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HUMAN CAPITAL AND INCOME INEQUALITY

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Abstract

This study investigates empirically how human capital, measured by educational attainment, is related to income distribution. The regressions, using a panel data set covering a broad range of countries between 1980 and 2015, show that a more equal distribution of education contributes significantly to reducing income inequality. Educational expansion is a major factor in reducing educational inequality and thus income inequality. Public policies that improve social benefits and price stability contribute to reducing income inequality, while public spending on education helps to reduce educational inequality. In contrast, higher per capita income, greater openness to international trade, and faster technological progress tend to make both income and education distribution more unequal. Using the calibration of empirical results, we find that we can attribute the rising income inequality within East Asian economies in recent decades to the unequalizing effects of fast income growth and rapid progress in globalization and technological change, which have surpassed the income-equalizing effects from improved equality in the distribution of educational attainment during the period.

Keywords: income distribution, inequality, human capital, education, globalization, technological change

JEL Classification: D31, H52, I24, O53

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1. INTRODUCTION

In recent decades, rising income inequality has attracted attention. In many countries, alongside income growth, income inequality has increased (Piketty 2014). Many East Asian economies that have achieved the “miracle” of “growth with equity” have also witnessed the deterioration of income distribution (Zhuang, Kanbur, and Rhee 2014; Jain-Chandra et al. 2016).

High income inequality, especially that originating from prevalent inequality of opportunities in a society, is undesirable from the perspective of social justice. Furthermore, unfair income distribution can be harmful to sustainable economic growth. Higher inequality provides fewer education opportunities for talented yet underprivileged individuals and discourages investment by making a society more unstable. Hence, all states endeavor to ensure basic livelihoods for the poor and disadvantaged by building social security systems and to reduce inequalities in wealth and income by adopting redistribution policies.

Research often emphasizes human capital as one of the major factors affecting the degree of income inequality. Human capital, measured by the educational attainment embodied in a worker, is a major determinant of the worker's lifetime earnings. Parents consider educational investment in their children as an important way to improve their children's future earnings. Many governments use higher spending on education as an effective tool for reducing educational inequality and thus income inequality. Despite this general perception of and interest in the importance of education for income distribution among the public and policy makers, the relationship between educational attainment and its distribution in populations experiencing income equality is not always clear in theoretical and empirical studies.¹

Recently, educational attainment has been expanding and educational inequality has been narrowing in many countries and regions, but at the same time income inequality has been widening, as shown in section 3. As researchers predict increases in the average educational attainment and educational equality to lower income inequality, this trend is puzzling. We must determine the exact contribution of education to income distribution by assessing the roles of all the important factors in income distribution. For example, during this recent period, rapid globalization and technological progress have occurred worldwide. While many studies have investigated the causes of income inequality, none have yet thoroughly analyzed the exact contribution of education to income inequality, especially in intertemporal, cross-national contexts.

Against this backdrop, this paper empirically analyzes the important factors for income inequality across countries over the past four decades and determines how the level and distribution of educational attainment are related to income distribution. We also assess the way in which international trade, technological progress, and public policies such as social benefits and expenditures on education are related to income and education distribution.

The remainder of this paper is organized as follows. Section 2 briefly reviews the literature on education and income inequality. Section 3 discusses the data and presents stylized facts on the evolution of education and income inequality. In Section 4, we analyze the determinants of income inequality using a panel data set covering a broad range of countries for the period between 1980 and 2015. Using the regression results, we discuss the role of educational attainment and its distribution in terms of

¹ See the literature survey in section 2.

income inequality. As an illustration, we also apply the results to East Asian economies and establish the extent to which education and other major determinants have contributed to the change in income inequality in recent decades. Section 5 analyzes the determinants of educational inequality and discusses how educational expansion can affect educational inequality and thus income inequality. Section 6 concludes.

2. LITERATURE REVIEW ON EDUCATION AND INCOME INEQUALITY

The human capital model suggests that the level and distribution of schooling across the population determines the distribution of earnings (Becker and Chiswick 1966; Mincer 1974). Hence, the model predicts that the supply and demand of educated people influence the earnings inequality in a society. While the model predicts an unambiguously positive association between educational inequality, as measured by the variance of schooling, and income inequality, the effect of the average years of schooling on income inequality may be either positive or negative, depending on the evolution of the rates of return on education.

Consider the following human capital earnings function (De Gregorio and Lee 2002):

$$\log Y_S = \log Y_o + \sum_{j=0}^S \log(1 + r_j) + u \quad (1)$$

where Y_S is the level of earnings with S level of schooling, r_j is the rate of return on the j^{th} year or level of schooling, and u represents other non-school-related factors that affect earnings. The following can approximate this function:

$$\log Y_S = \log Y_o + rS + u \quad (2)$$

Taking the variance yields the following earnings distribution function:

$$\text{Var}(\log Y_S) = \bar{r}^2 \text{Var}(S) + \bar{S}^2 \text{Var}(r) + 2\bar{r}\bar{S}\text{Cov}(r, S) + \text{Var}(u) \quad (3)$$

This implies that income inequality increases unambiguously with educational inequality, $\text{Var}(S)$, if controlling for other things. However, if the return on education, r , decreases with educational inequality, the relationship can be ambiguous. In most cases, however, educational inequality and the wage premium for higher education would move in the same direction, as an increase in the supply of higher-educated people tends to lower both the educational inequality and the wage premium. Meanwhile, educational expansion, that is, an increase in S , leads to a more unequal income distribution when r and S are independent. However, if the covariance between the return on education and the level of education is negative, the relationship between educational expansion and income inequality can reduce income inequality. Since the covariance term is expected to be negative, the relationship between educational expansion and income inequality should be ambiguous.

We would expect educational expansion, S , either to improve or to deteriorate educational distribution, $\text{Var}(S)$, depending on its initial level and distribution (De Gregorio and Lee 2002). In a society in which only a small fraction of the population has received formal education, the average educational attainment is low and the educational inequality is high. With an expansion of educational attainment, the level of educational inequality would increase if the more educated people received

a higher level of education, but it would decrease if the uneducated people received some education.

Knight and Sabot (1983) suggest that educational expansion has an ambiguous effect on income distribution. They show that educational expansion has two offsetting effects on income distribution: the “composition effect,” whereby wage inequality rises initially, when the educational expansion leads to an increase in the proportion of more educated workers; and the “wage compression effect,” implying that, when the supply of educated labor exceeds the demand as a result of educational expansion, the premium for educated workers will eventually diminish and thereby wage inequality will decline.

The empirical literature studying the relationship between education and income inequality using cross-country data often presents contradictory results. It commonly uses two measures of educational inequality: the standard deviation of schooling (Ram 1990; Lam and Levinson 1991; De Gregorio and Lee 2002) and the education Gini coefficient (Checchi 2001; Thomas, Wang, and Fan 2002).

Several studies, including those by Park (1997) and De Gregorio and Lee (2002), find that greater educational dispersion has an unequalizing effect on income distribution while higher educational attainment has an equalizing effect on income distribution. Jaumotte, Lall, and Papageorgiou (2013) show that income inequality decreases with the average years of schooling. However, holding the average education constant, income inequality tends to increase as the share of the population with secondary or tertiary education increases.

Conversely, Ram (1984) finds no adverse effect of educational inequality on income distribution, while higher educational attainment appears to have a mild equalizing effect. Földvári and van Leeuwen (2011) also identify an insignificant effect of schooling inequality on income inequality. Checchi (2001) confirms that educational achievement has a strong negative impact on income inequality. Furthermore, a U-shaped relationship between educational inequality and income inequality is apparent when controlling for educational attainment.

Cross-country studies also show a negative and nonlinear relationship between years of schooling and educational inequality (Ram 1990; De Gregorio and Lee 2002; Thomas, Wang, and Fan 2002), indicating that educational inequality increases as the average level of schooling increases but starts to decline after reaching a peak.

Lim and Tang (2008) suggest that it is possible to measure human capital inequality using the distribution of the Mincerian-type measure of human capital rather than the average years of schooling. They show that the measure of human capital inequality has an inverted U-shaped relation with the average years of schooling as well as educational inequality. Castelló-Climent and Doménech (2017) find that the distribution of Mincerian-type human capital has a positive relation with income distribution.

The findings of the existing studies using micro-level data are also broadly consistent with those of cross-country studies. Overall, educational inequality has an unequalizing effect on income distribution, while educational expansion has an ambiguous effect on income distribution.

Katz and Murphy (1992) show that changes in the relative earnings of college graduates, which were related to fluctuations in the supply of college graduates and a strong demand for skilled workers, could explain the changes in the wage structure in the United States in the period from 1963 to 1987. Goldin and Katz (2009) show that a slowdown in education caused much of the increase in US wage inequality in the recent period. The premium for higher education and skills has also risen across many

developed countries in recent decades, contributing substantially to the rise in earnings inequality (Autor 2014).

