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Trends in Income Inequality and its Impact on Economic Growth

Federico Cingano

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Federico Cingano

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ABSTRACT

1. In most OECD countries, the gap between rich and poor is at its highest level since 30 years. Today, the richest 10 per cent of the population in the OECD area earn 9.5 times the income of the poorest 10 per cent; in the 1980s this ratio stood at 7:1 and has been rising continuously ever since. However, the rise in overall income inequality is not (only) about surging top income shares: often, incomes at the bottom grew much slower during the prosperous years and fell during downturns, putting relative (and in some countries, absolute) income poverty on the radar of policy concerns. This paper explores whether such developments may have an impact on economic performance.

2. Drawing on harmonised data covering the OECD countries over the past 30 years, the econometric analysis suggests that income inequality has a negative and statistically significant impact on subsequent growth. In particular, what matters most is the gap between low income households and the rest of the population. In contrast, no evidence is found that those with high incomes pulling away from the rest of the population harms growth. The paper also evaluates the "human capital accumulation theory" finding evidence for human capital as a channel through which inequality may affect growth. Analysis based on micro data from the Adult Skills Survey (PIAAC) shows that increased income disparities depress skills development among individuals with poorer parental education background, both in terms of the quantity of education attained (e.g. years of schooling), and in terms of its quality (i.e. skill proficiency). Educational outcomes of individuals from richer backgrounds, however, are not affected by inequality.

3. It follows that policies to reduce income inequalities should not only be pursued to improve social outcomes but also to sustain long-term growth. Redistribution policies via taxes and transfers are a key tool to ensure the benefits of growth are more broadly distributed and the results suggest they need not be expected to undermine growth. But it is also important to promote equality of opportunity in access to and quality of education. This implies a focus on families with children and youths – as this is when decisions about human capital accumulation are made -- promoting employment for disadvantaged groups through active labour market policies, childcare supports and in-work benefits.

RÉSUMÉ

1. Dans la plupart des pays de l'OCDE, le fossé entre riches et pauvres est à son plus haut niveau depuis 30 ans. Aujourd'hui, dans la zone de l'OCDE, les 10% de la population les plus riches gagnent 9,5 fois le revenu des 10 % les plus pauvres; dans les années 1980, ce ratio s'élevait à 7: 1 et il a augmenté de façon continue depuis. Toutefois, la hausse de l'inégalité de revenu n'est pas (seulement) relative à la flambée de la part des plus hauts revenus : souvent, les revenus les plus bas ont augmenté beaucoup plus lentement pendant les années prospères, et sont tombés en période de ralentissement économique, mettant la pauvreté monétaire relative (et, dans certains pays, absolue) sur le radar des préoccupations politiques. Ce document cherche à savoir si ces évolutions peuvent avoir un impact sur la performance économique.

2. S'appuyant sur des données harmonisées couvrant les pays de l'OCDE au cours des 30 dernières années, l'analyse économétrique suggère que les inégalités de revenus ont un impact négatif et statistiquement significatif sur la croissance ultérieure. En particulier, ce qui importe le plus est l'écart entre les ménages à faible revenu et le reste de la population. En revanche, aucune preuve n'est trouvée sur le fait que les personnes ayant des revenus élevés s'élevant loin du reste de la population nuit à la croissance. Le document évalue également la «théorie de l'accumulation du capital humain" montrant le capital humain comme un canal par lequel les inégalités peuvent affecter la croissance. L'analyse fondée sur les micro données de l'Enquête sur les compétences des adultes (PIAAC) montre que l'augmentation des disparités de revenus inhibent le développement des compétences chez les personnes dont les parents ont un faible niveau d'instruction, aussi bien sur le plan quantitatif du niveau de scolarité atteint (par exemple, en années de scolarité), qu'en termes de qualité (niveau de compétences). Les résultats scolaires des personnes issues de milieux les plus riches, toutefois, ne sont pas affectés par les inégalités.

3. Il s'ensuit que les politiques visant à réduire les inégalités de revenus ne doivent pas seulement être poursuivies pour améliorer les résultats sociaux, mais aussi pour soutenir la croissance à long terme. Les politiques de redistribution via les impôts et les transferts sont un outil essentiel pour s'assurer que les bénéfices de la croissance sont plus largement distribués et les résultats suggèrent qu'on ne doit pas forcément s'attendre à ce que la redistribution nuise à la croissance. Mais il est également important de promouvoir l'égalité des chances dans l'accès et la qualité de l'éducation. Ceci implique de mettre l'accent sur les familles avec enfants et les jeunes - car c'est lorsque les décisions sur l'accumulation de capital humain sont prises - par la promotion de l'emploi pour les groupes défavorisés, grâce à des politiques actives du marché du travail, des supports de gardes d'enfants et des prestations d'activité.

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4. The disparity in the distribution of household incomes has been rising over the past three decades in a vast majority of OECD countries and such long-term trend was interrupted only temporarily in the first years of the Great Recession.[1] Addressing these trends has moved to the top of the policy agenda in many countries. This is partly due to worries that a persistently unbalanced sharing of the growth dividend will result in social resentment, fuelling populist and protectionist sentiments, and leading to political instability. Recent discussions, particularly in the US, about increased inequality being one possible cause of the 2008 financial crisis also contributed to its relevance for policymaking.[2]

5. But another growing reason for the strong interest of policy makers in inequality is concern about whether the cumulatively large and sometimes rapid increase in inequality might have an effect on economic growth and on the pace of exit from the current recession. Is inequality a pre-requisite for growth? Or does a greater dispersion of incomes across individuals rather undermine growth? And which are the short and long-term consequences of redistributive policies on growth?

6. This paper starts by giving a brief overview of long-run trends in income distribution in OECD countries (Section 1). Section 2 provides a brief review of the theoretical and empirical literature on how inequality might theoretically affect growth. Section 3 presents the core of the new empirical evidence on the links between income inequality and economic growth. Section 4 explores one of the main transmission mechanisms between inequality and growth, finding evidence that the wider is income inequality, the lower is the chance that low income households invest in education. Section 5 draws some concluding remarks.

