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Abstract

This study measures the intergenerational persistence of education attainment, using internationally comparable data for parents' and children's education levels by age cohort for 30 countries, and identifies its determinants. The estimated intergenerational regression coefficients show that educational mobility worsened over generations in most countries, but its degrees varies considerably across countries and over time. The country-cohort panel regressions show that intergenerational educational mobility decreases with educational expansion, income inequality and credit constraints, and increases with per-capita GDP. The results also highlight the importance of progressive public expenditure on education for improving intergenerational educational mobility.

Keywords: intergenerational mobility, education, income inequality, education spending, credit constraint
JEL classification codes: E24, I24, O50

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I. Introduction

In recent decades, declining intergenerational income mobility has attracted attention in many countries (Björklund and Jäntti, 1997; Blanden, 2013; Corak, 2013; Durlauf and Seshadri, 2018). The low degree of intergenerational mobility alongside the high level of income inequality raises a serious concern. Deterioration of income inequality might cause social instability and conflicts as well as economic issues. A number of governments around the world are now making efforts to tackle unequal income distribution and its persistence across generations, but there is a probability that some of the populist politics result in unproductive and undesirable economic outcomes.

Education is considered to play a critical role in the degree of intergenerational income mobility. It is well-known that educational attainment embodied in a worker is a major determinant of his or her lifetime earnings. Parents believe educational investment in children as a major means to improve their children's future earnings. This parental investment in education depends on parent's income and education levels. It is more likely that more-educated and high-income parents have more resources to invest in their children than less-educated and low-income parents do. Hence, it is likely that parents' education has significant influence on children's education. In other words, the distribution of educational attainment among the population may perpetuate across generations in a society, without any government efforts to improve it. The intergenerational persistence in education is an important channel that transmits interpersonal income inequality from one generation to the next (Restuccia and Urrutia, 2004; Corak, 2013; Becker et al., 2018; Narayan et al., 2018).

The purpose of this study is to construct an internationally comparable measure of the intergenerational educational mobility for a broad number of countries and identify its major determinants. This study contributes to the existing literature by analyzing the patterns and determinants of the changes in intergenerational persistence using internationally comparable survey data for parents' and children's education levels by birth cohorts for 30 countries.

The importance of intergenerational educational mobility is well-acknowledged. Many researchers have investigated the patterns and determinants of the changes in intergenerational persistence, confirming that the educational level of parent is positively associated with that of children. Quite a number of studies investigate intergenerational educational mobility in a specific country,

including Canada (Sen and Clemente, 2010), China (Li and Zhong, 2017; Yuan et al., 2018), Denmark (Landersø and Heckman, 2017), Germany (Gang and Zimmermann, 2000; Heineck and Riphahn, 2007), Greece (Daouli et al., 2010), Hong Kong, China (Lam and Liu, in press), Italy (Checchi et al., 1999, 2013), Japan (Niimi, in press), Norway (Kalil et al., 2016), Spain (Güell et al., 2014), India (Azam and Bhutt, 2015; Emran and Shilpi, 2015), Sweden (Amin et al. 2015; Lindahl et al., 2015), Switzerland (Bauer and Riphahn, 2006), and the US (Checchi et al., 1999; Mare, 2000; Landersø and Heckman, 2017).

There exists a volume of studies conducting a cross-country analysis on this subject. Hertz et al. (2007) measure the intergenerational persistence of educational attainment by birth cohort using national survey data for 42 countries from 1994 to 2004. They show that educational attainment is highly persistent within families and intergenerational mobility is low in Latin American countries while it is high in the Nordic countries. Chevalier et al. (2009) confirm the positive relationship between children and parent's education in the US and European countries. The degree of intergenerational educational mobility changes over time. Causa and Johansson (2010) assess the intergenerational educational mobility across OECD countries and find most southern European countries appear to be relatively immobile, while Austria and Denmark are more mobile. Torul and Oztunali (2018) focus on European countries and report intergenerational persistence of education decreases in Mediterranean countries, while it shows little change in other countries. Intergenerational mobility in Latin America is shown to be low in Daude and Robano (2015), but Neidhöfer et al. (2018) report that it has been rising on average. Azomahou and Yitbarek (2016) find downward trend of intergeneration persistence of education in nine African countries. A recent study of Narayan et al. (2018) expands the sample 148 economies around the world and reports that the mobility has improved in most developing economies except Sub-Saharan Africa economies, and, on average, the mobility is lower in developing countries than in advanced economies.

In this paper, we use the Programme for the International Assessment of Adult Competencies (PIAAC) survey data developed by OECD (2013, 2016). The survey involved 33 countries, in two rounds since 2008. It is harmonized to be valid for cross-country comparison. Using the PIAAC data, we estimate intergenerational regression coefficient, that is the response of children's years of schooling to an increase in years of parents schooling (Black and Devereux, 2011; Corak 2013).

It is used as a measure of intergenerational educational mobility or persistence. Its higher value implies less intergenerational mobility, or more intergenerational persistence, in educational attainment.[1]

In PIAAC survey data, children's schooling is well-defined. It is re-classified into the 15 levels of educational attainment ranging from incomplete primary to doctoral degree, but parents' (i.e. mother's or father's) schooling is classified in three broader categories— less than lower secondary education, upper secondary education, and higher than tertiary education. As pointed out by Rigobon and Stoker (2009), a linear model using top- and bottom-coding covariate causes upward bias on intergenerational regression coefficient. To tackle this issue and produce more precise estimates, this study adopts Qian et al. (in press)'s estimation technique for censored covariate.[2] To our knowledge, except Jerrim and Macmillan (2015), this is the only study that estimates intergenerational regression coefficients using PIAAC survey data. This study considers the censoring issue in the estimation and analyzes the change in intergenerational persistence across cohorts in individual countries, which has not been addressed in Jerrim and Macmillan (2015).

This study also investigates what determines intergenerational educational mobility. Existing theoretical and empirical studies suggest economic development, income inequality, credit constraint and government spending on education as the major determinants. The studies (Owen and Weil, 1998; Maoz and Moav, 1999; Jerrim and Macmillan, 2015) report that as the economy grows with capital accumulation and technological progress, the relative importance of social background lowers while individuals allocate human capital more efficiently, thus increasing intergenerational mobility. A high level of income inequality can distort opportunities and incentives so that talented and hard-working individuals from poor families cannot get the deserved schooling and earnings (Causa and Johansson, 2010; Corak, 2013). Parental investments

[1] There are other measures of intergenerational mobility. Intergenerational correlation coefficient is the impact of normalized years of parents schooling on children's years of schooling. Hertz et al. (2007) refer this measure as 'standardized persistence.' It gauges individual's propensity to have a difference position in the distribution of educational attainment than their parents. The correlation between child and parent ranks is another measure of mobility (Chetty et al., 2014). The transition matrix is also another measure for the probability that a child will have a specific socio-economic bracket given that parents' socio-economic status (Bhattacharya & Mazumder, 2011). Because parent education variable in our data set is censored, we cannot calculate accurately its standard deviation, the correlation between child and parent education or transition matrix.