A substantial body of literature also analyzes the change in the labor demand and supply and wage inequality in developing countries using micro-level data. Since the mid-1990s, the average returns on an additional year of schooling have increased significantly in the People's Republic of China (PRC) (Fleisher and Wang 2004; Zhang et al. 2005; Fang et al. 2012). In urban India, wage inequality has increased since the start of the economic reform in 1991, mainly owing to increases in the returns on skills (Kijima 2006). Lee and Wie (2017) show that the rapid development in the PRC and India was associated with an increase in the relative wage of workers with higher education.

Case studies on income distribution dynamics in three East Asian countries—Indonesia, Malaysia, and the PRC—and four in Latin America—Argentina, Brazil, Colombia, and Mexico—observe that, while the mean years of schooling rose and the schooling level became more equal among the working-age population during the period studied, income inequality also rose in most economies, except in Brazil, where the distribution improved slightly (Bourguignon, Ferreira, and Lustig 2004). They find that changes in the distribution of education also had an overall unequalizing effect on household income, except in Brazil and Taipei, China. For example, the greater improvement in education among high-income groups had the greatest unequalizing effect on household income in Indonesia. Conversely, in the case of Taipei, China, education increased substantially such that the average schooling among poor households also improved, and, as a result, inequality in education fell. Meanwhile, the rising trend of inequality in Latin American countries reversed from the mid-1990s. Lustig, Lopez-Calva, and Ortiz-Juarez (2013) explain that the decline in labor income inequality was associated with higher education and, consequently, with more equal educational distribution.

Using a microeconomic decomposition method and comparing the distributions of household incomes between the United States and Brazil in 1999, Bourguignon, Ferreira, and Leite (2008) find that educational distribution is important in explaining the differences in household income distribution between the two countries.

3. EVOLUTION OF EDUCATION AND INCOME INEQUALITY

Challenges of data comparability confront the analysis of income inequality for intertemporal, cross-country comparison. We rely on the Gini index of net income (that is, post-tax, post-transfer) taken from the Standardized World Income Inequality Database (SWIID) that Frederik Solt (2016) compiled. This data set provides measures of income inequality with reasonable comparability for the broad range of countries in the world since 1960. Since the database provides more observations from 1980 onwards, our analysis focuses on the period from 1980 to 2015.

We compile the net income equality of countries and economies since 1980. We use five-year averages, such as 1980–84, 1985–89, ..., and 2010–14 to reduce the short-term variations as well as the possible measurement errors. Figure 1 presents the trend of income equality by major regions, using the unweighted averages for the panel of 60 countries that have complete observations at five-year intervals. The regions consist of “advanced countries” and six “developing regions”: East Asia/Pacific, Eastern Europe/Central Asia, Latin America/Caribbean, Middle East/North Africa, South Asia,

and Sub-Saharan Africa.² The figure shows that the advanced countries and Eastern European countries, on average, have maintained considerably more equal distribution of income than countries from other developing regions throughout the period have. The levels of income inequality in Latin America and Sub-Saharan African countries have been higher than those in other regions but have followed declining trends in recent decades. In contrast, income inequality in the East Asian countries has been relatively low but has risen in recent decades.

Figure 1: Trends of the Net Income Gini Coefficient from 1980–84 to 2010–14 for a Balanced Panel of 60 Economies

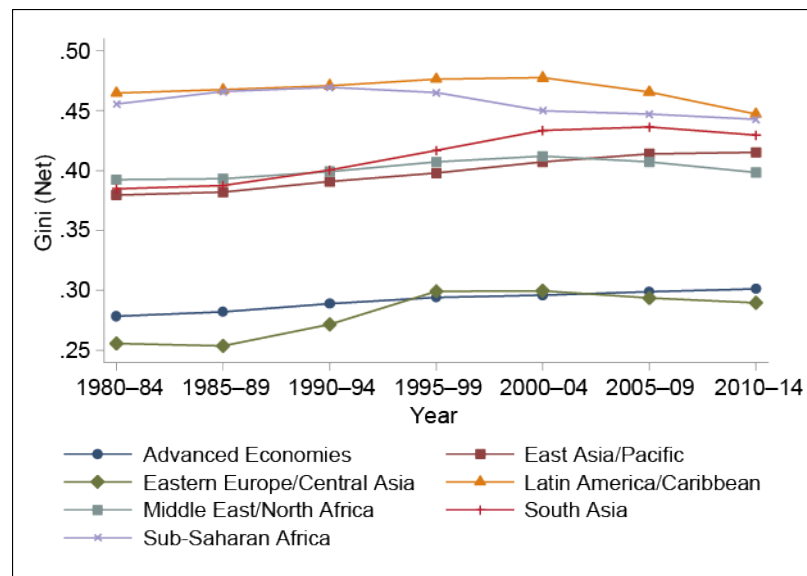


Figure 2 presents data for 16 individual economies in the East and South Asian regions. We observe that most Asian economies have experienced increasing income inequality in recent decades. The Gini coefficient of net income has worsened in 12 East and South Asian economies. From the late 1980s to the mid-2010s, it increased from 0.34 to 0.51 in the PRC, from 0.38 to 0.45 in Indonesia, and from 0.28 to 0.31 in the Republic of Korea. During the same period, it also rose from 0.43 to 0.48 in India and from 0.34 to 0.40 in Bangladesh. In contrast, four Asian economies, including Malaysia and the Philippines, have reduced their income inequality in recent decades. Figure 3 presents the changes in income inequality measured by the Gini coefficient of net income in the selected economies in other regions.

For the measure of human capital, we use the average years of schooling for the working-age population that Barro and Lee (2013, 2015) constructed. The most recent Barro–Lee data set provides estimates of educational attainment for the populations of 146 countries, disaggregated by gender and five-year age group, from 1950 to 2015 at five-year intervals. The data set distinguishes between seven different levels of education: no formal education, incomplete primary, complete primary, lower secondary, upper secondary, incomplete tertiary, and complete tertiary. We use these data to calculate the average years of schooling among the adult population both as a whole and at the primary, secondary, and tertiary levels.

² See Appendix Table 1 for a list of the countries included in each region/group.

