country in the base year (2012) of this graph are different from those of the end year (2013) in Figure SF2.1B. One factor is the difference in the number and composition of countries used in Ahmed et al. (2017) and World Bank (2016). A second factor is a difference in the level of disaggregation in the household surveys employed. Each country distribution in World Bank (2016) is represented by ten decile groups, while Ahmed et al. (2017) use every single observation in the household survey to assemble a global database of approximately 10 million observations. Nonetheless, the qualitative interpretation and direction of change are consistent. The line (measured on the right axis) shows the Gini Index, which ranges from 0 (perfect equality) to 100 percent (perfect inequality). The height of the stacked bars shows an alternative measure of inequality, the GE(0) index which can be decomposed into within- and between-country inequality and increases from 0 (perfect equality) with growing inequality. The red bars show the population-weighted average of within-country inequality; and the blue bars show the average between-country inequality. The numbers in the bars denote the relative contributions (in percent shares) of these two sources to total global inequality.

B. The global growth incidence curve indicates household income growth between 2012 and 2030 in the no-wave and the education-wave scenarios for households at every level of income.

C. D. EAP = East Asia and Pacific; ECA = Europe and Central Asia; LAC = Latin America and the Caribbean; MNA = Middle East and North Africa; SSA = Sub-Saharan Africa; and AEs = Advanced Economies.

C. Figure shows the share of countries in each region in which the within-country Gini coefficient is lower in the education-wave scenario than the no wave scenario (red bars "Lower inequality") or higher in the education-wave scenario than the no-wave scenario (blue bars "Higher inequality").

D. The population-weighted average difference in the Gini index is negative if there is an improvement in the within-country inequality between the education-wave relative to the no-wave scenario.

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[3] Lakner and Milanović (2016) reported a decline of 1.7 percentage points for the shorter period 1988-2008 and in 2005 PPPs.

[4] Another index of inequality, the mean log deviation GE(0), or the Theil-L index, also declined from 0.85 in 2012 to 0.80 by 2030. The contribution of within-country inequality is measured as its contribution to the GE(0) index. Note the different database used in Ahmed et al. (2017) and World Bank (2016) as described in the explanatory note of Figure SF2.4.A.

(by raising the incomes of EMDEs relative to AEs) and within-country inequality (by lowering the skill premia of wages in EMDEs) so that the two effects offset one another relative to the no-wave case.

**Growth incidence curves and country-specific inequality.** In the global distribution of household income, middle-income households would be the biggest beneficiaries of the education wave. The global growth incidence curves illustrate household income growth between 2012 and 2030 at every level of household income in the world under the education-wave and no-wave scenario (Figure SF2.4.B). Income growth under the education-wave scenario is higher almost everywhere than in the no-wave scenario, but the difference is largest among middle-income households.

The beneficial impact of the education wave on within-country inequality can be seen by comparing the Gini indices of the two scenarios. The differences in the country-specific Gini indices of the education-wave and no-wave scenarios appear widely negative, meaning inequality falls more in the education-wave scenario. By 2030, the number of countries with lower inequality in the education-wave is uniformly and significantly higher than under the no wave scenario across all regions encompassing both the EMDEs and advanced economies (Figure SF2.4.C). The population-weighted average of these differences in the Gini coefficient between the education-wave- and no-education-wave-scenarios is negative (indicating less inequality in the education wave-scenario) for all EMDE regions but practically zero for advanced economies (Figure SF2.4.D). Among EMDEs, the benefits of the education wave are likely to be highest in LAC, SAR, and SSA due to the high growth of skilled workers in these regions that takes place during the transition phases of the intergenerational demographic gap (the difference in population size between young and old cohorts) and the inter-generational education gap (the difference in the average years of schooling between young and old cohorts). Although inequality in many advanced economies would improve with the education wave, these gains would be offset by a few aging economies with larger deteriorations and populations so that the weighted average is close to zero.

**Other factors.** Several important factors are outside the scope of this analysis. They could influence the results in either direction.

**Trend improvements in educational attainment.** Especially in Africa, educational attainment has grown steadily over the past two decades (World Bank 2017; Ahmed et al. 2016). Many EMDEs have already attained advanced-economy levels of completion rates for "skilled labor" as defined here with 9 or more years of schooling. (An exception is Sub-Saharan Africa, where completion rates at lower secondary schooling are still below 45 percent.) If these trend improvements continue or if they accelerate—perhaps because greater female empowerment leads to better education for children (World Bank 2012)—the supply of skilled labor would expand more than assumed in the scenario, growth will be higher and income inequality lower than in the scenarios above. This is, of course, predicated on education delivering learning. The 2018 *World Development Report* (World Bank 2017) emphasizes that it is the learning outcomes that are critical for increasing productivity, employment, earnings, and economic growth. A number of structural changes could expand the supply of skilled labor even more than assumed in this scenario, as suggested by results for Sub-Saharan Africa (Ahmed et al. 2016). As jobs empower women to invest more in their children, poverty will likely fall according to the 2013 *World Development Report* (World Bank 2012).