[2] Detailed explanations of the estimation methodology are in Section 2.

in the human capital of their children also depend on credit constraints. Credit-constrained households are hard to pay for tuition fees and school supplies for their children (Becker and Tomes, 1979, 1986; Carneiro and Heckman, 2002; Hai and Heckman, 2017; Mogstad, 2017). Public education expenditure reduces the education cost for poor parents, improving mobility (Checchi et al., 1999). Progressive government spending on education is expected to improve intergenerational mobility (Herrington, 2015; Ng, 2014). Daude and Robano (2015) show that intergenerational educational mobility is closely associated with income inequality, return to education, and primary education spending using cross-section data of Latin America countries. This study contributes to the existing literature by investigating the determinants of intergenerational educational mobility in the intertemporal and cross-country context using the newly-constructed country-cohort panel dataset of the estimated intergenerational regression coefficients and covariates for 30 countries.

The remainder of this paper is organized as follows. Section 2 estimates the intergenerational educational mobility by country and cohort. Section 3 analyzes the determinants of intergenerational persistence of education using country-cohort panel data. Section 4 concludes.

II. Intergenerational Educational Mobility

This section explores the patterns of intergenerational educational mobility in 30 countries by cohort. It first explains the strategy for estimating intergenerational educational mobility and the data. We estimate the intergenerational regression coefficient by country and cohort using conventional intergenerational regression equation adding variables influencing a person's educational attainment.

1. Empirical strategy

Following the literature, we estimate intergenerational regression coefficient using equation (1):

$$\mathrm{Edu}_{\mathrm{i,j,k}}^{child} = \alpha_0 + \alpha_1 Edu_{i,j,k}^{parent} + \alpha_2 Z_{i,j,k} + e_{i,j,k,} \qquad (1)$$

where $\mathrm{Edu}_{\mathrm{i,j,k}}^{child}$ and $Edu_{i,j,k}^{parent}$ denote the years of schooling of respondent *i*'s and her or his parents' highest years of schooling of country *j* and cohort *k* and $Z_{i,j,k}$ denotes a vector of important personal and environmental characteristics that influence a person's educational

attainment such as respondent *i*'s parents' assortative mating index, number of books at home at age 16, female dummy, and immigration indicator in country *j* and cohort *k*.[3] Controlling these personal and environmental variables influencing children's educational attainment is important to measure accurately the intergenerational regression coefficient (Björklund et al., 2010; Björklund and Jäntti, 2012). Mazumder (2011) reports the magnitude of intergenerational mobility declines after controlling personal and environmental variables. While parent's income and occupation are also important, the PIAAC data do not report them. The regression is applied to six age cohorts defined as 25-29, 30-34, 35-39, 40-44, 45-49, and 50-54. We also estimate equation (1) for the whole sample aged 25-54.

The focus of our analysis is estimating the intergenerational regression coefficient (α_1), which shows the effect of one additional year of parents' schooling on the respondent's schooling. α_1 is the measure of intergenerational educational persistence, and thereby a high value of α_1 means a low degree of intergenerational educational mobility. The increase in α_1 means deterioration of intergenerational educational mobility.

The survey data reports a respondent's years of schooling into 15 categories from incomplete primary education to Ph.D. degree. Unlike respondents' years of schooling, the survey data do not report detailed information about parents' education level. The survey reports parents' education level into three broad categories— lower secondary education and below, upper secondary education, and tertiary education and above. In the sample, 63.4% of the observations are censored at top or bottom. Turkey has the highest rate at 91% and Czech Republic has the lowest rate at 25%. The two-sided coding variable cannot give accurate estimation of intergenerational regression coefficient because of lack of information. OLS regression causes an expansion bias in the estimates of two-sided coding variable (Rigobon and Stoker, 2009). The intergenerational regression coefficient is overestimated without considering censored covariates.[4] To solve this problem, we adopt Qian et al. (in press)'s threshold regression approaches for censored covariates. The methodology is based on the multiple imputation method that consists of imputation,

[3] Instead of parents' highest years of schooling, one could use father and mother's years of schooling or average years of schooling of both parents. The estimate of intergenerational regression coefficients changes little by choice.

[4] We estimate intergenerational regression coefficients with and without considering censored covariates together and compare between two coefficients. It confirms that the expansion bias exists.

completed data analysis, and pooling steps. The imputation step draws multiple sets of imputed values for the censored observations from the distribution given the observed data. The completed data analysis estimates the coefficient multiple times. The pooling step combines the estimates from the previous steps into a single estimate.

Assortative mating is expected to affect positively children's educational attainment because increase in resemblance of parent's education enhances the inheritance mechanism and contributes more to the children's education (Mare, 2000; Güell et al., 2014; Handy, 2015). We use Handy (2015)'s assortative mating index that is the negative of the squared difference in the parent's educational ranks:

$$\mathrm{r_i} = -\left(rank_i^{father} - rank_i^{mother}\right)^2. \qquad (2)$$

We set the value 1 for tertiary education and above, 2 for upper secondary education, and 3 for lower secondary education and below. Maximum and minimum values of assortative mating index are 0 and -4. The higher the value is, the higher the resemblance in parents' education level is.

The number of books at home at age 16 represents a proxy of parent's spending on education because the survey data doesn't have information about parents' income or educational spending. We use a set of dummy variables—11-200 books, 201-500 books, and more than 500 books. It is expected to have a positive impact on children's education level. Parental investment determines the human capital of children (Becker and Tomes, 1979, 1986). The more parents have invested in their children's education, the higher children education level is.

The female dummy enters as an explanatory variable to capture gender difference in educational investment and achievement. The immigration indicator is also a dummy variable. Immigration status is considered to have an ambiguous effect on children's educational attainment. Parents invest more in children's education in the host country, when the return to education is higher than that at home country as supported by Dustmann (2008) and Lam and Liu (in press). In contrast, immigrants' ethnic environment can lead to discrimination and lack of access to credit market, worsening intergenerational mobility (Borjas, 1992). If immigrants cannot join the mainstream of society, they face 'second-generation decline' (Gans, 1992, Portes and Zhou, 1993, Park and Myers, 2010).

The functional form of the regression equation may have a specification bias from a linear model. Bratsberg et al. (2007) and Landersø and Heckman (2017) argue that individual countries have different functional forms of the intergenerational relationship. Bratsberg et al. (2007) apply high-order polynomial functions to reduce the specification bias – second-order for Finland, United Kingdom, and U.S., third for Norway, and fourth for Denmark. Landersø and Heckman (2017) use a local linear regression to account for non-linearity. We do not consider this issue because the estimation technique we adopted for censored covariates cannot take account of the non-linear specification.

2. Data

Our empirical analysis uses the Programme for the International Assessment of Adult Competencies (PIAAC) survey data developed by OECD (2013, 2016). The PIAAC is designed to measure adult skills. The survey is harmonized to be valid for the cross-country analysis. The PIAAC collects respondent's and their parent's educational levels and personal background such as their sex and immigration status. It is available for 30 countries.[5] Most of them are OECD member countries. It surveyed 195,123 adults aged between 16 and 65. We focus our analysis to those respondents aged between 25 and 54.

Our final sample consists of 108,851 respondents. We define six age cohorts for analysis, which are 25-29, 30-34, 35-39, 40-44, 45-49, and 50-54. The 25-29 age cohort corresponds to those who were born in 1983-1987 (for 2012 survey data) or 1986-1990 (for 2015 survey data) whereas the 50-54 age cohort group corresponds to those who were born in 1958-1962 (for 2012 survey data) or 1961-1965 (for 2015 survey data). The average number of observations in the 180 (30*6) country-cohort cells is 605, and minimum and maximum numbers are 262 and 2,846. Appendix table 1 shows the descriptive statistics of the variables in the sample.