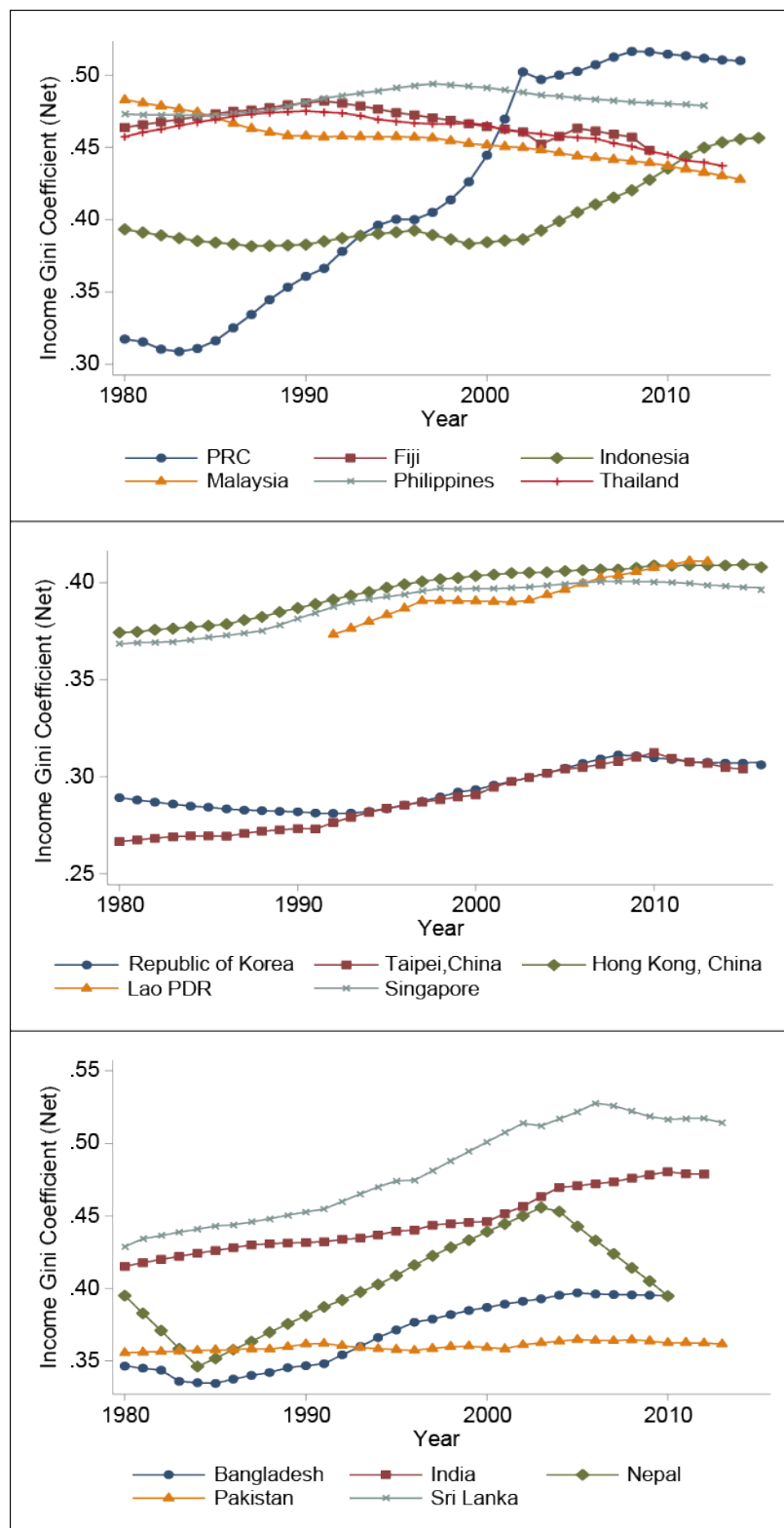
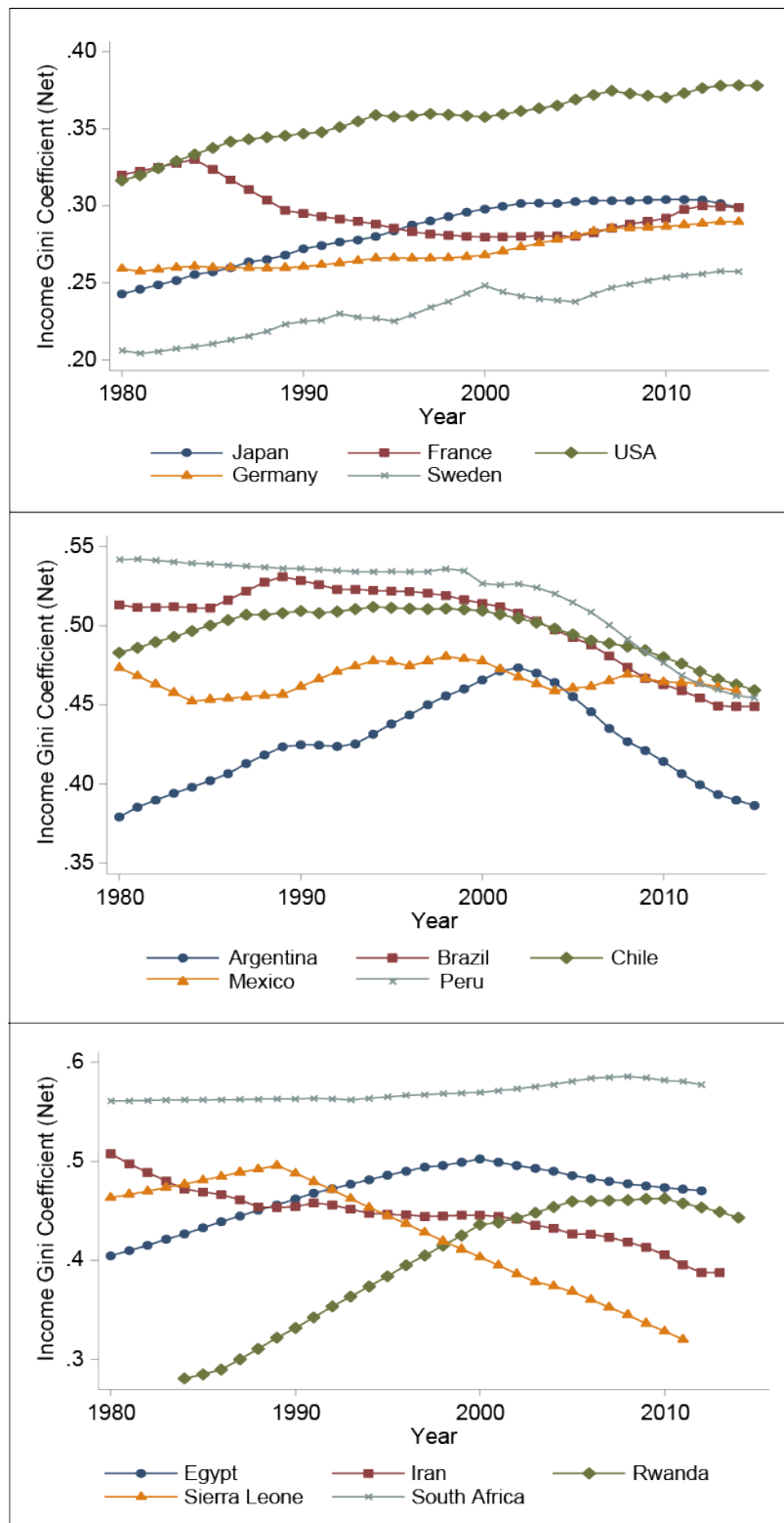
Figure 2: Trends of Income Inequality in East and South Asian Economies

Figure 3: Trends of Income Inequality in Selected Economies of Other Groups/Regions



We construct the average number of years of schooling for the population aged 15–64, S , as:

$$S_t = \sum_{a=1}^A l^a S^a = \sum_{a=1}^A l^a (\sum_j h_j^a \text{Dur}_j^a) \quad (4)$$

where l^a is the population share of five-year age group a in the working-age population and S^a is the number of years of schooling of age group a . We construct the average years of schooling of age group a as the sum of the fraction of group a that has attained the educational level j (h_j^a) weighted by the corresponding duration in years (Dur_j^a).

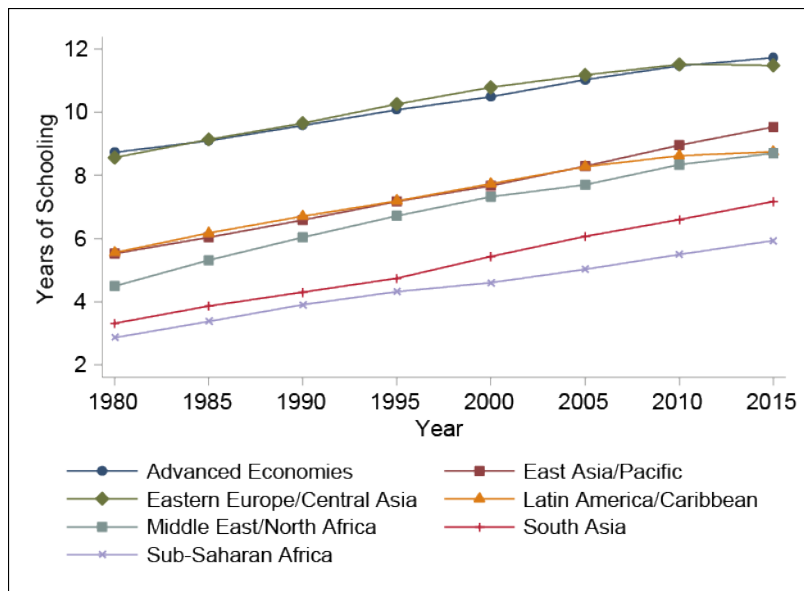
To measure educational inequality, we construct the Gini coefficient of educational distribution following Castelló and Doménech (2002):

$$\text{Education Gini} = \frac{1}{2S} \sum_{i=0}^6 \sum_{j=0}^6 |\hat{x}_i - \hat{x}_j| l_i l_j \quad (5)$$

where S is the average years of schooling in the population aged 15–64 years, i and j stand for different levels of education, \hat{x}_i refers to the cumulative average years of schooling of each level of education, and l is the share of the population with a given level of education.

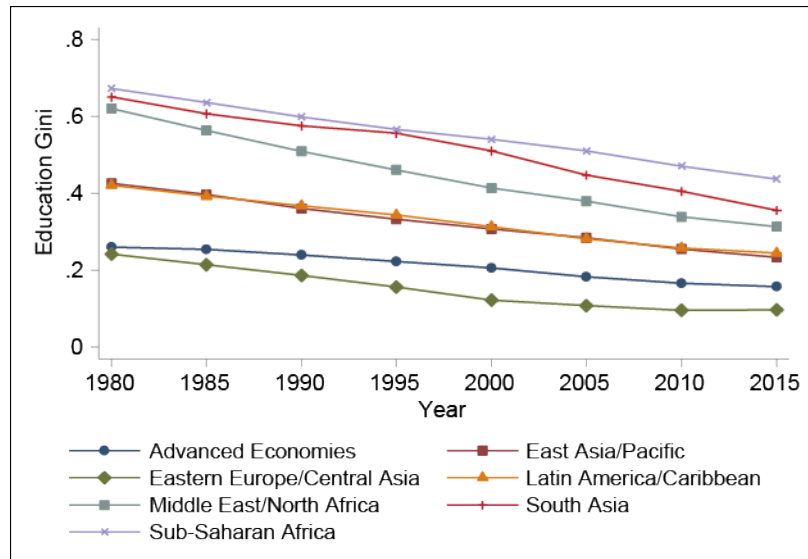
Figure 4 presents the trend of educational attainment for each region from 1980 to 2015 for the 138 countries that have complete information. The numbers are unweighted averages for the countries in each region. The figure shows that education has expanded greatly within the region and worldwide. This dramatic increase in educational attainment reflects increases in school enrollment, especially at the secondary and tertiary levels in the earlier periods (Barro and Lee 2015). Notwithstanding the significant improvements, the gap between advanced countries and developing countries, in particular South Asian and Sub-Saharan African countries, remains.