**External and domestic shocks.** Internal and external shocks could present severe setbacks to the scenarios outlined above (Devarajan et al. 2015, Chapters 1 and 2). Internal shocks include conflicts and droughts while external shocks include commodity price falls, sudden stops or even reversals in capital inflows, and recessions in major trading partners.

**Labor market frictions.** The analysis presumes that additional workers will be absorbed as their wages adjust flexibly to ensure full employment. In

practice, such flexibility may be imperfect. This could dampen the decline in within-country inequality.

**Other sources of income.** The scenario analysis here focuses on shocks that affect labor income. While labor income inequality may decline, inequality in other sources of income may grow. This could, for example, be caused by slow growth in investment, the scarcity of which would then raise its returns, or job-replacing technological change (Acemoglu and Restrepo 2016).

**Trade.** The pattern of growth and the structure of demand can affect growth, inequality, and poverty (Loayza and Raddatz 2010; Messina and Silva 2017). Tradable and non-tradable sectors can have different skill demands, and wage dispersions can exist across workers of similar skills depending on their sectors of employment. For wage differentials across sectors that go beyond the broad categories of skilled and unskilled labor and between urban and rural unskilled labor in the analysis, the relative growth in each sector will also affect the skill premium and labor incomes, especially over long periods.

**Technological change.** The nature of technical change will likely affect different groups of countries in different ways. Technological change that is biased toward skilled workers can mitigate or offset the distributional benefits of rising educational attainment, especially in advanced economies. It partly accounts for the rising college premium in the United States despite a rapid increase in the relative number of skilled workers in the 60 years after 1939 (Acemoglu 2009 and 1998). In contrast, in Latin America and the Caribbean and other developing countries, the growing number of skilled workers has been accompanied by falling education and skill-wage premia after 2000s (Cruz and Milet forthcoming; De la Torre et al. 2015; Lopez-Calva and Lustig 2010). Also, the world is undergoing a significant technological transformation characterized by the adoption of cyber-physical systems such as robotics, 3D printing, and machine learning (Cirera et al. 2017; Hallward-Driemeier and Nayar 2017). The pace of diffusion of these new technologies globally is an additional source of uncertainty, as they could have direct implications on income distribution across and within countries. Yet, the evidence is still weak that automation and trade also polarize labor markets in developing countries (Maloney and Molina 2016).

**Alternative parameter values.** The distributional benefits of education can also be mitigated by greater substitutability of skilled labor for capital or for unskilled labor (de la Granville and Solow 2009). The scenario analysis above assumes that skilled labor and capital are substitutable (through a constant elasticity of substitution or CES function) for each other and, together, are substitutable with unskilled labor. In contrast, skilled and unskilled labor could be substitutable for each other and, together, they could be indirectly substitutable with capital. The latter would dampen the decline in skill premia and raise global inequality compared to the education-wave scenario but would still improve inequality compared with the no-wave scenario.

## Conclusions

The next big wave of change in the global labor market, the rising share of educated workers in EMDEs, will likely lift global potential growth (Chapter 3) and be accompanied by a further decrease in global income inequality. This decline will be driven by a reduction in inequality between countries, which will largely be lowered by the convergence of EMDE per capita incomes with advanced-economy levels as productivity gaps close. At the global level, the relative importance of overall within-country inequality would steadily rise. Even so, the education wave would decrease country-specific inequality in most instances. The population-weighted average of the Gini difference between education-wave and no-education-wave scenarios would decline for all regions among EMDEs but not for AEs as a group. Nonetheless, several caveats exist. Factors such as biased technological change, the global diffusion of new technologies, and changes in the substitutability between factors of production may alter the results.

Over the next two decades, policies that raise current attainment rates and learning outcomes in education could further reduce inequality for two reasons. First,

a sizeable pool of students will eventually translate into a larger number of skilled workers. That, combined with the large size and growing pool of younger cohorts relative to the older ones, would amplify the effects estimated above. Second, a modest productivity increase through better educational attainment or learning outcomes could further reduce country-specific inequality. Improving learning outcomes in education is a policy challenge as discussed in the 2018 *World Development Report* (World Bank 2017). This will require systemic changes that make learning an overriding priority, supported by diagnostics, reforms that make schools work for learners, motivated teachers, and the removal of political and technical barriers that hinder a focus on learning.

## ANNEX SF2.1 Methodology, data, and measures of inequality[5]

**Methodology.** To examine how education demographics will shape future global labor market and inequality, the analysis combines the World Bank's global microsimulation model *Global Income Distribution Dynamics* (GIDD) and the global computable general equilibrium (CGE) model *LINKAGE* (Bourguignon and Bussolo 2013; van der Mensbrugghe 2013). Both models employ labor data that uses a consistent definition of skills based on the level of education as well as corresponding wages and skill premia as constructed from extensive household surveys. Ensuring such consistency is key for estimating the transmission of labor income shocks, in line with education demographics, into the distribution of household income.[6] By doing so, the analysis captures consistently the full distributional change—between and within countries—due to demographic trends.