3. Estimation results

[5] The 30 surveyed countries are Austria, Belgium, Canada, Chile, Cyprus, Czech Republic, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Ireland, Israel, Italy, Japan, Republic of Korea, Lithuania, Netherlands, Norway, New Zealand, Poland, Russian Federation, Singapore, Slovakia, Slovenia, Sweden, Turkey, USA. Twenty-four countries participated the survey from 2011 to 2012 and the other countries including Chile, Greece Lithuania, Singapore, Slovenia, Turkey participated from 2014 to 2015.

We first estimate equation (1) for the whole sample aged 25-54 for cross-country comparison. Estimation results are reported in Table 1. Intergenerational regression coefficients are statistically significant at 1 percent level in all countries. Intergenerational educational persistence varies across the country. The estimates of the intergenerational regression coefficient are relatively low in the Nordic countries, including Finland, Sweden and Norway, Austria, New Zealand, United Kingdom, and Korea, while they are high in Russia, Czech Republic and the US. Figure 1 displays intergenerational regression coefficient by country.

[Table 1 here]

[Figure 1 here]

Assortative mating index and the number of books at home are positively statistically significant in most of the countries, as consistent with our predictions. Interestingly, the assortative mating index is negative and statistically significant only in Korea, suggesting that the lower resemblance in Korean parents' education levels is associated with more investment in children's education. It may come from "education fever" among Korean mothers. In a typical Korean household where a mother tends to have less schooling than a father, it is the mother that has stronger desire and greater decision-making power to educate their children often at the highest tertiary levels.

Female dummy is statistically significant in most of the countries. The estimated coefficients are positive or negative, controlling for other variables, implying that daughters obtain more or less schooling than sons depending on the country's characteristics. Notably, the estimates are negative in Asian countries including Japan, Korea, and Singapore, and Turkey, while they are positive in most OECD countries.

Immigrant status is statistically significant in two third of the countries in the sample. The estimated coefficients appear either positive or negative. The estimates are positive and large in magnitude in Turkey, Poland, New Zealand and Canada, but negative in Japan, Korea and France.

We estimate intergenerational regression coefficients by country and cohort, using the same specification in Table 1. The estimated intergenerational regression coefficients are statistically significant at 1 percent level in all cohorts and countries. The estimates are reported by cohort for individual countries in Appendix Table 2 and displayed in Appendix Figure 1. As can be seen in

Appendix Table 2 and Figure 1, educational mobility worsened across generations in most countries, although its degree varies considerably across countries and over time. Figure 2 presents the estimated intergenerational regression coefficients by cohort in the selected countries and for the unweighted average of all 30 countries in the sample. On average, the estimates have fluctuated over time but increased steadily from the 45-49 age cohort to the 30-34 age cohort and then declined in the 25-29 cohort. The estimates show upward trends in Finland, Japan and the UK, implying that intergenerational mobility has deteriorated. In the US, the estimates continued to rise between the 50-54 cohort and the 30-34 cohort, but declined sharply in the 25-29 cohort. Contrastingly, in Korea the estimates continued to decline from the 50-54 cohort to the 35-39 cohort and then rose in the recent cohorts.

[Figure 2 here]

Figure 3 presents a snapshot that compares the intergenerational regression coefficients of the 50-54 and 25-29 aged cohorts by country. We list the countries in the order in which the intergenerational mobility deteriorated most from the 50-54 age cohort to the 25-29 age cohort. A half of countries experience the deterioration of mobility between the two cohorts. Japan (-0.29), Lithuania (-0.23), and Slovakia (-0.26) show greatest deterioration. Turkey (0.28), Israel (0.13) and Korea (0.11) show improvements.

[Figure 3 here]

III. Determinants of Intergenerational Educational Mobility

The previous section shows that the intergenerational educational mobility varied significantly across countries and over time. In this section, we investigate the determinants of intergenerational educational mobility using country-cohort panel data. The empirical strategy is identifying the effects of variables such as income inequality, educational inequality household debt, and government spending on the estimated intergenerational persistence of education.

1. Estimation specification and data

The following represents the empirical framework:

$$\text{Intergenrational Educational Persistence}_{j,k} = \beta_0 + \beta_1 Education\ level_{j,k}^{15-64} + \beta_2 \log\left(per\ worker\ GDP_{j,k}\right) + \beta_3 Income\ Gini_{j,k} + \beta_4 Inflation_{j,k} + \beta_5 Education\ spending_{j,k} + \beta_6 Household\ debt_{j,k} + \varepsilon_j + \theta_k + u_{j,k}, \quad (3)$$

where $Education_{j,k}^{15-64}$ denotes average years of schooling of working-age population aged 15-64 of country j and cohort k. $\text{Log}\left(per\ worker\ GDP_{j,k}\right)$, and $Income\ Gini_{j,k}$ denote log of per worker GDP and income gini of country j and cohort k. $Inflation_{j,k}$ denotes inflation rate of country j and cohort k. $Education\ spending_{j,k}$ and $Household\ debt_{j,k}$ denote government education spending and household debt of country j and cohort k.[6] We also separate government education spending by different levels – primary, secondary and tertiary education. The regression applies to a panel set of cross-country data for 30 countries over six age cohorts from 25-29 to 50-54, corresponding to 25-29, 30-34, 35-39, 40-44, 45-49, and 50-54.

The dependent variable is the estimates of intergenerational regression coefficient by cohort and country. All explanatory variables are averaged over the five years in each cohort. They are average values at the time when the respondents were 15 years old. The data on averaged years of schooling of working-age population and per worker GDP are sourced from Barro and Lee (2013) and Peen World Table 9.0 of Feenstra et al. (2015). Income gini is from Solt (2016)'s the Standardized World Income Inequality Database (SWIID) version 7.0. Inflation, education spending and household debt are from the World Bank database (World Bank, 2018a, 2018b, 2018c). Appendix Table 3 shows descriptive statistics of the variables in the regression sample.

The regression includes average years of schooling of working-age population as an explanatory variable to figure out if the overall education level has any influence on the intergenerational regression coefficient. Some studies suggest that the functional form of the intergeneration regression of children's education on parents' education can be non-linear (Bratsberg et al., 2007; Landersø and Heckman, 2017). The average years of schooling variable in equation (3) can capture

[6] Democratic political regime may contribute to deterioration of intergenerational mobility (Gugushvili, 2017). When we add democracy indicator as an explanatory variable in regression (1) of Table 2, the estimated coefficient of democracy indicator is positive but statistically insignificant. The inclusion of democracy variable reduces the sample size significantly.

this non-linear effect of parent education in equation (1).[7] The positive estimate implies a nonlinearity effect in that the response of one additional year of parent's schooling on the respondent's schooling can be larger in an economy where the parent's average education level is higher. If the expansion of higher education is not equally distributed between poor and rich families, and children from high-income families are more benefited, it would widen the education participation gap between children from low income and those from high-income families (Blanden and Machin, 2004). Checchi et al. (2013) report that the high persistence of educational attainment in Italy and this is mainly because children with highly educated fathers have a higher probability of obtaining a college degree than those with less educated fathers. In addition, children's educational attainment is also related to parents' income level. In this regard, an increase in average education level may raise intergenerational educational mobility. This effect should disappear if the regression controls for effects from income.