1. The long-term rise in income inequality in the OECD area

1.1 A trend toward growing disparities before and since the Great Recession

7. Over the 20 to 25 years leading up to the global economic crisis, *average* real disposable household incomes increased in all OECD countries, on average by 1.6% annually (see Annex Table A1.1, first three columns). However, in three quarters of OECD countries household incomes of the top 10% grew faster than those of the poorest 10%, resulting in widening income inequality. Differences in the pace of income growth across household groups in the pre-crisis period were particularly pronounced in most of the English-speaking countries but also in Israel, Germany and Sweden. The picture changes when looking at the post-crisis period (i.e. the years from 2007 through 2011/12) as average real household income stagnated or fell in most countries, particularly – by more than 3.5% per year – in Spain, Ireland, Iceland

1 . The pre-crisis trends in inequality have been amply documented in successive OECD studies, most notably *Growing Unequal?* (2008) and *Divided we Stand* (2011). A series of "inequality updates" (OECD, 2013; OECD 2014a; 2014b) tracked the most recent developments, and a forthcoming publication (OECD, 2015) will analyse the impact of the economic crisis and fiscal consolidation policies on household income distribution.

2 . Rajan (2010) argued that rising inequality in the US induced low-income individuals to borrow beyond their means to sustain consumption, and that this overleveraging sowed the seeds of crisis. Stiglitz (2012) and Acemoglu (2011) claimed that increasing political influence of the rich and the financial industry contributed to the financial excesses that generated the crisis. Fitoussi and Saraceno (2010) argue that the roots of the crisis lie in a structural change in income distribution that has been going on for the past three decades.

and Greece. In almost all countries where incomes fell, those of the bottom 10% fell more rapidly. Similarly, in about half of those countries where incomes continued to grow, the top 10% did better than the bottom 10%.

8. Taken together, these developments confirm the long-term trend towards higher inequality. Going into the crisis, most OECD countries recorded historical highs of income inequality. Today, the average income of the richest 10% of the population in OECD countries is about 9.5 times that of the poorest 10%. In the 1980s, this ratio was 7:1. However, the ratio varies widely across OECD countries. It is much lower than the OECD average in the Nordic and many Continental European countries, but reaches around 10 to 1 in Italy, Japan, Korea, Portugal and the United Kingdom, between 13 and16 to 1 in Greece, Israel, Turkey and the United States, and between 27 and 30 to 1 in Mexico and Chile (see Annex Table A1.2).

9. These ratios present only a partial picture, however, since they depend on only two values in the income distribution. A more synthetic indicator, which takes into account the whole distribution, is the Gini coefficient. This widely-used standard measure of inequality ranges from zero (when everybody has identical incomes) to 1 (when all income goes to only one person). It stood at 0.29 in the mid-1980s, on average, across OECD countries but by 2011/12, it had increased by 3 points to 0.32. The Gini coefficient increased in 17 out of the 22 OECD countries for which long time series are available (Figure 1), rising by more than 5 points in Finland, Israel, New Zealand, Sweden and the United States and falling slightly only in Greece and Turkey.[3]

Figure 1. Income inequality increased in most, but not all OECD countries

Gini coefficients of income inequality, mid-1980s and 2011/12

Note: Income refers to disposable household income, corrected for household size. Information on data for Israel: *http://dx.doi.org/10.1787/888932315602.*

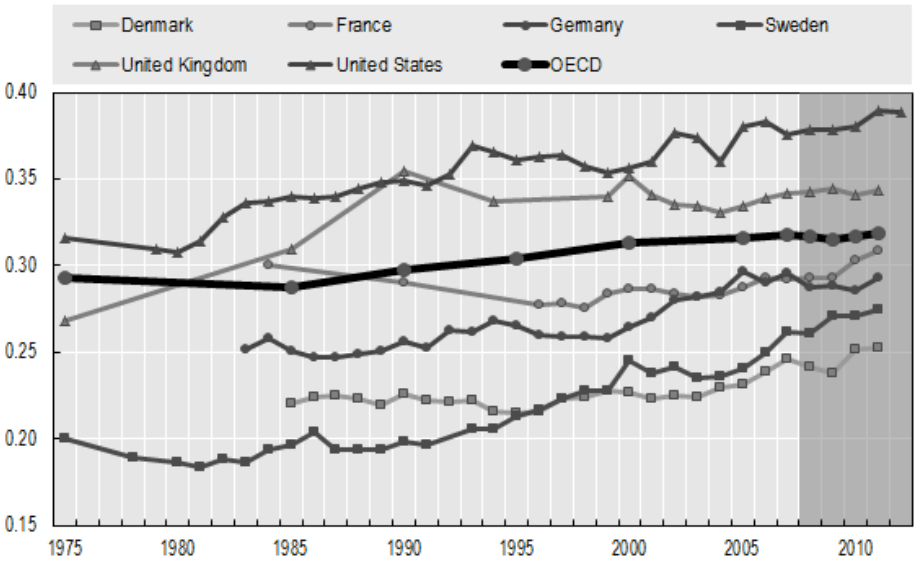
Source: OECD Income Distribution Database (IDD).

3. Looking at a more recent period, since the mid-1990s, inequality fell also in other high-inequality countries, notably in Mexico and Chile, and since the early 2000s in Portugal, Spain and Poland. Nonetheless, these trends stopped in all those countries toward the end of the 2000s, with the onset of the Great Recession.

10. The paths and patterns of income inequality over time differ across OECD countries and regions. Income inequality first started to grow in the late 1970s and early 1980s in some of the English-speaking countries, notably in the United Kingdom and the United States, but also in Israel. From the late 1980s onwards, the increase in income inequality became more widespread (Figure 2). The 1990s and early 2000s witnessed a widening gap between poor and rich in some of the already high-inequality countries, such as Israel and the United States, but also, for the first time, in traditionally low-inequality countries, such as Germany and the Nordic countries. Figure 2 also shows that with the onset of the Great Recession, the trend to increasing net income inequality came to a halt in many countries or was even slightly reversed during the very first years of the crisis. However, since 2010 (and, in some countries, earlier) inequality is on the rise again.

Figure 2. Inequality increased over the long run but temporarily stalled during the first crisis years

Gini coefficients of income inequality in selected OECD countries, 1975 – 2011/12



Note: Income refers to disposable household income, corrected for household size.

Source: OECD Income Distribution Database (IDD).

2. How inequality may affect economic growth

11. Over the last decades, a large body of theoretical and empirical research attempted to determine whether inequality is good or bad for growth. Theoretical work has provided mechanisms supporting both possibilities, and the large empirical literature attempting to discriminate between these mechanisms has been largely inconclusive. This section provides a brief overview of both theoretical and empirical works, highlighting the main methodological and measurement issues and setting the stage for the new work on OECD countries, described in Sections 3 and 4.