Figure 4: Trends of Educational Attainment from 1980 to 2015 for a Balanced Panel of 138 Economies



In contrast, educational inequality has declined continuously in all regions during the period (Figure 5). Even the regions with greater inequality, such as South Asia and Sub-Saharan Africa, have experienced a substantial reduction in educational inequality.

Figure 5: Trends of Educational Inequality from 1980 to 2015 for a Balanced Panel of 138 Economies



We examine the simple cross-correlation between income inequality and educational variables. Figure 6 plots educational inequality against the income Gini coefficient from 1980 to 2015 at five-year intervals. It shows a positive relationship between income and educational inequality. However, the correlation between the income and the education Gini coefficients is low (correlation coefficient = 0.318). Figure 7 shows that there is a negative relationship between educational attainment and income inequality but that their correlation is also not particularly high (0.42).

Figure 6: Education Gini and Income Gini Coefficients across Countries, Five-Year Intervals from 1980 to 2015

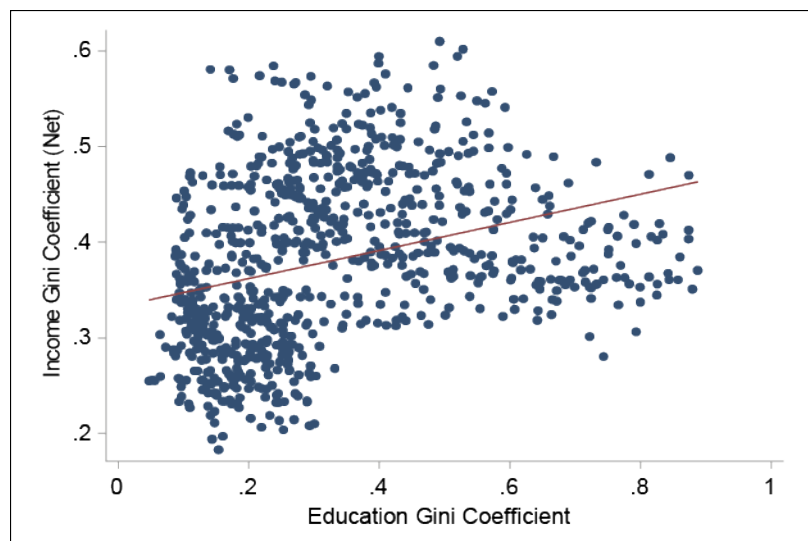
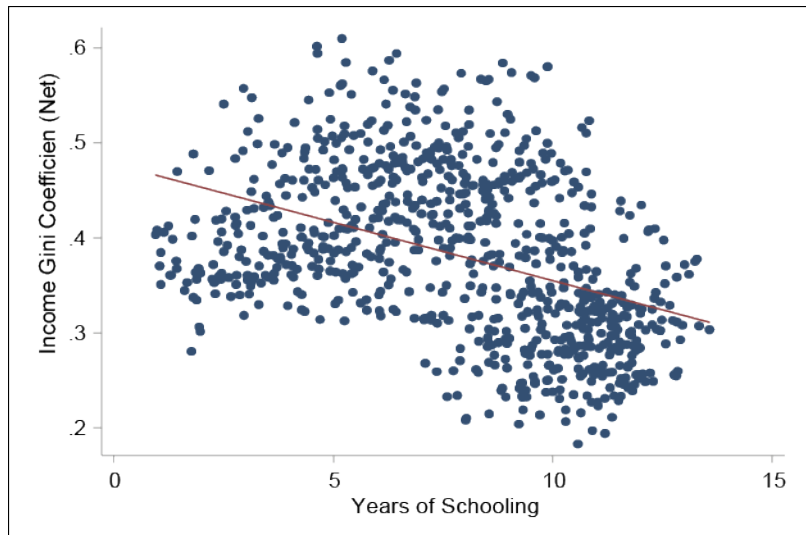


Figure 7: Education Attainment and Income Gini Coefficients across Countries, Five-Year Intervals from 1980 to 2015



We also consider the relationship between the changes in income inequality and educational inequality. Figure 8 indicates that there is a positive relationship between changes in income inequality and educational inequality from 1980 to 2015. However, they are weakly correlated (0.14). Some countries (e.g., Brazil, Iran, Peru, and Sierra Leone) achieved decreases in both income and educational inequality over the period, as human capital theory predicted. Conversely, others (e.g., the PRC, Egypt, India, and Nepal) have experienced improvement in educational distribution but deterioration in income distribution. Figure 9 shows that the relationship between the changes in educational attainment and income inequality is negative but very weak (0.15).

Figure 8: Change in Income and Education Gini Coefficients from 1980 to 2010 for a Balanced Sample of 60 Economies

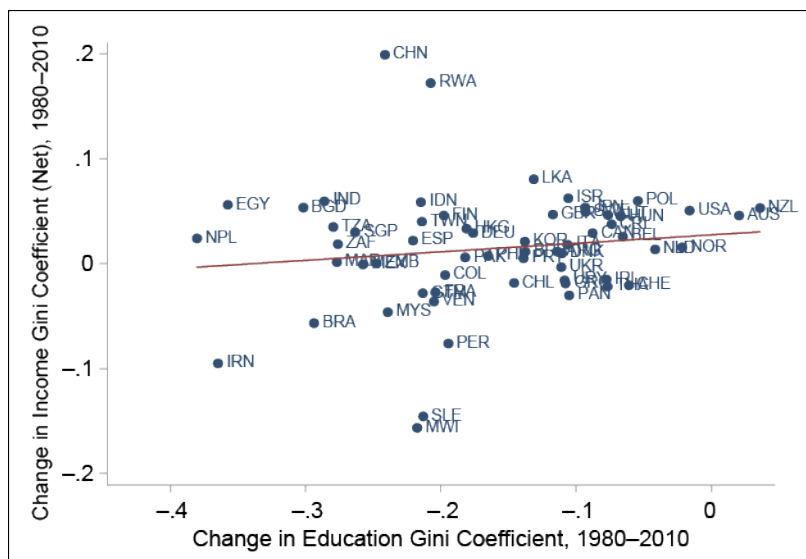
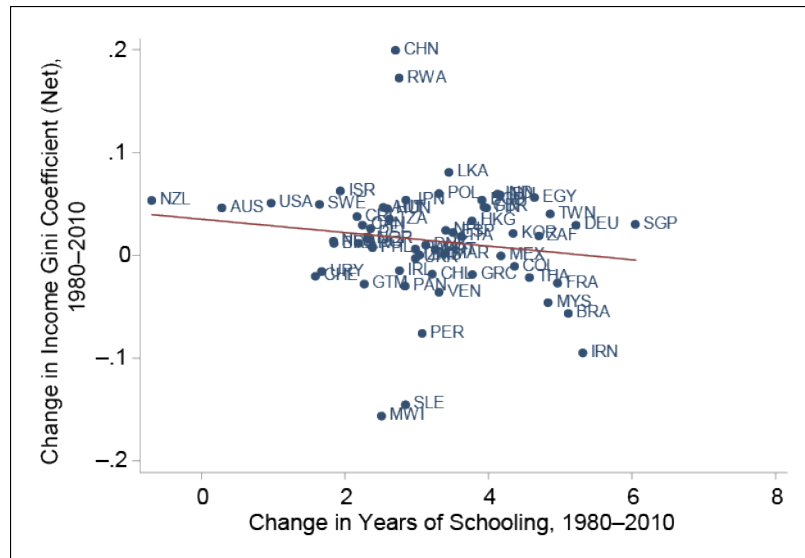


Figure 9: Changes in the Educational Attainment and Income Gini Coefficients across Countries from 1980 to 2010 for a Balanced Sample of 60 Economies



We also confirm that educational attainment has a strong negative relation with educational inequality in terms of both level and change (Figures 10 and 11). As discussed in the previous section, the expansion of education to less-educated, lower-income people appears to reduce the level of educational inequality.