Per worker income is likely to be associated negatively with intergenerational educational persistence. Owen and Weil (1998) and Maoz and Moav (1999) report that as the economy grows, individuals efficiently allocate human capital and then intergenerational mobility increases. Technological progress reduces the importance of social background and brings up the allocation of individuals depending on their innate ability (Hassler et al., 2000).

Income inequality is expected to reduce intergenerational mobility in education. A more unequal distribution of income implies that many families cannot afford to let their children attend school and invest in their children's education. Poor families in developing countries often rely on the additional income from the children's employment. Income inequality shapes and skews opportunities and incentives so that talented individuals are hard to get the deserved rewards (Causa and Johansson, 2010; Corak, 2013).

Lower inflation can favor educational investment of poorer households by alleviating poverty or reducing inequality. In addition, inflation can have a direct effect on intergenerational mobility in education. Higher level of inflation or macroeconomic instability increases the uncertainty

[7] Including parent's education level instead of averaged years of schooling of working-age population in regressions of (6) changes the estimation results only slightly. When parent's education variable is excluded in the regressions, per-worker GDP, income inequality and primary and tertiary education expenditure variables remain statistically significant.

associated with expected costs of and returns to human capital investment, and thus tends to reduce human capital investment especially for less-schooled, lower-income parents. In the presence of imperfect markets for information, higher-income households with more-schooled parents may have better information and means to deal with the uncertainty (Behrman et al. 1999).

Public expenditure on education is expected to improve intergenerational mobility.[8] The public education spending reduces the education cost for poor parents (Checchi et al., 1999). Higher and more progressive education spending that relaxes the credit constraint of low-income households improves mobility (Solon, 2004; Herrington, 2015). In contrast, as pointed out by Ng (2014), regressive government education spending and increasing tertiary education fees that are more favorable to rich students tends to reduce educational mobility.

The credit constraints affect education investment and intergenerational mobility (Becker and Tomes, 1979, 1986; Carneiro and Heckman, 2002; Hai and Heckman, 2017; Mogstad, 2017). Credit-constrained households have difficulties in supporting children's education, and thereby raising the level intergenerational educational persistence. Since we do not have an adequate measure of the severity of credit constraints in an economy, we use household debt to GDP ratio as a proxy measure.

Figure 4 presents the bilateral relationship between intergenerational regression coefficient and each of the covariates. Average years of schooling of working-age population is weakly positively correlated to intergenerational persistence of schooling in Figure 4.A. The correlation coefficient is 0.17. It suggests that the estimated intergenerational educational persistence can be larger in an economy where the parent's average education level is higher. Log of per worker GDP is weakly negatively correlated to intergenerational persistence of schooling in Figure 4.B. This suggests that intergenerational persistence of education may differ by the level of economic development, as suggested by existing studies. The mobility can be higher in a more developed economy. Income gini is positively correlated to intergenerational persistence of schooling in Figure 4.C. The correlation coefficient is 0.31. The unequal society tends to have lower intergenerational mobility, as suggested by 'Great Gatsby Curve' (Corak 2013). Inflation is weakly positively correlated to

[8] Total government expenditures and social spending are also considered as explanatory variables. These variables appear statistically insignificant without changing the estimates on other variables qualitatively.

intergenerational persistence of schooling in Figure 4.A. The correlation coefficient is 0.17. It suggests that the intergenerational educational persistence can be larger in an economy where the inflation is higher. Public education spending— in total and by education level— is negatively correlated to intergenerational persistence of schooling in Figure 4.E-H. Higher levels of public education spending lower the burden of household's education investment, especially to low-income families, and thus improves the mobility. Household debt is negatively correlated to intergenerational persistence of schooling in Figure 4.I. It is opposite to our prediction. Although the bilateral relationships are well-describe in Figure 4 further statistical analysis is necessary to assess the independent effect of each explanatory variable on intergenerational educational persistence across cohorts and countries after controlling for other important covariates.

[Figure 4 here]

2. Estimation results

We estimate this system of six equations of (3) by adopting panel data regression with country and cohort fixed effects. The fixed-effects estimation controls for possible bias when unobserved and persistent country characteristics influencing the intergenerational regression coefficient correlate with the explanatory covariates. In the estimation, the reverse causality issue is unlikely to occur because the data on the intergenerational regression coefficients are estimated for each cohort using micro-level data and the explanatory variables covariates including macro variables are measured at the time when the respondents were 15 years old.[9]

[Table 2 here]

Regression (1) of Table 2 presents the estimation results of the basic specification (3) using average years of schooling, log of per worker GDP, income gini, and inflation with country and cohort fixed effects. The sample includes 151 observations for six cohorts for 30 countries.

In this specification, the average years of schooling has a positive and statistically significant effect

[9] Reverse causality may occur if public expenditure on education tends to increase when intergenerational mobility is lower. We have tried to adopt heteroskedasticity-based identification by Lewbel (2012) to control for the possible endogeneity of public educational expenditures. When this IV estimation is adopted in column (3), public expenditure on primary education is negatively statistically significant at 10% level, whereas public expenditure on secondary and tertiary education are statistically insignificant.

on intergenerational mobility with other covariates controlled for, which is consistent with the predictions. The estimated coefficient, that is 0.034, implies that an increase in average years of schooling of 1 standard deviation (1.72) increases the intergenerational regression coefficient by about 0.06, which accounts for about 56% of the standard deviation of the intergenerational regression coefficient.

The log of per worker GDP has a significantly positive impact on intergenerational mobility. The estimated coefficient, that is -0.111, suggests that an increase in the log of per worker GDP of 0.44 (1 standard deviation) decreases the intergenerational regression coefficient by about 0.05, which accounts for about 44% of the standard deviation of the intergenerational regression coefficient.

The positive estimate of the coefficient of income gini also supports the theoretical prediction. At the given level of average income, more unequal income distribution has a negative effect on intergenerational mobility. The estimated coefficient, that is 2.05, implies that an increase in income gini of 1 standard deviation, that is 0.06, increases the intergenerational regression coefficient by about 0.12, which accounts for about 111% of the standard deviation of the intergenerational regression coefficient. In this specification, inflation has a positive but statistically insignificant effect on intergenerational mobility when controlling for other covariates.

Regression (2) of Table 2 adds public education spending. The inclusion of education spending data reduces the sample size. The estimation result shows that education spending is not significantly related to intergenerational mobility when controlling for other covariates. In contrast, the estimates on average years of schooling, per worker GDP, and income gini remain statistically significant and change little in magnitude, while the estimate on inflation remain positive but statistically insignificant.

Regression (3) of Table 2 adds primary, secondary, and tertiary education spending as explanatory variables. Primary and tertiary education spending have significantly positive and negative effect on intergenerational mobility, respectively. The negative estimate of primary education spending means the redistribution of public education spending toward primary education can have a positive role for improving mobility, as it reduces household’s burden on education investment. In contrast, the positive estimates of tertiary education spending indicate more government spending for tertiary education, controlling for the spending for primary and secondary education, can

worsen the mobility. Secondary education spending has an insignificant effect on intergenerational mobility. The estimated coefficients of primary and tertiary education spending (-0.045 and 0.048) indicate that increases in primary and tertiary education spending by 0.58 and 0.48 (1 standard deviation) change the intergenerational regression coefficient by about -0.03 and 0.02, respectively.