2.1 Theoretical literature

12. Alternative theories predict that inequality can affect growth in either a positive or negative direction. Greater inequality might **reduce** growth if:

a. Greater inequality becomes unacceptable to voters, so they insist on higher taxation and regulation, or no longer trust business, and pro-business policies, all of which may reduce the

incentives to invest (this refers to the "endogenous fiscal policy" theory, see Bertola 1993; Alesina and Rodrick 1994; Persson and Tabellini 1994; Bénabou, 1996; Perotti 1996).[4] In extreme cases, inequality may lead to political instability and social unrest, with harmful effects on growth (Alesina and Perotti, 1996; Knack and Keefer, 2000).

b. In presence of financial market imperfections, implying that the ability to invest of different individuals depends on their income or wealth level. If this is the case, poor individuals may not be able to afford worthwhile investments. For example, lower-income households may choose to leave full-time education if they cannot afford the fees, even though the rate of return (to both the individual and society) is high. In turn, under-investment by the poor implies that aggregate output would be lower than in the case of perfect financial markets.[5] We will refer to this view, first formalized by Galor and Zeira (1993, 1998), as the "human capital accumulation" theory.[6]

   Interestingly, the idea that higher inequality may result in under-investment in human capital by the poorer segments of society has also spurred a significant amount of research on the consequences of inequality on social mobility and the allocation of talents across occupations (Banerjee and Newman, 1993; Fershtman et al., 1996, Owen and Weil, 1998, Maoz and Moav, 1999, Checchi, et al., 1999, and Hassler et al., 2007).

c. If the adoption of advanced technologies depends on a minimum critical amount of domestic demand. While originating from Murphy et al. (1989) modelling of the first stages of industrial take-off, and therefore initially perceived as tangential to the case of advanced economies, the domestic demand channel has recently been put forward again in, for example, the recent debate on the consequences of rising US inequality for economic performance (Krueger, 2012, Bernstein, 2013).

13. On the other hand, greater inequality might **increase** growth if:

---

4. According to the "endogenous fiscal policy" theory, the (reduced form) negative link between inequality and growth rests on two basic (structural) mechanisms. An economic mechanism positing that available redistributive tools (e.g. capital income taxes) are necessarily distortionary and lower the private returns to investment. And a political mechanism predicting that higher inequality would induce more redistribution as (capital) poor individuals would prefer larger tax rates than the rich. The first assumption is obviously crucial. Saint Paul and Verdier (1996) proposed a version of the model where redistribution occurs through public education and the median voter determines a proportional tax on labour income, which implies that more unequal economies grow relatively faster (see also Lee and Roemer, 1998).

5. With perfect financial markets, all individuals would invest in the same (optimal) amount of capital, equalizing the marginal returns of investment to the interest rate. This occurs as complete markets allow poor individuals, whose initial wealth would not allow reaching the optimal amount of investment, to borrow from the rich (infra-marginal gains from trade). If, on the contrary, financial markets are not available, and the returns to individual investment projects are decreasing, under-investment by the poor implies that aggregate output would be lower, a loss which would in general increase in the degree of wealth heterogeneity (see e.g. Benabou, 1996; Aghion et al, 1999).

6 . Aghion and Bolton (1997) and Piketty (1997) explicitly modelled the supply side of the credit market, explaining imperfections based on moral-hazard (e.g. problems of input verifiability) or enforcement problems stemming from contract incompleteness (e.g. due to output verifiability). Moral-hazard would occur, for example, with limited liability (i.e. when a borrower's repayment to his lenders cannot be greater than his wealth); if the probability of success of the project depends on a (costly) effort exerted by the borrower, her incentives to exert efforts would be lower the larger the fraction of externally financed investment. Thus the interest rate on the loan will be an increasing function of its size (i.e. higher for the poorer).

d. High inequality provides the incentives to work harder invest and undertake risks to take advantage of high rates of return (Mirrlees, 1971; Lazear and Rosen, 1981).[7] For example, if highly educated people are much more productive, then high differences in rates of return may encourage more people to seek education.

e. Higher inequality fosters aggregate savings, and therefore capital accumulation, because the rich have a lower propensity to consume (Kaldor, 1956; Bourguignon, 1981).[8]

2.2 Empirical evidence

14. The large empirical literature attempting to establish the direction in which inequality affects growth is summarized in the literature review Table A2.1 (see Annex 2). That survey highlights that there is no consensus on the sign and strength of the relationship; furthermore, few works seek to identify which of the possible theoretical effects is at work. This is partly traceable to the multiple empirical challenges this literature faces, ranging from the poor quality of available data to the limited possibilities of capturing changes in the shape of income distribution and an estimation approach reflecting a lack of time series variation. More specifically, the literature review highlights the following main issues which often have limited the interpretation of results of early studies:

- *Data quality*: The literature has been constrained by the availability and quality of income distribution data across countries, which are largely assembled based on heterogeneous national sources (i.e. "secondary" datasets). This implies that the inequality measures usually differ as to coverage, reference unit, weighting and definition of income. Even the widely used and "high quality" data assembled by the World Bank since the mid-1990s (Deininger and Squire, 1996) has been shown to differ significantly from those that can be obtained (for a limited set of advanced countries) starting from a homogeneous set of underlying micro-data (as the Luxembourg Income Survey, LIS; see Atkinson and Brandolini, 2001).

- *Coverage:* The literature survey also highlights a role for the data country coverage in affecting the results. The channels predicting a negative inequality-growth relationship (in particular, the credit market imperfections and the socio-political instability channels) are likely to be stronger in developing than in advanced countries. Previous work suggested that that the link between inequality and growth is negative among poor countries, but positive or insignificant among rich countries (Barro, 2000). Studies which include both developing and developed countries may therefore capture an average effect, giving misleading results.

- *Estimation method*: Reduced-form estimates tend to yield negative coefficients when exploiting cross-sectional variation (see e.g. Alesina Rodrick, 1994; Persson and Tabellini, 1994, Perotti

7. Mirrlees (1971) focused on principal-agent setting where a (observable) output depends on an unobservable effort. In that context, rewarding the agent independently from output performance will discourage her from putting any effort while allowing for wage dispersion would encourage exerting the effort. More broadly, Rebelo (1991) showed that in a variety of growth models high investment or income tax rates would discourage capital accumulation and imply to lower growth rates.