Figure 10: Relationship between Educational Inequality and Educational Attainment, Five-Year Intervals from 1980 to 2015

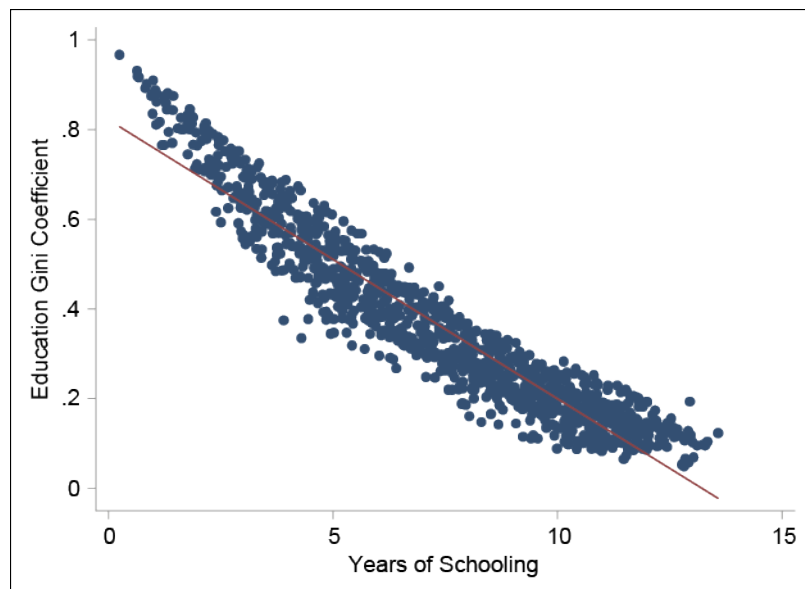
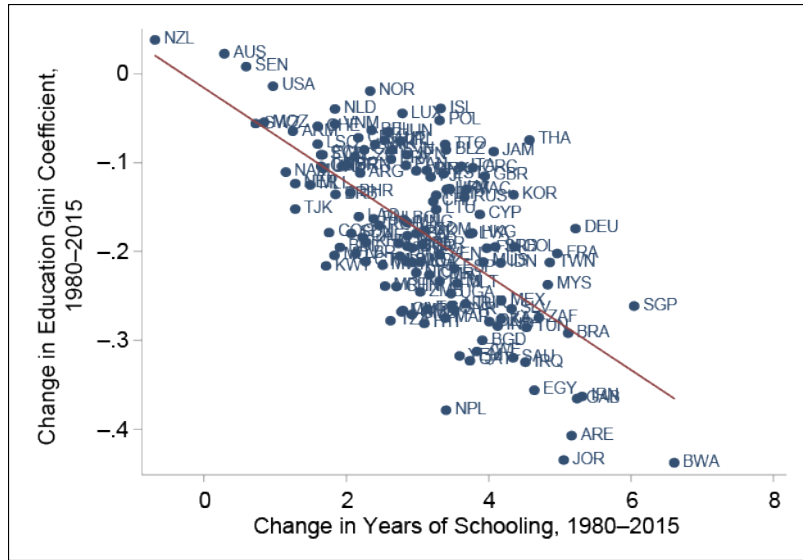


Figure 11: Change in the Educational Attainment and Education Gini Coefficients from 1980 to 2015 for a Balanced Sample of 60 Economies



Although the evidence presented in this section is suggestive, further statistical analysis is necessary to assess the magnitude of the independent effect of educational factors in explaining the differences in income distribution across countries after controlling for other important explanatory variables for income distribution.

4. EMPIRICAL ANALYSIS OF INCOME INEQUALITY

This section explores the major factors that can explain income inequality for a broad number of countries over three decades. The empirical strategy is to identify the relationship between educational variables and income inequality when controlling for other important determinants of income inequality.

The following represents the empirical framework:

$$\begin{aligned} \text{Income Gini}_{i,t} = & \beta_0 + \beta_1 \log(y_{i,t}) + \beta_2 \log(y_{i,t})^2 + \beta_3 \text{Education Gini}_{i,t} + \\ & \beta_4 \text{Educational Attainment}_{i,t} + \beta_5 X_{i,t} + \varepsilon_i + \theta_t + u_{i,t}, \end{aligned} \quad (6)$$

where $y_{i,t}$ is the country's per capita income and $X_{i,t}$ denotes a group of environmental and policy variables that influence country i 's income inequality. The specification includes period dummies.

The regression applies to a panel set of cross-country data for 95 economies over seven five-year periods from 1980 to 2014, corresponding to 1980–1984, 1985–1989, 1990–1994, 1995–1999, 2000–2004, 2005–2009, and 2010–2014.³ The dependent variable is the net Gini coefficient of income distribution, averaged over each period.

³ The sample is an unbalanced panel of 95 economies, because many economies have incomplete data on income inequality in the 1980s. The main results reported here are robust when the sample is restricted to the balanced panel of 59 countries that have complete data.

The basic specification controls for the log of per capita GDP and its square to capture the Kuznets inverted-U curve for the relationship between the income distribution and the level of income (Kuznets 1955). We want to assess the effect of education factors, independently from per capita income, on income inequality. For the environmental and policy variables, we consider trade openness, inflation, fiscal policy (government consumption and social benefits), a democracy indicator, and technological progress.

We measure trade openness using the ratio of exports plus imports to the GDP. Theoretically and empirically, we consider international trade to influence income inequality. According to a Heckscher–Ohlin trade model, when it opens up to trade, a country with abundant low-skilled labor will experience an increase in the relative wage of unskilled workers, thus reducing wage inequality. However, if trade transmits skill-biased technological change to developing countries, increased trade openness could cause higher wage inequality by shifting the labor demand towards more skilled workers. The evidence suggests that trade liberalization has a significant effect on wage inequality through its impact on the adoption of new skill-intensive technologies (Berman, Bound, and Machin 1998; Bourguignon, Ferreira, and Lustig 2004; Lee and Wie 2015).⁴

We expect inflation (measured using changes in the consumer price index over five-year intervals) to worsen income distribution. Inflation tends to decrease the real wage and redistribute income from wage earners to profit takers, which can deteriorate income distribution. Easterly and Fisher (2001) find that high inflation tends to reduce the share of the bottom quintile and the real minimum wage, increasing income inequality. As inflation is a tax on cash balances, it can disproportionately hurt poor households, whose wealth is mostly held in liquid assets such as currency, thereby increasing inequality (Albanesi 2007).

We also add democracy as a determinant of income inequality. For nondemocratic regimes, in which political power is concentrated within a narrow segment of the society, we expect income inequality to be higher. Democratic institutions, by shifting the median voter towards poorer people, can increase redistributive activities, reducing income inequality. On the other hand, democracy can cater to the preferences of the richer population or the middle class, thus exacerbating inequality (Acemoglu et al. 2015). The empirical evidence does not support a strong effect of democracy on income inequality. However, it appears to support the idea that democracy influences income inequality through the indirect channels of the tax rate and education (Acemoglu et al. 2015). As the measure of democracy, we use the Freedom House Political Rights Index (converted from seven categories into a scale from zero to one, with higher values representing the increasing presence of political rights).

Fiscal policy is an important factor that influences income distribution. We expect redistributive policies to reduce income inequality (Benabou 2000; De Gregorio and Lee 2002). The effect of overall government expenditures on income distribution must depend on composition, coverage, and targeting. We consider the extent of government consumption, defined as the ratio of government consumption to the GDP, as a fiscal policy variable. We also use social benefit expenditure, which includes direct transfers to the poor for unemployment compensation, social security pensions, and

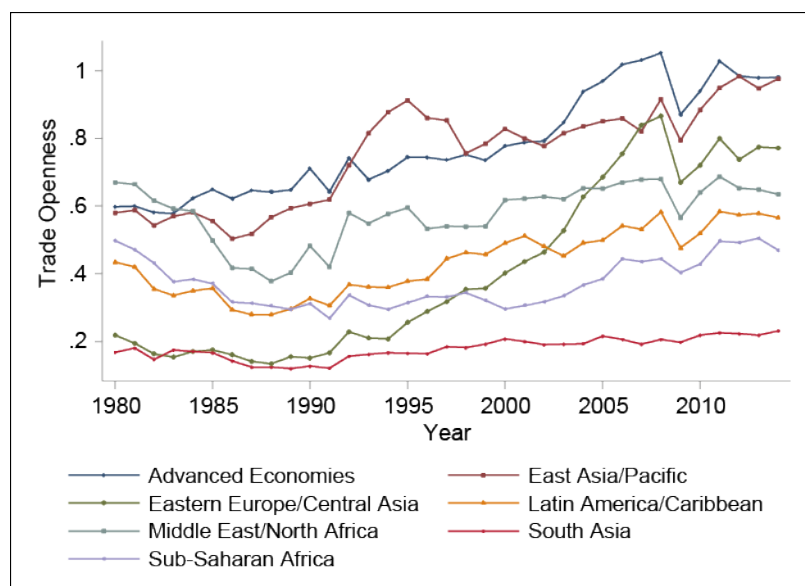
⁴ We also consider financial openness as a potential driver of income inequality, but it turns out to be statistically insignificant.

the provision of medical services, as another fiscal policy variable redistributing income from rich to poor.⁵