Regression (4) of Table 2 adds household debt as a proxy for the credit constraint. The sample size substantially shrinks and the log of per worker GDP becomes statistically insignificant. The estimate of the coefficient of household debt is positive, which is consistent with the theoretical prediction. The estimated coefficient (0.002) implies that an increase in household-debt-to GDP ratio of 1 standard deviation (22.1) increases the intergenerational regression coefficient by about 0.04, which accounts for about 38% of the standard deviation of the intergenerational regression coefficient.

IV. Concluding Remarks

This paper estimates the intergenerational persistence of education attainment by cohort for 30 countries using internationally comparable data from the PIAAC. The high and rising figures of intergenerational regression coefficients suggest that the distribution of education among the population tend to perpetuate across generations in many countries. Individual's probability to have higher educational attainment than their parents has been lowered in younger cohorts in many countries. The regressions using country-cohort panel data confirm that a more unequal distribution of income and a lower per-worker GDP contributed significantly to worsening intergenerational educational mobility. Increase in public expenditure on primary education and improvement in household credit constraints can help to enhance intergenerational educational mobility.

Reducing intergenerational persistence of education is an important means of promoting intergenerational mobility of income. Understanding the main determinants of intergenerational educational mobility is important to design and implement deliberate policies toward a more equitable society. Our empirical results suggest that governments should work to enhance both economic growth and income equality in order to reduce intergenerational persistence of educational attainment. Policy measures to enhance inclusive growth must include effective policies for human capital development such as strong investment in education and skills trainings

targeting at less-educated and low-income population. A more equal distribution of schooling will contribute to improving mobility in education and earnings over generations.

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Table 1 Regression Result for Intergenerational Educational Persistence Equation by Country (Sample aged 25-54)

Country	Parent's highest years of schooling	Assort-ative mating index	No. of books at home			Female	Immi-grant	No. of Obs.	R^2
			11-200	201-500	501+				
Austria	0.132***	0.111*	0.012***	0.024***	0.028***	-0.328***	-0.040	3,115	0.169
Belgium	0.209***	0.131**	0.013***	0.020***	0.018***	0.144	-0.575***	2,863	0.222
Canada	0.244***	0.173***	0.012***	0.018***	0.017***	0.258***	1.339***	14,832	0.212
Chile	0.252***	0.239***	0.020***	0.039***	0.034***	-0.111	-0.202	2,912	0.319
Cyprus	0.207***	0.158***	0.018***	0.028***	0.031***	-0.102	-0.127	2,801	0.272
Czech Republic	0.479***	0.543***	0.010***	0.020***	0.023***	0.111	0.101	3,088	0.206
Denmark	0.261***	0.189***	0.015***	0.023***	0.026***	0.269***	-0.345***	3,783	0.192
Estonia	0.233***	0.235***	0.026***	0.044***	0.042***	0.811***	-0.520***	4,212	0.172
Finland	0.083***	0.083	0.020***	0.028***	0.031***	0.739***	-0.459**	3,073	0.128
France	0.195***	0.200***	0.012***	0.022***	0.025***	0.111	-0.918***	3,392	0.254
Greece	0.219***	0.310***	0.020***	0.033***	0.038***	0.064	-0.266	3,317	0.242
Ireland	0.158***	-0.065	0.008***	0.015***	0.016***	0.216**	0.245**	3,908	0.200
Israel	0.218***	0.268***	0.019***	0.032***	0.034***	0.739***	0.366***	2,915	0.221
Italy	0.300***	0.426***	0.021***	0.030***	0.028***	0.620***	-0.433**	3,014	0.291
Japan	0.290***	0.381***	0.017***	0.018***	0.014***	-0.454***	-1.499**	2,991	0.185
Korea	0.111***	-0.177***	0.022***	0.038***	0.042***	-0.538***	-0.682**	4,292	0.274
Lithuania	0.275***	0.365***	0.010***	0.018***	0.019***	0.594***	0.137	2,995	0.232
Netherlands	0.146***	0.083*	0.018***	0.025***	0.025***	-0.187**	-0.202	2,943	0.158
New Zealand	0.132***	0.086***	0.009***	0.020***	0.024***	0.204**	1.369**	3,137	0.182
Norway	0.176***	0.172***	0.013***	0.018***	0.022***	0.181**	0.079	2,998	0.148
Poland	0.231***	0.379***	0.014***	0.022***	0.024***	0.979***	1.793**	3,714	0.292
Russia	0.533***	0.310***	0.010***	0.015***	0.019***	0.822***	0.043	1,880	0.199
Singapore	0.213***	-0.039	0.020***	0.035***	0.038***	-0.658***	0.534***	3,346	0.265
Slovakia	0.201***	0.217**	0.011***	0.020***	0.022***	0.191**	-0.609**	3,375	0.300
Slovenia	0.142***	0.171***	0.014***	0.020***	0.020***	0.467***	-0.473***	3,175	0.267
Spain	0.237***	-0.003	0.022***	0.040***	0.038***	0.498***	-0.597***	3,794	0.235
Sweden	0.151***	0.179***	0.010***	0.018***	0.018***	0.472***	-0.003	2,464	0.186
Turkey	0.345***	0.208***	0.018***	0.025***	0.031***	-1.178***	2.460***	3,642	0.342
United Kingdom	0.114***	-0.049	0.025***	0.035***	0.044***	0.05	0.591***	4,337	0.126
USA	0.395***	0.513***	0.021***	0.030***	0.031***	0.320***	0.318**	2,543	0.284

Notes: The regressions include cohort dummies. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2 Panel Fixed Effect Regression Results for Intergenerational Educational Mobility

	(1)	(2)	(3)	(4)
Average years of schooling, 15-64 aged	0.0340**	0.0362**	0.0385*	0.0690***
	(0.0157)	(0.0166)	(0.0208)	(0.0247)
Log of per worker GDP	-0.111**	-0.142***	-0.105*	-0.0372
	(0.0439)	(0.0461)	(0.0553)	(0.101)
Income gini	2.053***	1.852***	1.654***	2.501***
	(0.370)	(0.392)	(0.462)	(0.527)
Inflation	0.0110	0.0246	0.0023	-0.0148
	(0.0112)	(0.0297)	(0.0306)	(0.0236)
Public education spending/GDP		-0.0003		
		(0.0082)		
Public spending on primary education/GDP			-0.0448*	
			(0.0243)	
Public spending on secondary education/GDP			-0.0263	
			(0.0197)	
Public spending on tertiary education/GDP			0.0478**	
			(0.0226)	
Household debt/GDP				0.0019*
				(0.0011)
Country fixed effect	Yes	Yes	Yes	Yes
Cohort fixed effect	Yes	Yes	Yes	Yes
No. of countries, No. of obs.	30, 151	27, 135	24, 114	24, 93
R^2	0.377	0.368	0.374	0.549

Notes: The system consists of six equations that apply to an unbalanced panel dataset for 30 countries. The dependent variable is the intergenerational regression coefficient for 25-29, 30-34, 35-39, 40-44, 45-49, and 50-54 cohorts. The variables are the figures at 15-year-old. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Figure 1 Intergenerational Regression Coefficient by Country (Sample aged 25-54)