8 . Kaldor (1956) suggested that, because the savings propensity out of labour income is lower than that out profits, richer individuals (i.e. those earning more income from capital) will tend to save more than the poor. This hypothesis was formalized in the context of a Solow model by Bourguignon (1981) who showed that when savings are a convex function of income, there may exist multiple steady states characterized by different degrees of inequality. In this case, output is shown to be larger in the unequal steady states not only at the aggregate level, but also for all individuals (i.e. the unequal equilibrium Pareto dominates the egalitarian one)

1996); most empirical work using within-country variation (i.e. cross-country, time series panel data techniques), on the other hand, found the link to be positive or not significant (Li and Zou, 1998; Forbes, 2000).[9] One interpretation of these differences is that panel-data approaches are successful in controlling for country-specific effects. Another possibility, however, is that they end up eliminating most of the variation in the data, exacerbating measurement error biases and reflecting in practice only the short-run effects of inequality. But many of the theoretical effects of inequality on growth may take a significant amount of time to materialise (changes in education, or in political stability, for example). Accordingly, more recent analyses attempt to take advantage of both within-country and cross-country variation in order to identify possible effects from a number of the potential transmission mechanisms between inequality and growth.

- *Inequality indicators*: The impact of inequality on growth has been often analysed based on a single measure of income inequality (typically, the Gini coefficient). However, the positive and negative theoretical mechanisms behind the links between inequality and growth might be rather associated with inequality in different parts of the income distribution (Voitchovsky, 2005). For example, many of the negative mechanisms (e.g. financial market imperfections, political instability) are associated with inequality at the bottom end of the distribution; most of the positive mechanisms (e.g. based on different savings propensities or on incentive considerations) are more likely to depend on the degree of inequality in the top of the income distribution. Hence, a single inequality statistic may end up capturing a relatively unimportant average effect of inequality on growth and more complex indicators of the profile of income inequality should be used (for example, ratios of income percentiles on either side of the median, or decile share ratios).

15. Parallel to the reduced-form inequality-growth literature a more limited set of studies looked at the channels through which inequality may affect growth, focusing in particular on the endogenous fiscal policy (theory *a* above) and on the human capital accumulation and social mobility channels (theory *b*).

- Research on the endogenous fiscal policy channel provide very weak evidence of a positive association between inequality and fiscal redistribution (see Perotti 1994, 1996; Persson and Tabellini, 1994, and De Mello and Tiongson, 2006 for a survey); moreover, the link between redistribution (e.g. the amount of taxes) and growth is found to be weakly negative, or even positive (see Bergh and Henrekson, 2011).

- Direct estimates of the interplay between inequality and imperfect-financial-markets in shaping investment decisions are limited by the difficulty in appropriately measuring the extent of financial imperfections and credit rationing across countries.[10] Evidence based on aggregate data, however, does not allow inferring whether the sign and strength of the relationship varies across individuals depending on their socio-economic background, as predicted by core models following Galor and Zeira (1993).

- Available evidence on the links between inequality and social mobility is also largely based on cross-country correlations as the so-called “Great Gatsby Curve”, showing a negative relationship between inequality and intergenerational earnings mobility in a subset of OECD countries

9 . Andrews et al. (2011) exploit yearly data for 12 developed countries over a long time period, and find a positive link between inequality (as measured by top income shares) and growth during the following year.

10 . Perotti (1994, 1996) obtains (weak) evidence that the negative impact of income inequality on investment in human capital increases according to the degree of financial imperfection (measured by loan-to-value ratio for home mortgages). See also Deininger and Squire (1998).

(D'Addio, 2007; Corak, 2013). Cross country correlations are clearly only suggestive of the possible link between inequality and mobility, however, due to the likely biases induced by observed and unobserved country-level confounding factors. Recent work by Chetty et al. (2014) based on millions of administrative data looks at income mobility in the US finding that (upward) mobility is robustly negatively correlated with income inequality (and positively with school quality).[11]

3. The impact of inequality on growth

3.1 A summary of the approach and the new evidence

16. The new work on how inequality affects growth in OECD countries presented below takes into account the issues discussed above that hindered past analyses, in the following ways.

17. Estimation method: The empirical equation estimates growth as a linear function of initial inequality, income, human and physical capital; the model is similar to that used in most empirical analyses of growth determinants and, as shown in Annex 3, it can be derived from an augmented Solow growth model. The equation is estimated using panel data, so the baseline regression specification takes the form:

$$lny_{i,t} - lny_{i,t-1} = \alpha lny_{i,t-1} + X_{i,t-1}\beta + \gamma Ineq_{i,t-1} + \mu_i + \mu_t + \epsilon_{i,t} \quad (1)$$

where *i* denotes a particular country and (*t*, *t-1*) is a time interval of 5 years. The variable ln*y* is the log of real GDP per capita so that the left-hand side of equation (1) approximates 5-year growth in a country. On the left hand-side, *Ineq* is a summary measure of inequality (typically, the Gini index); per capita GDP (y_{t-1}) is the standard control for convergence, and the vector *X* contains a minimum set of controls for human and physical capital (see Annex 3 for a detailed description of variables and sources). Using panel data allows accounting for country (and time) fixed effects (μ_i and μ_t). The country dummies are included to control for time-invariant omitted-variable bias, and the period dummies are included to control for global shocks, which might affect aggregate growth in any period but are not otherwise captured by the explanatory variables.

18. In the baseline specification the relevant explanatory variables are measured at the beginning of the growth spell in order to mitigate the concerns that GDP dynamics feeds back to inequality (reverse causality). Moreover, the analysis will exploit Generalised Method of Moments (GMM) as opposed to OLS or the Least Square Dummy Variable estimators (see Box 1 for a description). More specifically, all results are based on the "system GMM" estimator, which exploits variation in inequality both between- and within-country (over time). Hence, it exploits the largest source of variation in inequality (i.e. across countries) while accounting for other potentially relevant country-specific explanatory factors. GMM allow taking into account the estimation issues arising due to the presence of a lagged dependent variable ($\ln y_{i,t-1}$), the so-called "Nickell-bias". More generally, the GMM approach exploits a set of internal instruments, built from past observations of the instrumented variables (as inequality), providing several tests for the

11 . More specifically, upward mobility is negatively related to inequality when this is measured by Gini coefficients, consistent with the "Great Gatsby Curve" documented across countries. Top 1% income shares are not highly correlated with intergenerational mobility, however. By contrast, Bloome (2013) finds that US states in which income inequality has increased the most haven't been more likely to suffer a decline in intergenerational income mobility.

validity of such instruments.[12] They have been used in several contemporaneous empirical analyses of the inequality growth nexus (e.g. Ostry et al., 2014; Halter et al. 2014).