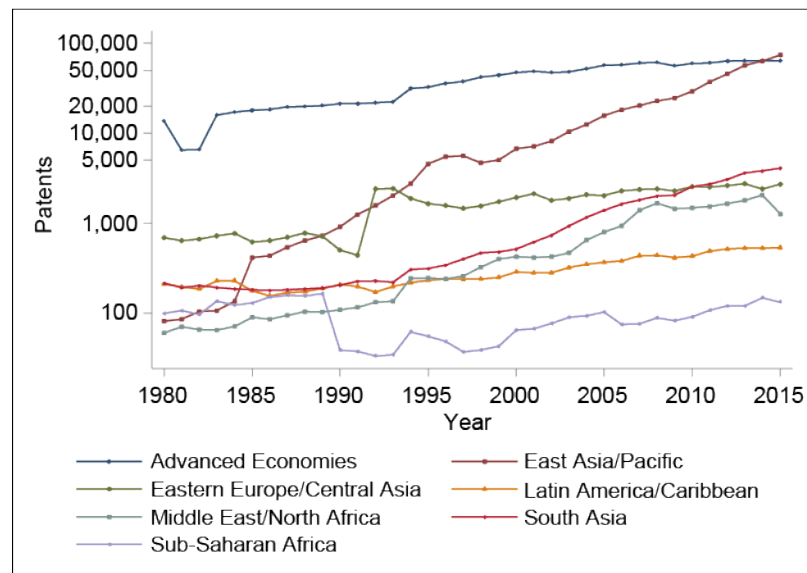
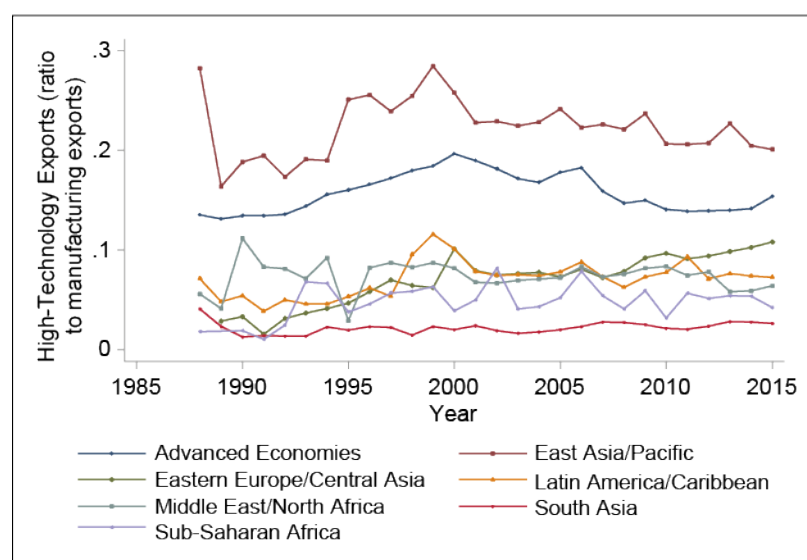
The principal link between technology and income inequality is the channel of skill-biased technical change. Technological change, which causes a relative demand shift favoring those with a high level of education, increases the relative wage of more-educated workers relative to under-educated workers. A difficulty arises regarding the accurate measurement of technological change. In this study, we adopt two measures, considering data availability: the number of patents and the share of high-technology exports in the total manufactured exports. The number of patents is the total number of applications filed by “applicant’s origin” under the World Intellectual Property Organization (WIPO)’s Patent Cooperation Treaty (WIPO 2016). High-technology exports are products with high research and development (R&D) intensity, such as those in aerospace, computers, electrical machinery, pharmaceuticals, and scientific instruments (World Bank 2017).

Figures 12 and 13 present the trends of trade openness and technological progress, respectively, for each region from 1980 to 2015 for the sample of countries that have complete information. The numbers are unweighted averages for the countries in each region. Trade openness shows significant variation across regions. It has been high and risen fast on average in advanced economies and East Asian economies. The measures of technological progress also show significant regional variations but have been high in advanced economies and East Asian economies.

**Figure 12: Trends of Trade Openness by Region
for a Balanced Sample of 123 Economies**



⁵ We also consider public education appending as another fiscal variable that can influence income distribution, but it turns out to be statistically insignificant. However, spending on education has a significantly positive effect on educational equality, as shown in Section 5.

Figure 13: Trends of Technology by Region, Unbalanced Sample**(a) Number of Patents (log scale)****(b) High-Technology Exports (Ratio to Manufacturing Exports)**

We estimate this system of seven equations in (6) with country fixed effects. The fixed-effects estimation controls for possible bias when unobserved and persistent country characteristics that influence the income Gini variable correlate with the explanatory variables. To reduce the reverse causality, we use per capita income and educational variables at the beginning of the period. For other policy variables, we use the values for the contemporaneous period corresponding to the income distribution variable. However, considering that the reverse causality from income distribution to our environmental and policy measures may cause biased estimates, we also adopt instrumental variable (IV) estimation techniques. The IV estimation uses lagged values of policy variables as instruments. Note that it is practically difficult to adopt instrumental variable estimation techniques by constructing a set of fully convincing exogenous instruments in this panel structure.

Regression (1) of Table 1 presents the estimation results of the basic specification (6) using income, education, and four policy variables (namely trade openness, inflation, democracy, and government consumption) with country fixed effects. The sample includes 608 observations for seven periods for 95 countries.

The estimates of per capita GDP support the nonlinear effects of per capita income that the Kuznets curve proposes. The coefficients of per capita GDP and its square terms are positive and negative, respectively. The estimates are individually and jointly statistically significant, but the square term is only marginally significant. This configuration of coefficients indicates an initial increase and a subsequent decline in the income Gini coefficient with log per capita income when controlling for other variables. However, the estimated coefficients—the linear term of 0.0672 and the squared term of -0.0027—imply that the breakpoint is well above the range of per capita income in the sample. Hence, an increase in income tends to worsen income inequality. According to the estimated coefficients, an increase of 1 standard deviation (1.16) at the mean (9.03 or \$8,350) in the log per capita income leads to an increase in the income Gini coefficient of about 0.018 (that is, 1.8 percentage points), which accounts for about 20% of the standard deviation of the Gini coefficient.

Educational inequality, measured by the Gini coefficient of educational attainment among the population, has a significantly positive effect on income inequality. In regression (4), the estimated coefficient (-0.089) suggests that an increase in the education Gini coefficient of 1 standard deviation (0.18) increases the income Gini coefficient by about 0.016 (that is, 1.6 percentage points), which accounts for about 18% of the standard deviation of the Gini coefficient.

In contrast, educational attainment has a statistically insignificant effect on income inequality when controlling for other variables, including per capita income and educational inequality. Note that, as long as educational inequality is related to the level of educational attainment, the average level of educational attainment can have an indirect effect on income inequality by changing educational inequality. We discuss this issue in the next section.

We find that trade openness has a significantly positive impact on income inequality. The estimated coefficient (0.017) suggests that an increase in the international trade-to-GDP ratio of 0.56 (1 standard deviation) increases the Gini coefficient by about 1 percentage point.

The positive estimate of the coefficient of inflation also supports the theoretical prediction. The estimated coefficient (0.019) implies that an increase in inflation of 1 standard deviation (1.42) increases the income Gini coefficient by about 0.3 percentage points. Conversely, democracy and government consumption are not statistically significant when controlling for per capita income, educational inequality, average educational attainment, and other policy variables.

Table 1: Regression Results for Income Inequality

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation Technique	Panel FE	Panel FE	Panel FE	Panel FE	Panel FE IV	Panel FE IV	Panel FE IV	Panel FE IV
Log (per capita GDP)	0.0672** (0.0281)	0.0782*** (0.0280)	0.0509 (0.0311)	−0.0283 (0.0395)	0.0424 (0.0278)	0.0489* (0.0290)	0.0393 (0.0375)	−0.0989** (0.0490)
Log (per capita GDP) squared	−0.0027* (0.0016)	−0.0035** (0.0016)	−0.0023 (0.0017)	0.0008 (0.0022)	−0.0014 (0.0015)	−0.0021 (0.0016)	−0.0018 (0.00197)	0.0049* (0.0027)
Educational inequality	0.0893** (0.0441)	0.0888** (0.0437)	0.103** (0.0490)	0.0658 (0.0546)	0.101** (0.0440)	0.111** (0.0449)	0.148** (0.0576)	0.0699 (0.0534)
Educational attainment	0.0002 (0.0031)	0.0007 (0.0031)	0.0023 (0.0033)	−0.0035 (0.0033)	0.0008 (0.0032)	0.0024 (0.0032)	0.00704* (0.0037)	−0.0032 (0.0031)
Trade openness/GDP	0.0168*** (0.0057)	0.0172*** (0.0056)	0.0127** (0.0062)	0.0050 (0.0057)	0.0142** (0.0057)	0.0152*** (0.0057)	0.0118* (0.0066)	0.0039 (0.0058)
Inflation	0.0019** (0.0008)	0.0017** (0.0008)	0.0024*** (0.0007)	0.0011* (0.0006)	0.0021*** (0.0007)	0.0020*** (0.0007)	0.0028** (0.0012)	0.0015** (0.0006)
Democracy indicator	0.0042 (0.0060)	0.0041 (0.0060)	0.0118* (0.0069)	0.0191*** (0.0063)	−0.0004 (0.0064)	−0.0004 (0.0065)	0.0146 (0.0096)	0.0194*** (0.0071)
Government consumption/GDP	−0.0206 (0.0231)	−0.0242 (0.0229)	0.0265 (0.0319)	−0.0256 (0.0327)	−0.0300 (0.0234)	−0.0353 (0.0237)	0.0436 (0.0394)	0.0547 (0.0384)
Patents		0.182*** (0.0384)				0.163*** (0.0383)		
High-technology exports/ manufacturing exports			0.0379* (0.0214)				0.0091 (0.0251)	
Social spending/GDP				−0.0862* (0.0504)				−0.101* (0.0553)
<i>N</i> , <i>N</i> of country	608, 95	595, 93	460, 91	333, 71	578, 95	553, 93	369, 90	265, 67
<i>R</i> ²	0.131	0.167	0.156	0.305	0.103	0.148	0.128	0.338