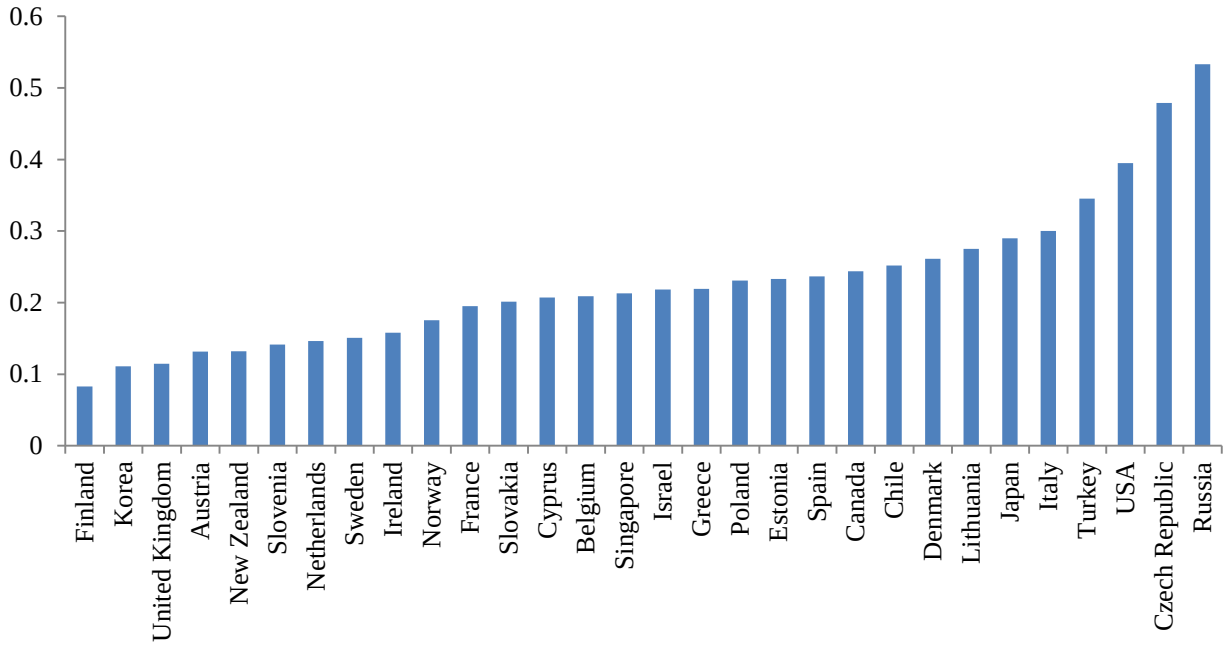
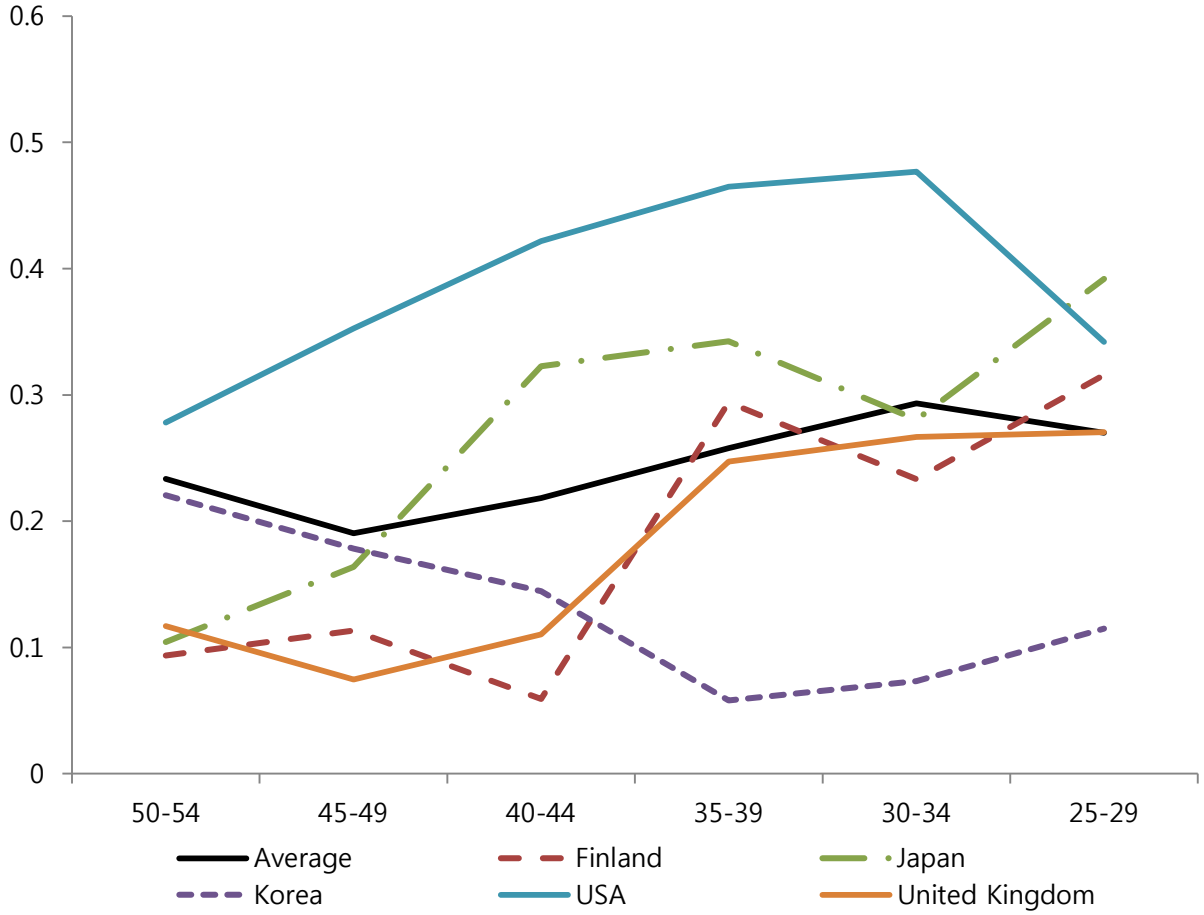


Figure 2 Intergenerational Regression Coefficient by Cohort in Selected Countries



Note: The figures of "Average" are the unweighted averages by cohort of all 30 countries in the sample.