Box 1. GMM estimators in growth regressions

Because most empirical growth models are based on the hypothesis of conditional convergence, growth equations as (1) contain some dynamics in lagged output (the independent variable $\ln y_{i,t-1}$) and can be rewritten as a dynamic panel data model

$$lny_{i,t} = (1+\alpha)lny_{i,t-1} + X_{i,t-1}\beta + \gamma Ineq_{i,t-1} + \mu_i + \epsilon_{i,t} \qquad \text{(1a)}$$

Standard panel data approaches to estimate model (1a), as the Least Square Dummy Variable estimator, are unlikely to yield to unbiased estimates of the parameters of interest (α and β). In fact, applying the within transformation, or taking first differences creates a correlation between $\ln y_{i,t-1}$ and the error term so that the fixed-effect estimator of α is necessarily biased (Nickell, 1981). More importantly, these approaches would yield biased estimates of the coefficients of any independent variable, including $Ineq_{it-1}$, that is correlated with $\ln y_{i,t-1}$.

Specific GMM estimation techniques have been developed to deal with these problems: the first-difference GMM estimator and the System GMM estimator. The first-difference GMM estimator, developed by Arellano and Bond (1991), eliminates the country-specific effect by differencing model (1a), and uses lagged values of the right-hand-side variables (e.g. $\ln y_{i,t-2}$, $\ln y_{i,t-3}$, $Ineq_{i,t-2}$ etc.) as instruments for their change. Arellano and Bond (1991) show that, in particular, consistently estimating the first differenced requires the absence of serial correlation in the error term, $\varepsilon_{i,t}$. Accordingly, they provide a test of autocorrelation in the residuals, i.e. a test that the differenced error terms are not show second-order serially correlated.

The main drawback of first-difference GMM estimates in the current context is that variables as inequality display notable persistence within a country. Hence, taking first differences eliminates most of the variation in the data, and implies that the lagged levels of the explanatory variables are weak instruments for the variables in differences giving rise to large biases and imprecision (see, e.g., Blundell and Bond 1998; Bond et al. 2001).

Following the most recent papers on inequality and growth (Ostry et al., 2014; Halter et al. 2014) the empirical analysis exploits System GMM estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998).

The system GMM estimator combines first-differenced equations (as in the difference GMM), with an additional set of equations in levels where lagged first-differences of the right hand side variables are used as instruments. It therefore rests of the assumption that first-differences are not correlated with the country fixed-effect. In the context of growth regressions, this implies assuming that the deviation of initial observations (e.g. $\ln y_{i,1}$) from their steady states must be uncorrelated with the country-specific fixed effects (see Blundell-Bond (1998, p. 124). To detect possible violations of these requirements, we regularly apply difference-in-Hansen tests to the instruments for the level equation as a group (as suggested by Roodman 2009).

The analysis also follows Roodman (2009) suggestion to account for the problem of "too many instruments" imposing that the number of variables in the instrumental matrix is lower than the number of countries. It's important to note, however, that even System GMM have shown to be subject to weak instruments problems (Bazzi and Clemens, 2013).

19. *Data Quality*: The analysis focuses on a sample of advanced and relatively similar economies to avoid the problem that a different relationship between inequality and growth may exist depending on the level of development (see Barro, 2000). A newly-assembled unbalanced panel was exploited, with

12 . These tests include the Arellano-Bond test of autocorrelation in the residuals (which would invalidate the use of lagged levels of potentially endogenous variables as instrument for their first differences. As reported in Table 1, however, serial correlation does not appear to be an important concern in this application. The analysis also reports tests for the joint validity of all instruments (the Hansen tests of over-identifying restrictions), which do not suggest that any instruments might be invalid (see Roodman, 2009).

variables measured at 5-year intervals over the period 1970-2010 covering 31 OECD countries (see Annex 3 for details). Data on GDP, working age population, and gross fixed capital formation are from the OECD Annual National Accounts. Average years of schooling of the working age population are from the recently updated version of the Barro and Lee (2013) dataset.

20. The inequality indicators are sourced from the OECD Income Distribution Dataset (IDD). Over time, the IDD has become a high-quality data source whose inequality indicators standardised are based on the concept of "equivalised household income", i.e. the total income received by the households adjusted for household size with an equivalence scale. It contains information on income measured both before and after taxes and transfers, which provides a measure of the extent of redistributive policies. In-kind benefits and consumption taxes, however, are excluded as the underlying income surveys do not provide this information. Redistribution through public services, such as health, education, social housing and assistance, or of services to the unemployed and active labour-market policies is therefore not taken into account.[13]

21. *Inequality indicators:* The IDD allows a variety of measures of inequality to be tested, including the Gini coefficient (measured in terms of either disposable or market income) and measures which focus specifically on either the upper or lower ends of the distribution. Bottom inequality in a country is obtained as the ratio between (overall) average income and average income of one bottom decile (e.g. the second). An increase in this ratio signals a widening gap between the average and poor households, i.e. higher inequality at the bottom. Top inequality is measured as the ratio between average income in one top decile (e.g. the eighth) and overall average income, and therefore informs about the gap between the rich and the average households. Hence the analysis can allow for the possibility that different forms of inequality have different consequences for growth.

3.2 Baseline results

22. The first part of the analysis focuses on net income inequality as measured by the Gini coefficient, and measures the extent of redistribution as the difference between market and disposable (Gini) income inequality.

23. The empirical results show that inequality has a negative impact on economic growth. The baseline results are reported in columns 1 to 4 of Table 1. Results in column 1 refer to a baseline specification in which growth only depends on initial income and inequality. In column 2 the model is augmented with standard growth determinants as human and physical capital, which does not affect the above finding.[14] Columns 3-4 explore the same model changing the specification of the instrumental variable matrix to address the problem of "instrument proliferation", which has been shown to lead to severe biases and weakened tests of instrument validity (see Roodman 2009).[15] While the p-values on the

13 . See chapter 8 in OECD (2011) which suggests that the combined effect of in-kind transfers for education, health and care reduces net income inequality by around a fifth in OECD countries, on average.

14 . On the other hand, the estimated coefficients on human and physical capital are not statistically significant, a result that is not affected by using alternative measures or specifications. This result is not completely surprising as several other GMM studies focusing on advanced economies, estimated non-significant coefficients for one or more of the growth controls. This issue will be discussed in detail at the end of the section.