Notes: Panel FE indicates panel regression with country fixed effects and Panel FE IV uses values over the previous five years or in the initial year of each period of the explanatory variables as instrumental variables (IVs). The regression applies to an unbalanced panel data set for 95 economies over seven five-year periods from 1980 to 2014. The dependent variable is the net income Gini coefficient, averaged over each period. The per capita GDP, educational inequality, and educational attainment are the values in the initial year of each period, and the other explanatory variables are period averages. The specification includes period dummies. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Regression (2) of Table 1 adds the number of patents as a measure of technological progress.⁶ The sample size shrinks, because fewer observations of this variable are available. The estimation result shows that, when controlling for other explanatory variables, income inequality is strongly positively associated with technological development. The estimated coefficient (0.146) suggests that an increase in the log value of patents of 0.05 (1 standard deviation) increases the Gini coefficient by about 0.9 percentage points. In regression (3), income inequality is also positively, though only marginally statistically significantly, related to high-technology exports, which is another measure of technological development. The estimated coefficient of high-technology exports (0.038) suggests that an increase of 0.12 in the ratio of high-technology exports to manufacturing exports increases the income Gini coefficient by about 0.5 percentage points.

Regression (4) of Table 1 adds government social benefits as an explanatory variable. Because the sample size shrinks substantially, the results for the other explanatory variables change considerably. Notably, the estimates for the per capita income and educational inequality variables become statistically insignificant. Nevertheless, social benefit spending has a significantly negative effect on income inequality. The

⁶ The patent variable is the log value of (1+number of patents).

estimated coefficient (−0.086) indicates that an increase in government social expenditures of 0.07 (1 standard deviation) reduces the education Gini coefficient by about 0.6 percentage points. Interestingly, democracy enters regressions (3) and (4) positively and statistically significantly with these samples, implying that a democratic regime tends to be associated positively with activities that worsen income inequality, especially when controlling for redistributive activities.

Regressions (5)–(8) of Table 1 present the results from the IV estimation techniques to control for the endogeneity of the policy variables, using their lagged values as IVs. The use of lagged values as instruments reduces the number of observations in the early period in some specifications. The table shows that the major results in regressions (1)–(4) change very little in IV estimation.

To assess the effects of education and other explanatory variables on income distribution quantitatively, we decompose the evolution of income inequality in the East Asian region. Researchers have seen many East Asian economies as examples of “growth with equity,” but in recent decades they have experienced significant deterioration of income distribution. Columns (1)–(3) of Table 2 show the actual values of the income Gini coefficient and all the explanatory variables for 1985–89 and 2010–14 and the differences between the two periods for the average of eight economies that have complete data: the PRC; Hong Kong, China; Indonesia; Malaysia; the Philippines; the Republic of Korea; Singapore; and Thailand. Columns (1)–(3) show the actual values of the income Gini coefficient and all the explanatory variables. The actual average values were 0.396 and 0.429 for 1985–89 and 2010–14, respectively, and increased by 3.3 percentage points over 25 years in East Asia. Using the regression result in column (2) of Table 1, we construct the values of the income Gini coefficient that each explanatory variable predicts for each period and the difference between the two periods. The model-based predicted values of the income Gini coefficient in 1985–89 and 2010–14 were about 2 percentage points lower than the actual values and increased by 2.8 percentage points between the two periods.

Column (4) of Table 2 shows the extent to which the change in each explanatory variable contributes to the predicted change in the income Gini coefficient of 2.8 percentage points over the period in the region. We find that the per capita income increase played an important role, contributing 1.6 percentage points. Trade openness and technological progress also made significant contributions of about 1.0 and 1.5 percentage points, respectively. More equal distribution of education counterbalanced these unequalizing effects by reducing the income Gini coefficient by as much as 1.5 percentage points. However, an increase in educational attainment had a deteriorating effect on income distribution of about 0.3 percentage points.⁷

We can also gauge the role of social benefits in explaining the change in income inequality. During this period, the share of social benefits in the GDP increased from 0.7% to 2.9% on average in East Asian economies. Using the estimated coefficient of social benefits in column (4) of Table 1, we estimate the increase in government social spending to have contributed to reducing income inequality by about 0.2 percentage points. Hence, the small increase in social benefits had only a minor impact on income distribution in East Asia. If social spending had increased to 10% of the GDP, the world average, it would have decreased the income Gini coefficient by 0.8 percentage points, as much as education factors.

⁷ Note that educational expansion can have an indirect effect on income inequality through its effect on educational inequality. According to the estimation result in the next section, a 3.5-year increase in the average schooling years in East Asia over 1985–89 and 2010–14 would have a significantly positive effect on educational distribution and thus income distribution.

Table 2: Explaining the Change in Income Inequality in East Asia

	Actual Values			Income Gini Change Explained by Each Factor
	(1)	(2)	(3)	(4)
	1985–89	2010–14	Change	
Income Gini				
Actual	0.396	0.429	0.033	
(Predicted)	(0.379)	(0.407)	(0.028)	
Determinants				
Log per capita GDP	8.615	9.795	1.180	0.0158
Log per capita GDP squared	74.80	96.68	21.88	
Educational inequality	0.369	0.205	–0.165	–0.0146
Educational attainment	6.62	10.1	3.48	0.0026
Trade openness	0.802	1.370	0.568	0.0098
Inflation	0.060	0.034	–0.026	–0.0001
Democracy indicator	0.415	0.473	0.058	0.0002
Government consumption	0.168	0.124	–0.044	0.0011
Patents	0.001	0.082	0.080	0.0146

Notes: We use the regression result in column (2) of Table 1 to calculate the predicted values of income inequality, on average, for the group of eight East Asian economies consisting of the PRC; Hong Kong, China; Indonesia; Malaysia; the Philippines; the Republic of Korea; Singapore; and Thailand. Columns (1)–(3) show the actual values of the income Gini coefficient and all the explanatory variables for 1985–89 and 2010–14 and their changes between the two periods, and column (4) contains the predicted change in income inequality between 1985–89 and 2010–14 using the regression result in column (2) of Table 1. The value of per capita GDP includes both level and square terms.

In sum, economic growth, trade openness, and technological progress are three major factors that have led to the deterioration of income distribution in East Asia in recent decades. The unequalizing effects of these factors on income distribution have surpassed the income-equalizing effects of educational equality and government social expenditures. Improvements in the level and distribution of education are important factors that have counterbalanced the forces of deteriorating income distribution.

5. EMPIRICAL ANALYSIS OF EDUCATIONAL INEQUALITY

The previous section shows that income inequality is positively related to educational inequality. In this section, we analyze the determinants of educational inequality.

The empirical framework is represented by:

$$\begin{aligned} Education\ Gini_{i,t} = & \beta_0 + \beta_1 \log(y_{i,t-1}) + \beta_2 Income\ Gini_{i,t-1} + \\ & \beta_3 Educational\ attainment_{i,t-1} + \beta_4 X_{i,t-1} + \varepsilon_i + \theta_t + u_{i,t} \end{aligned} \quad (7)$$

The regression applies to a panel set of cross-country data for 95 economies at five-year intervals from 1985 to 2015. The dependent variable is the Gini coefficient of educational distribution for 1985, 1990, 1995, 2000, 2005, 2010, and 2015. This system of seven equations in (7) is estimated with country fixed effects. To reduce the reverse causality, we use one-period lagged values for per capita income and the educational attainment variables and averaged values over the previous five years for

the environmental and policy variables. Because school enrollments and other factors in much earlier periods determine the distribution of educational attainment among the adult population, the endogeneity issue is less of a concern. The regression includes a lagged value of income inequality to identify the possible impact from income distribution on educational distribution.

We use public spending on education, instead of social benefits (which turns out to be statistically insignificant), as a fiscal policy variable. We expect spending on education to help the poor to gain access to education, thereby contributing to education equality, especially when credit markets are imperfect (Benabou 2000; De Gregorio and Lee 2002).