Figure 3 Comparison of Intergenerational Regression Coefficients (25-29 and 50-54 age cohorts)

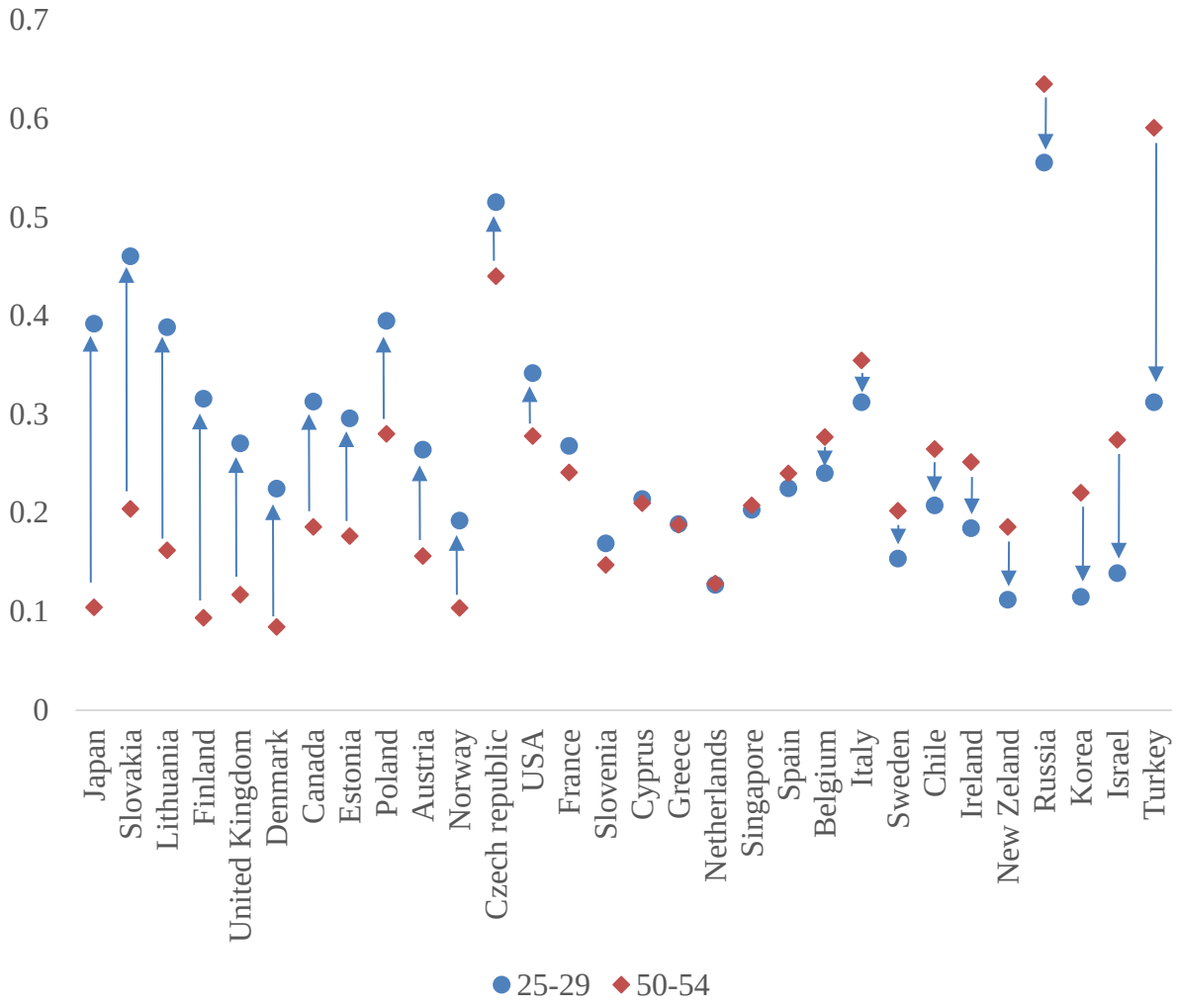
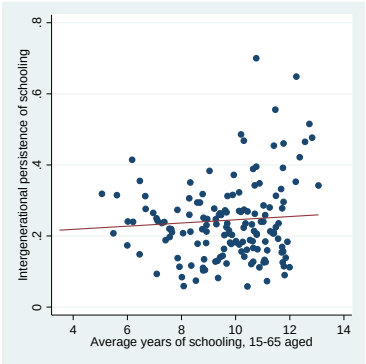
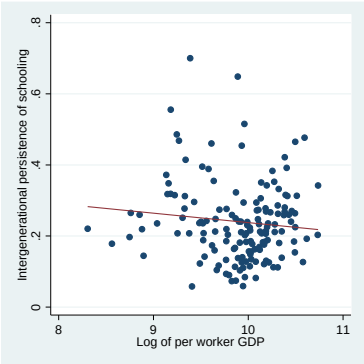


Figure 4 Relationship between Intergenerational Persistence of Schooling and Covariates for Cohort Panel Regression

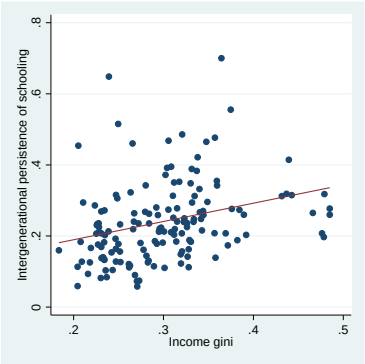
A. Average year of schooling



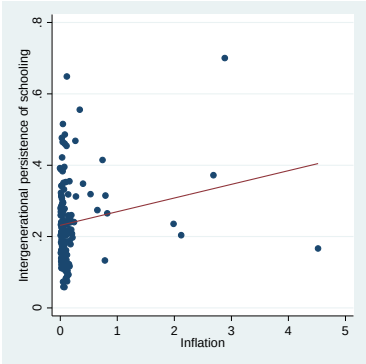
B. Log of per worker GDP



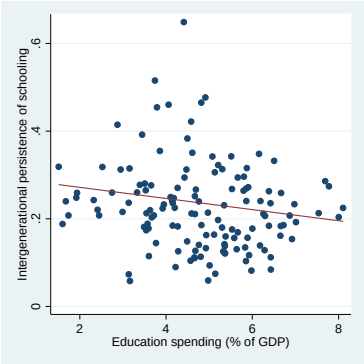
C. Income gini



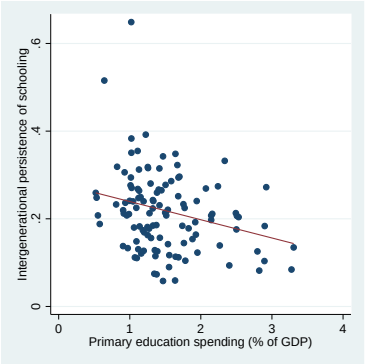
D. Inflation



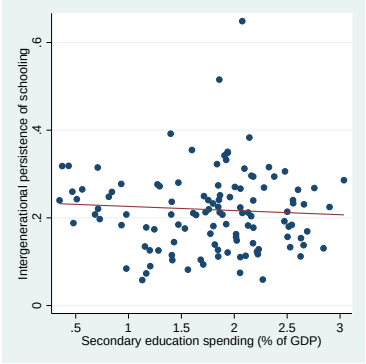
E. Public education spending/GDP



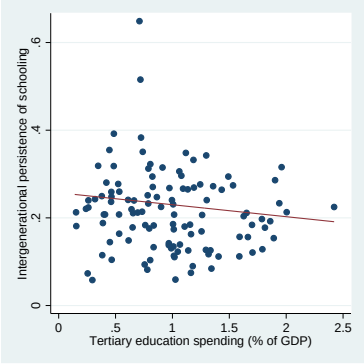
F. Primary education spending/GDP



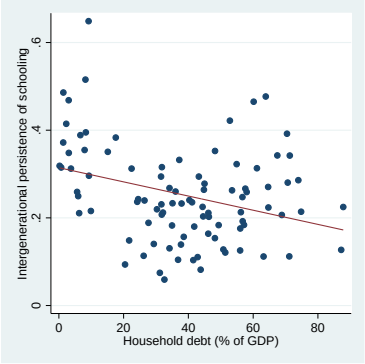
G. Secondary education Spending/GDP



H. Tertiary education spending/GDP



I. Household debt/GDP



Appendix Table 1 Descriptive Statistics for Regression of Intergenerational Educational Mobility