15 . With GMM estimators the set of available instruments (i.e. the lagged values of the independent variables) is potentially large, and using too many instruments may weaken their effectiveness (Roodman 2009). It is therefore important to check the robustness of the results to reducing the instrumental variable matrix. Specifically, for the Inequality variable two lags are used as instruments in cols 1 and 2, and one lag is used in col. 3. In col 4, one lag is used and the instrument matrix has been collapsed into one column (i.e., col. 5

Hansen tests fall with respect to their high value when using a high number of instruments relative to the number of countries (potentially mirroring an instrument-proliferation problem in unrestricted regressions) the estimated coefficient are if anything slightly larger.[16]

Table 1. The inequality-growth nexus in OECD countries: baseline results

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Net inequality (t-1)	-0.774**	-0.800**	-0.809***	-1.003**		-1.257**	-1.207**	
	(0.319)	(0.306)	(0.282)	(0.376)		(0.517)	(0.473)	
Gross inequality (t-1)					-0.640	0.138		
					(1.092)	(0.595)		
(Gross–Net) ineq. (t-1)							0.064	-0.365
							(0.706)	(1.476)
y (t-1)	-0.136**	-0.080	-0.054	-0.079	0.038	-0.070	-0.079	0.133
	(0.054)	(0.051)	(0.057)	(0.106)	(0.178)	(0.121)	(0.131)	(0.231)
Human Capital (t-1)		-0.005	-0.007	-0.000	0.006	-0.009	-0.010	0.013
		(0.011)	(0.007)	(0.015)	(0.021)	(0.011)	(0.012)	(0.021)
Investment (t-1)		0.197	0.428	0.045	1.545	-0.245	-0.243	2.484
		(0.318)	(0.544)	(1.311)	(1.304)	(1.310)	(1.477)	(2.138)
M2 (p-val)	0.722	0.558	0.623	0.723	0.860	0.606	0.665	0.916
Hansen Statistics (p-val)	0.847	0.614	0.377	0.129	0.471	0.129	0.174	0.535
Observations	127	127	127	127	124	124	124	124
Number of countries	31	31	31	31	30	30	30	30
Number of instruments	27	31	26	16	16	18	18	16

Note: The dependent variable is $\Delta \ln y_t$ where y_t is per capita GDP, and [t-(t-1)] is a 5-year period. Inequality is measured by Gini indexes. Robust, 2-step System GMM estimator with Windmeijer-corrected standard errors. All regressions include country and period dummies. M2 are the p-values of the tests for second order serial correlation in the differenced error terms; Hansen denotes the p-value on the Hansen test of over identifying restrictions. ***, **, * denote significance at the 1, 5, 10% levels, respectively

24. The impact of inequality on growth turns out to be sizeable. Based on the estimated coefficients in column 1, for example, lowering inequality by 1 Gini point would translate in an increase in cumulative growth of 0.8 percentage points in the following 5 years (or 0.15 points per year). As discussed in Annex 3, interpreting the estimated coefficients in light of the Solow model allows recovering the implied effect of changes in inequality over the longer run, as the economy converges to the new steady state.[17] Focusing on

has the minimum possible set of instruments). For all other variables, only one lag is used as instrument, and the instrument matrix has been collapsed.

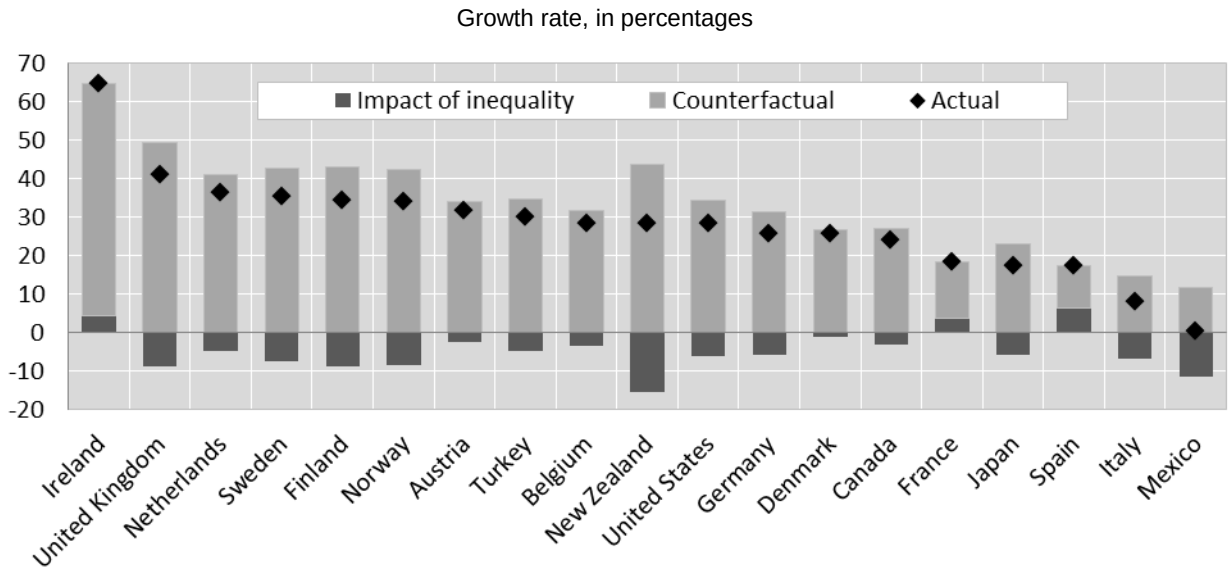
16 . The Arellano-Bond test indicate that serial correlation in the residuals, potentially undermining the use of lagged variables as intruments, should not be a concern. The Hansen test of over-identifying restrictions does not suggest that any instruments might be invalid.

17. As shown in detail in Mankiw et al., 1992, the Solow model implies that the growth of GDP depends on (increases with) its distance from the steady state, to which it converges at a constant rate (the speed of convergence). The steady state of GDP is in turn a function of underlying determinants including human and physical capital and, in the current application, inequality. Hence, estimates of the speed of convergence and of the sensitivity of the steady state to each determinant would allow computing, for

a 25-year horizon, for example, the estimated coefficients imply that a 1 Gini point reduction in inequality would raise average growth by slightly more than 0.1 percentage points per year, with a cumulative gain in GDP at the end of the period of around 3%.