In particular, LINKAGE is a multi-sectoral, multi-country and multi-agent dynamic recursive CGE model that is consistent with neo-classical growth theory. Aggregate growth depends on changes in the labor force, the capital stock, and total factor productivity. The economic impact of demographic change must, therefore, occur through one of these channels, and the key growth drivers sensitive to demographics are the labor force and the capital stock. As a simulation is implemented over time, the skilled and unskilled labor forces for a given country are defined following educational attainment rates and pipeline effects of schooling. At the same time, the model keeps track of the young (less than 15 years of age), working age (15-64 years of age), and aged (over 64 years of age) populations, following the values of the medium fertility scenario of the United Nations (2015).

Using the economy-wide effects of education demographics over time computed in LINKAGE, the GIDD microsimulation framework generates income distributions under the various scenarios. GIDD draws on household level survey data for many countries to estimate income distributions by country that account for demographics, household characteristics (e.g., age, gender, and education of different members), sector of employment, skill premia on wages, and income. Using the simulated income and employment under future scenarios from LINKAGE, and accounting for the demographic shifts characterized in the United Nations (2015) and skill implications of the assumed educational attainment rates, GIDD generates income distributions by country that are consistent with both the more 'aggregated' changes under the CGE simulations and what is known about households from survey data. In the simulation, the GIDD methodology updates the household survey data for the terminal year by reweighting the population characterized by the base year household surveys using non-parametric cross-entropy methods but keeping it consistent with the United Nations' population projections.

[5] This annex summarizes the methodology in Ahmed et al. (2017) that underpins the results of the forward-looking analysis.

[6] The GIDD microsimulation draws on per capital household income, which includes labor and non-labor income, to estimate global inequality. The GIDD transmits three key shocks derived from scenarios conducted in the LINKAGE model to household income: 1) Changes in per capita growth for each country; 2) Changes in wage skill premia, defined as the ratio between the average wage of skilled and of unskilled workers; 3) Changes in wage due to labor mobility across sectors. In addition, the GIDD updates the household survey data for the end year of the simulation, 2030. Further details on GIDD methodology are provided by Bussolo, Hoyos, and Medvedev (2010) and Ahmed et. al. (2017).

The analysis, therefore, focuses on forces of the educational wave that shape future supply and demand in the labor markets and their ensuing effects on global income distribution. On the supply side, it considers demographic shifts, improvement in education achievements, and policies that increase access to education and enable inter-sectoral mobility. On the demand side, it accounts for technological change, sectoral patterns of growth, and trade. It then draws the effects of these forces on global inequality by 2030, which is the target year of the Sustainable Development Goals (SDGs) as well as the World Bank's goals of ending extreme poverty and boosting shared prosperity. Because it usually takes longer than 15 years for the stock of skilled workers to show significant improvement from the new inflow of younger and more educated workers reaching the labor market, the time horizon to 2030 will present only a partial effect of the education wave, hence a very conservative scenario.

**Data.** The methodology combines a large data set from three sources. First, the population projections come from United Nations (UN 2015). Second, harmonized household surveys for many countries are employed in the *GIDD* database, which covers 10.5 million individuals in 127 countries that constitute 83 percent of global GDP and 86 percent of the global population. Third, data in *LINKAGE* comes from the uniform social accounting matrices of the *Global Trade Analysis Project*, which encompasses 129 regions/countries and 57 commodities that are linked by bilateral trade and other external flows (GTAP 2015).

To achieve consistency with the *GIDD*, *LINKAGE* is modified to adopt the former's skilled-unskilled labor definition, whereby a skilled worker is anybody with more than nine years of education, and an unskilled worker is anybody with less than nine years of education. This redefinition necessitates an adjustment of the GTAP data on value added by labor type in production, such that the number of workers of a given skill type in a given sector is consistent in the 2011 benchmark year across the two modeling frameworks.

**Measures of inequality.** Two measures of inequality are used in the analysis—the Gini coefficient and the log mean deviation (Theil-L index or general entropy measure GE(0)). The Gini (1913) coefficient is an intuitive measure of statistical dispersion that represents the income or wealth distribution of a nation's residents and is the most widely used measure of inequality. A high Gini coefficient denotes great inequality; it has an upper bound of one for perfect inequality and a lower bound of zero for perfect equality. However, the Gini does not allow a decomposition into a between-country and within-country component since it is not additive across sub-groups.

In contrast, the log mean deviation, or Theil index as proposed by Theil (1967), allows a decomposition into between-country and within-country inequality (Bourguignon 1979). The measure is equal to zero when everyone has the same income and takes on larger positive values as incomes become more unequal.

To measure inequality by either measure, every household observation of the 10.5 million individuals in the database is utilized. Moreover, each household is assigned its proper weight relative to the country's total population so that the resulting frequency distribution is reflective of the entire country. When the frequency distributions of all countries are added up, the resulting aggregates will also be reflective of the regional and global totals. The global and regional collections will entail reranking. That is, the bottom household may belong to Niger, and the next one may belong to another country like Eritrea, etc. Finally, the inequality measures use household consumption wherever available and income when consumption expenditure is not available (e.g. in many LAC economies).

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