Country	Respondent's years of schooling	Parent's highest years of schooling	Assortative mating index	No. of books at home (%)			Female (%)	Immigrant (%)
				11-200	201-500	501 +		
Austria	12.30	11.71	-0.50	67.4	12.6	7.5	50.3	18.8
Belgium	13.10	11.57	-0.50	63.4	9.7	4.0	48.7	7.9
Canada	13.87	12.89	-0.56	65.9	13.4	6.4	50.0	28.3
Chile	12.08	10.98	-0.40	52.7	3.1	2.7	49.6	4.5
Cyprus	13.06	10.86	-0.33	67.2	5.5	2.7	53.8	16.4
Czech Republic	13.51	13.27	-0.33	64.6	23.0	10.7	48.6	5.1
Denmark	13.13	12.48	-0.61	58.6	21.0	13.0	49.7	13.6
Estonia	12.60	12.78	-0.48	56.7	26.1	14.9	51.5	10.9
Finland	13.18	11.77	-0.44	64.6	19.7	9.7	49.1	7.0
France	12.07	11.40	-0.42	63.0	10.9	7.3	50.7	14.7
Greece	12.29	10.57	-0.25	60.6	5.2	2.3	50.7	10.5
Ireland	15.13	12.80	-0.50	64.1	10.8	5.2	52.0	23.3
Israel	13.33	12.86	-0.48	60.1	14.7	9.2	51.6	22.1
Italy	11.24	9.54	-0.18	63.9	6.3	3.1	50.4	11.3
Japan	13.54	12.81	-0.46	70.9	9.9	4.5	50.9	0.3
Korea	13.53	10.99	-0.39	71.0	8.2	3.5	49.4	1.7
Lithuania	13.61	13.21	-0.42	73.0	10.0	5.2	52.5	3.2
Netherlands	13.73	11.51	-0.62	60.8	16.5	9.3	49.8	14.3
New Zealand	14.28	13.57	-0.80	62.2	17.2	10.3	52.5	33.6
Norway	14.58	13.65	-0.65	57.8	22.0	15.0	48.7	16.9
Poland	13.29	11.59	-0.25	70.9	12.0	4.7	50.3	0.1
Russia	13.87	10.69	-0.48	66.9	14.3	7.5	51.8	6.0
Singapore	12.40	11.62	-0.39	60.4	3.3	1.8	50.4	29.0
Slovakia	13.47	12.47	-0.27	75.3	11.2	3.8	49.5	1.7
Slovenia	10.72	11.45	-0.37	68.6	7.8	4.0	48.2	13.3
Spain	11.91	11.08	-0.36	68.2	9.9	5.2	49.4	15.7
Sweden	12.67	12.36	-0.61	54.4	24.1	14.7	49.7	20.1
Turkey	8.38	8.47	-0.13	40.6	1.0	0.6	48.4	0.4
U.K.	13.53	13.22	-0.55	63.9	16.1	9.7	51.1	20.1
USA	13.82	13.09	-0.44	66.1	10.3	5.8	51.6	18.6

Appendix Table 2 Intergenerational Regression Coefficient by Country and Cohort

Country	Cohort					
	25-29	30-34	35-39	40-44	45-49	50-54
Austria	0.264***	0.180***	0.306***	0.138***	0.081***	0.156***
Belgium	0.240***	0.233***	0.183***	0.140***	0.231***	0.277***
Canada	0.313***	0.259***	0.263***	0.236***	0.161***	0.186***
Chile	0.208***	0.277***	0.318***	0.260***	0.197***	0.265***
Cyprus	0.214***	0.224***	0.181***	0.213***	0.197***	0.210***
Czech Republic	0.515***	0.649***	0.454***	0.365***	0.406***	0.440***
Denmark	0.225***	0.286***	0.269***	0.272***	0.135***	0.084***
Estonia	0.296***	0.348***	0.265***	0.203***	0.159***	0.177***
Finland	0.316***	0.233***	0.294***	0.059*	0.113***	0.094***
France	0.268***	0.131***	0.212***	0.240***	0.148***	0.241***
Greece	0.189***	0.216***	0.259***	0.248***	0.208***	0.188***
Ireland	0.185***	0.163***	0.186***	0.142***	0.123**	0.252***
Israel	0.139***	0.332***	0.207***	0.240***	0.204***	0.274***
Italy	0.312***	0.383***	0.351***	0.211***	0.250***	0.355***
Japan	0.392***	0.280***	0.342***	0.323***	0.164***	0.104***
Korea	0.115***	0.073***	0.058***	0.145***	0.178***	0.221***
Lithuania	0.389***	0.486***	0.372***	0.226***	0.127***	0.162***
Netherlands	0.127***	0.112***	0.121***	0.156***	0.178***	0.128***
New Zealand	0.112***	0.184***	0.157***	0.126***	0.090***	0.186***
Norway	0.192***	0.213***	0.207***	0.176***	0.082***	0.103***
Poland	0.395***	0.468***	0.236***	0.219***	0.234***	0.280***
Russia	0.556***	0.700***	0.555***	0.380***	0.403***	0.635***
Singapore	0.203***	0.260***	0.274***	0.276***	0.174***	0.208***
Slovakia	0.460***	0.236***	0.160***	0.174***	0.175***	0.204***
Slovenia	0.169***	0.208***	0.133***	0.166***	0.147***	0.147***
Spain	0.225***	0.294***	0.220***	0.236***	0.243***	0.240***
Sweden	0.154***	0.211***	0.126***	0.128***	0.183***	0.202***
Turkey	0.312***	0.414***	0.315***	0.319***	0.297***	0.591***
U.K.	0.271***	0.267***	0.247***	0.110***	0.075***	0.117***
USA	0.342***	0.477***	0.465***	0.422***	0.353***	0.278***

Note: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix Table 3 Summary Statistics of the Variables in the Regression

Description	Data Source	Mean	Std. Dev.	Min	Max
Intergenerational regression coefficient	OECD (2013, 2016), PIAAC	0.24	0.11	0.06	0.70
Average years of schooling, 15-64 aged	Barro and Lee (2013)	9.75	1.72	5.06	13.06
Log of per worker GDP	Feenstra et al. (2015), PWT 9.0	10.31	0.44	8.83	11.16
Income gini	Solt (2016)	0.30	0.06	0.18	0.49
Inflation rate (consumer price index)	World Bank (2018a), World Development Indicators	0.19	0.54	-0.004	4.52
Public education spending (% of GDP)	World Bank (2018b), Education Statistics	4.79	1.41	1.51	8.11
Public spending on primary education (% of GDP)	World Bank (2018b), Education Statistics	1.50	0.58	0.52	3.31
Public spending on secondary education (% of GDP)	World Bank (2018b), Education Statistics	1.78	0.63	0.35	3.04
Public spending on tertiary education (% of GDP)	World Bank (2018b), Education Statistics	0.98	0.48	0.15	2.42
Household debt (% of GDP)	World Bank (2018c), International Debt Statistics	38.30	22.06	0.23	87.84

Appendix Figure 1 Intergenerational Regression Coefficient by Country and Cohort