25. Figure 3 proposes an alternative representation of the implied effects, focusing on actual changes in inequality in individual countries. The Figure shows the estimated impact on the 1990-2010 growth rate of GDP of changes in inequality occurred between 1985 and 2005 (the most recent inequality trends are not taken into account as they affect future growth patterns). For each country, it also reports the actual rate of growth and a counterfactual figure, obtained subtracting the estimated impact of inequality from actual growth. This latter figure is to be interpreted as the growth rate that would have been observed in the country had inequality not changed (and holding all other variables constant). Rising inequality is estimated to have knocked more than 10 percentage points off growth in Mexico and New Zealand. In the United States, the United Kingdom, Sweden, Finland and Norway, the growth rate would have been more than one fifth higher had income disparities not widened. On the other hand, greater equality helped increase GDP per capita in Spain, France and Ireland prior to the crisis.

Figure 3. Estimated consequences of changes in inequality on cumulative per capita GDP growth (1990-2010)



Note: The chart reports the estimated consequences of changes in inequality (observed in 1985-2005) on the cumulative growth rate of GDP per capita over the period 1990-2010. GDP per capita is computed relative to the population aged 25-64. "Actual" is the actual growth rate; "Impact of inequality" is obtained based on the observed changes in inequality across OECD countries (in 1985-2005) and the impact of inequality on growth estimated in the analysis (see Annex 3 for details); "Counterfactual" the difference "Actual - Impact of inequality". Actual growth in Germany is computed starting in 1991; the changes in inequality are limited to the period 1985-2000 in the case of Austria, Belgium, Spain and Ireland.

26. Columns 1 to 4 in Table 1 are based on inequality of disposable income. Of the theoretical models referred to in Section 2, this measure is relevant for those approaches which predict that inequality generates missed opportunities by the poor (theory b) but also those models in which inequality rather represents the reward to costly investments in human or physical capital (theory d). However, disposable income is not the correct measure for testing the "endogenous fiscal policy" theory (theory a). Based on this view, increased market (rather than disposable) income inequality would induce voters to choose a

example, the implied effects of changes in inequality on GDP per capita at future dates. Annex 3 details how the results discussed here are obtained from the parameters estimated in Table 1.

high level of (distortionary) taxation (Milanovic, 2000). Accordingly, the results reported in column 5 of Table 1 replicate the previous specification measuring inequality of income before taxes and transfers. Though still negative, the estimated coefficient is lower in magnitude and is not statistically significant. Hence, the analysis provides little support for this theory – at least in OECD countries.

27. One prediction of some of the theories about how inequality might impact growth is that the effect might be non-linear. Some of the political economy and the socio-political instability theories discussed above (see Benhabib, 2003) suggest that while some inequality is unlikely to cause unrest and provides growth-enhancing incentives, inequality can disrupt economic relations after it reaches some 'tipping point' by inviting political interference through rent-seeking behaviour and appropriation. A similar argument might be made about investment in education, for example. In practice, no such non-linearity was found[18] – the effect on growth of an increase in inequality from 20 to 21 Gini points was found to be the same as the effect of increasing the Gini from 40 to 41. Nor was there any evidence found that effects varied significantly in the short and long term.[19] Attempts to identify differences in the effect of inequality by sub-groups of countries (e.g. income per capita, geography or institutions) were uninformative, most likely because of the relatively small country sample.

3.3 Redistribution

28. If inequality has a negative impact on long-term growth, a relevant policy question is how to promote a win-win process to reduce inequality and boost growth. The main, direct, policy tool to reduce market income inequality is via taxes and benefits, which however may also have a negative *direct* effect on growth. This would happen, for example, if high levels of taxes and transfers imply a waste of resources and generate aggregate inefficiencies (as in Okun's famous "leaky bucket" analogy).[20] If this is the case, the specification should account for the fact that reaching a given level of disposable income inequality would entail a stronger drag on growth in countries featuring higher market inequality. Column 6 of Table 1 extends the baseline exercise to include both market and disposable ("net") income inequality. The coefficient estimated on net inequality therefore reflects the effects of changes in inequality due to redistribution. The coefficient remains negative, statistically significant and almost unchanged from the previous columns. The non-significant estimate of the coefficient on market inequality indicates that the extent of redistribution necessary to achieve a given level of net equality has no negative direct consequences on economic growth.

29. This finding is further supported by alternative specifications. Column 5 shows that after controlling for net inequality, the extent of redistribution in a country (the difference between market and net income inequality) has no significant impact on growth. This specification is the same as the one used by Ostry *et al.* (2014), in which they got similar results looking at a broader set of countries. Finally, the extent of redistribution is not significant when taken as the only core independent variable (see column 6). Taken together, these results suggest that inequality in disposable incomes is bad for growth, and that redistribution is, at worst, neutral to growth.

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18 . This was tested by adding in a quadratic term ($Gini^2$).

19 . This was tested by adding further lags of the inequality variable (e.g. $Gini_{t-2}$). Using data on a larger sample of countries, Halter et al. (2014) find that higher inequality helps economic performance in the short term but reduces the growth rate in the longer run.

20 . Okun's (1975) prominent "leaky bucket experiment" refers to the fact that, when government attempts to transfer income from rich to poor individuals "…money must be carried […] in a leaky bucket. Some of it will simply disappear in transit, so the poor will not receive all the money that is taken from the rich" (Okun 1975, p. 91). Okun attributed these losses to the administrative costs of taxing and transferring, and to the disincentive effects, mainly in the labour supply.

30. These results are based on a partial and relatively crude measure of redistribution and do not therefore imply that all redistribution measures would be equally good for growth.[21] For one thing, they do not independently consider the possible contribution to growth of other redistributive tools, such as "pre-distributive" policies that affect market outcomes and alter income disparities before taxes and transfers. These include, for example, education policies allowing a larger fraction of the population to benefit from higher (skilled) wages, or labour market activation policies favouring participation and employment of under-represented groups. More importantly, the impact of the various redistributive measures on efficiency and growth is in practice likely to be different, both in terms of sign and magnitude. Previous OECD work (Arjona et al., 2001) looked at the effects of social spending on growth, dividing such spending into 'active' (social spending which attempts to change the distribution of market income by promoting the labour market participation of part of the population that would have lower-than-normal market incomes) and 'passive'. Active spending included active labour market policies, but also in-work benefits and spending on childcare. This work found that active spending is associated with higher growth, whereas more "passive" social spending is associated with lower growth. While the approach is different from the one followed here, it suggests that not all redistribution is necessarily equally good for growth.