Table 3: Regression Results for Educational Inequality

	(1)	(2)	(3)	(4)
	Panel FE	Panel FE	Panel FE	Panel FE
Log (per capita GDP)	0.0191 ^{***} (0.0061)	0.0188 ^{***} (0.0062)	0.0136 (0.0090)	0.0223 ^{***} (0.0065)
Income Gini	0.0819 (0.0556)	0.0704 (0.0574)	0.103 (0.0757)	0.102 (0.0647)
Educational attainment	−0.0354 ^{***} (0.0026)	−0.0355 ^{***} (0.0027)	−0.0322 ^{***} (0.0032)	−0.0356 ^{***} (0.0027)
Trade openness/GDP	0.0311 ^{***} (0.0070)	0.0316 ^{***} (0.0071)	0.0248 ^{***} (0.0090)	0.0337 ^{***} (0.0077)
Inflation	0.0008 (0.0010)	0.0008 (0.0010)	0.0013 (0.0010)	0.0016 (0.0013)
Democracy indicator	0.0035 (0.0075)	0.0034 (0.0076)	−0.0058 (0.0010)	0.0058 (0.0083)
Government consumption/GDP	0.166 ^{***} (0.0271)	0.166 ^{***} (0.0274)	0.175 ^{***} (0.0438)	0.162 ^{***} (0.0314)
Patents		0.0397 (0.0498)		
High-technology exports/ manufacturing exports			−0.0375 (0.0309)	
Education spending/GDP				−0.0034 ^{**} (0.0017)
<i>Country fixed effect</i>	Yes	Yes	Yes	Yes
<i>N, N of country</i>	608, 95	595 93	460, 91	506, 94
<i>R²</i>	0.820	0.818	0.765	0.806

Notes: The system consists of seven equations that apply to an unbalanced panel data set for 95 economies. The dependent variable is the education Gini coefficient for 1985, 1990, 1995, 2000, 2005, 2010, and 2015. The per capita GDP, educational inequality, and educational attainment are five-year lagged values, and the other variables are averages over the previous five years. Panel FE indicates panel regression with country fixed effects. The specification includes period dummies. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Regression (1) of Table 3 includes per capita income, income inequality, educational attainment, and four policy variables—trade openness, inflation, government consumption, and a democracy indicator— as explanatory variables, controlling for country fixed effects. The estimated coefficient of the income level is statistically significant and positive. Hence, increases in per capita income over time tend to increase educational inequality. The estimated coefficient (0.019) suggests that an increase in log per capita income of 1 standard deviation (1.16) increases the education Gini coefficient by 2.2 percentage points. However, income inequality is statistically insignificant.

The regression result shows a strong negative effect of educational attainment on income inequality. The estimated coefficient of educational attainment (−0.035) suggests that an increase in the average schooling of about 3 years (amounting to 1 standard deviation) decreases the education Gini coefficient by about 0.11 (that is, 11 percentage points), which accounts for about 60% of the standard deviation of the education Gini coefficient. Therefore, the increase in educational attainment is the major driver improving the education Gini coefficient. According to the result in Table 1, a decrease in the education Gini coefficient of 0.11 reduces the income Gini coefficient by about 1 percentage point. Hence, an increase in the level of educational attainment can contribute significantly to reducing income inequality through the channel of change in educational inequality.

In Regression (1), the coefficient of trade openness is significantly positive. The estimated coefficient (0.031) suggests that an increase in international trade of 0.56 (1 standard deviation) increases the education Gini coefficient by about 1.7 percentage points. Government consumption is also significantly positive. The estimated coefficient (0.166) suggests that an increase in government consumption of 0.07 (1 standard deviation) increases the education Gini coefficient by about 1.2 percentage points. Conversely, inflation and democracy are not statistically significant. The positive effects of trade openness and government consumption on educational inequality, controlling for income and educational attainment variables, seem to suggest that the distribution of education among the population tends to become more uneven, for instance by disproportionally increasing the schooling years of higher-educated people when an economy increases its openness to international trade or the size of government consumption.

Regressions (2)–(3) include technology variables. In contrast to the regressions of income inequality, there is no significant effect of technological development, measured using either the number of patents or the number of high-technology exports, on educational inequality.

Regression (4) adds government spending on education as an explanatory variable. The coefficient of spending on education is negative, implying that higher public expenditure on education helps to decrease the inequality of schooling. The estimated coefficient (−0.0034) suggests that an increase in government spending on education of 0.016 (1 standard deviation) reduces the education Gini coefficient by about 0.5 percentage points. The results for the other explanatory variables in this regression remain quite similar to those in Regression (1).

The results in Tables 1 and 3 show that public policies are effective in reducing income inequality. Government social expenditure helps to reduce income inequality, and spending on education can reduce the dispersion of education and thereby income inequality.

6. CONCLUDING REMARKS

This paper provides evidence that human capital, measured by educational attainment, plays an important role in income distribution. The regressions using panel data for a broad range of countries for the period between 1980 and 2015 show that more equal distribution of education has contributed significantly to reducing income inequality. An increase in educational attainment reduces educational inequality and thus helps to reduce income inequality. The empirical results also show that we can attribute the rising income inequality in many economies in recent decades to a fast income increase, trade expansion, and rapid technological progress. Reduced educational inequality is an important factor that counterbalanced these income-unequalizing forces over the period. We also find that increased social benefit expenditures and lower inflation contributed to making income distribution more equal. Increased public spending on education also played an important role in improving education distribution and thus income distribution.

Understanding the impact of education, globalization, and technological changes on income distribution is important to design and implement deliberate policies towards more inclusive and sustainable economic development. Policy measures to reduce income inequality should include effective human capital policies, such as inclusive education and training for unskilled workers, rather than building barriers to international trade and technological innovation that would be harmful to sustaining economic growth. In addition, social benefits and redistributive policies should be enhanced to protect the weak and ameliorate income distribution.

An important question is how education affects the degree of intergenerational mobility. Studies show that greater income inequality at a given point in time is associated with less intergenerational mobility, which is known as the “Great Gatsby Curve.” One important link between income equality and intergenerational mobility must be the distribution of schooling (in terms of quantity and quality) among the population. More unequal income distribution among families causes opportunities for economic advancement to be distributed more unequally among children. The distribution of educational attainment and income among the population is likely to be transmitted from one generation to the next. Our subsequent research will focus on this important issue.

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APPENDIX

Appendix Table 1: Sample Countries

Groups/Regions		
<i>Advanced Economies (24)</i>		
Australia	Greece	Norway
Austria	Iceland	Portugal
Belgium	Ireland	Spain
Canada	Italy	Sweden
Denmark	Japan	Switzerland
Finland	Luxembourg	Turkey
France	Netherlands	United Kingdom
Germany	New Zealand	US
<i>East Asia/Pacific (11)</i>		
PRC	Lao	Singapore
Fiji	Malaysia	Taipei, China
Hong Kong, China	Philippines	Thailand
Indonesia	Republic of Korea	
<i>Eastern Europe/Central Asia (7)</i>		
Bulgaria	Poland	Russian Federation
Czech Republic	Romania	Slovakia
Hungary		
<i>Latin America/Caribbean (20)</i>		
Argentina	Dominican Republic	Panama
Barbados	Ecuador	Paraguay
Bolivia	El Salvador	Peru
Brazil	Guatemala	Trinidad and Tobago
Chile	Honduras	Uruguay
Colombia	Mexico	Venezuela
Costa Rica	Nicaragua	
<i>South Asia (5)</i>		
Bangladesh	Nepal	Sri Lanka
India	Pakistan	
<i>Middle East/North Africa (9)</i>		
Algeria	Iran	Morocco
Cyprus	Israel	Qatar
Egypt	Jordan	Tunisia
<i>Sub-Saharan Africa (19)</i>		
Botswana	Mauritania	South Africa
Cote d'Ivoire	Mauritius	Sudan
Gambia	Niger	Swaziland
Ghana	Rwanda	Tanzania
Kenya	Senegal	Uganda
Lesotho	Sierra Leone	Zambia
Malawi		

Appendix Table 2: Summary Statistics of the Variables in the Regression

Description	Data Source	Mean	Std Dev.	Min.	Max.
Income Gini	Solt (2016)	0.38	0.09	0.19	0.61
Log of per capita GDP	Feenstra, Inklaar, and Timmer (2015), PWT 9.0	9.03	1.16	6.43	11.71
Educational inequality	Barro and Lee (2013)	0.34	0.18	0.05	0.89
Educational attainment	Barro and Lee (2013)	7.72	2.96	1.04	13.24
Democracy indicator	Freedom House (2016)	0.65	0.33	0.00	1.00
Trade openness (ratio to GDP)	Feenstra, Inklaar, and Timmer (2015), PWT 9.0	0.56	0.56	0.06	4.59
Government consumption (ratio to GDP)	Feenstra, Inklaar, and Timmer (2015), PWT 9.0	0.18	0.07	0.06	0.60
CPI inflation rate (%)	World Bank (2017), WDI	0.27	1.42	−0.02	20.96
Patents (million; log (1+x) value)	World Intellectual Property Organization (2016)	0.012	0.050	0.000	0.455
High-technology exports (ratio to manufacturing exports)	World Bank (2017), WDI	0.114	0.121	0.000	0.730
Education spending (ratio to GDP)	World Bank (2017), WDI	0.043	0.016	0.008	0.116
Social spending (ratio to GDP)	International Monetary Fund (2017), GFS	0.100	0.070	0.000	0.254