3.4 Top and bottom inequality

31. A further step in the empirical analysis is to look at the growth consequences of inequality in different parts of the income distribution (see also Voitchovsky, 2005). This result is obtained by replacing the Gini index of inequality with several measures of "top" and "bottom" inequality. For example, top income inequality was measured by the ratio of mean disposable income in one top decile with average income in the country, and vice versa for bottom income inequality.[22]

32. The results, presented in Table 2, suggests that lowering inequality by reducing income disparities at the bottom of the income distribution has a greater positive impact on economic performance than if the focus were on reducing top inequality. The estimated coefficients imply that lowering bottom inequality by half of a standard deviation (which is the same as changing bottom inequality in the UK to be like that in France, or that of the US to become like that of Japan, or Australia) would increase average annual growth by nearly 0.3 percentage points over the subsequent 25-year period, with a cumulated gain in GDP at the end of the period in excess of 7 per cent.

21 . A detailed report investigating how tax structures can best be designed to support GDP per capita growth is OECD (2010)

22 . More specifically, denote average disposable income in the country as $\bar{Y}$, and the mean disposable income of the nth decile as $\bar{y}_n$. Bottom inequality is measured as the ratio between $\bar{Y}$ and average income in the lower deciles of the distribution (the focus is on the first to the fourth decile): $BI = \bar{Y}/\bar{y}_n$ (for n<5). Vice versa, top inequality is measured as the ratio between average income in the upper decile and average disposable income in the country: $TI = \bar{y}_n/\bar{Y}$ (for n>7).

Table 2. Inequality at the bottom and at the top of the income distribution

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	**Bottom inequality** based on mean income in				**Bottom and Top inequality** based on mean income in				**Top inequality** based on mean income in	
	1st decile	2nd decile	3rd decile	4th decile	1st and 8th decile	2nd and 8th decile	3rd and 8th decile	4th and 8th decile	9th decile	10th decile
Bottom inequality	-0.015**	-0.070*	-0.119*	-0.189*	-0.032*	-0.083***	-0.132***	-0.198**		
	(0.007)	(0.036)	(0.064)	(0.110)	(0.018)	(0.029)	(0.047)	(0.084)		
Top inequality					-0.054	-0.377	-0.233	-0.085	-0.563	-0.064
					(0.723)	(0.465)	(0.395)	(0.441)	(0.442)	(0.049)
Observations	93	93	93	93	93	93	93	93	93	93
Number of countries	30	30	30	30	30	30	30	30	30	30
Number of instruments	11	11	11	11	13	13	13	13	11	11
M2 (p-val)	0.362	0.349	0.363	0.494	0.282	0.212	0.253	0.308	0.327	0.406
Hansen statistic (p-val)	0.793	0.572	0.708	0.979	0.803	0.830	0.878	0.848	0.472	0.321

Note: The dependent variable is $\Delta \ln y_t$ where [t-(t-1)] is a 5-year period. Bottom inequality is measured by the ratio between mean disposable income in the economy ($\bar{Y}$) and mean income of one bottom decile specified in the column heading ($\bar{y}_n$, with n=1,..,4). An increase in the indicator in col. 1, for example, implies a widening disparity between average overall income and average income of the bottom 10% of the population. Top inequality is measured as the ratio between average income of one top decile, specified in the column heading, and overall average income in the economy ($\bar{Y}$). Robust, 2-step System GMM estimator with corrected (Windmeijer, 1985) standard errors. All regressions include country and period dummies and a control for beginning of period GDP per capita. M1 and M2 are the p-values of the tests for first-order and second order serial correlation in the differenced error terms; Hansen denotes the p-value on the Hansen test of over identifying restrictions. ***, **, * denote significance at the 1, 5, 10% levels, respectively

33. The negative effect of bottom income inequality on growth proves robust. The basic approach is to focus on the poorest households in the population (i.e. the gap in incomes between the poorest decile and the average, see col. 1). But it also holds -- and is remarkably similar in magnitude -- when focusing on the second, third and fourth income decile, which rather capture the relative income conditions of the lower-middle class (cols. 2 to 4).[23] Moreover, it holds even when inequality on the upper end of the distribution is simultaneously accounted for in the specification (cols. 5 to 8). These findings imply that the negative effect of inequality on growth is not (just) about tackling poverty and the least well-off in society, it needs to be about addressing low incomes more generally.

34. Changes in top income inequality, however, are found to have no statistically significant impact on economic growth (see cols. 9 and 10, which confirm the results obtained when top inequality is considered together with bottom inequality, in cols 5 to 8). Note that the income data used may not accurately capture the very top of the income distribution.[24]

35. These findings shed further light on the relative importance of the alternative avenues through which income inequality is supposed to affect subsequent growth across OECD countries. As first pointed out by Voitchovsky (2005), most of the mechanisms predicting a negative effect of income inequality on growth emphasize the role of income disparities at the bottom end of the distribution. For example, the

23 . This is because the increase in the estimated coefficient on bottom inequality as one moves from specification in col. 1 to col. 4 is almost entirely offset by a fall in the standard deviation of the corresponding variable

24 . Unfortunately, the available sources of top income data (e.g. the World Top Income Database) only include pre-tax income shares of top deciles and percentiles. Further, only 18 OECD countries are included in this dataset (see Atkinson et al., 2011; OECD, 2014a). As a result, it is not possible to extend the analysis to consider the role of top inequality based, for example, on top 1 per cent pre-income shares.

human capital accumulation theory (theory b above) predicts that inequality would be harmful because it raises the relative costs of education of an increasing fraction of families in the bottom half of the distribution. Higher inequality at the top is unlikely to induce such consequences. In fact, increased inequality at the top end is rather a signal of the existence of high rewards to risky investments, and therefore more directly linked to the theories implying a positive effect of inequality on growth (theory d above, for example). However, the present findings differ from those of Voitchovsky (2005), who found support for both bottom and top inequality having negative growth consequences.

36. In terms of the theoretical mechanisms highlighted in Section 2.1, the findings in this section seem to indicate that one important way in which income inequality affects growth is by lowering investment and/or occupational opportunities of disadvantaged individuals, as in the financial market imperfection/human capital accumulation theory (theory b). Accordingly, the next section attempts to test the theory more directly, looking at the links between inequality and investment in human capital by individuals with different socio-economic backgrounds.

37. Before turning to this part of the analysis, it is however important to briefly discuss the possible reasons why the results shown in Table 1 do *not* point to a positive effect of human capital on growth. Those findings are in fact hard to reconcile with the large amount of evidence on the positive consequences of education on individual productivity (from the labour literature) and on the significant contribution of human capital to aggregate growth (from growth accounting). And yet, these findings parallel those obtained in several other growth studies exploiting panel data (Islam, 1995; Prichett, 2000) and more GMM estimation techniques (Caselli et al 1996, Bond et al 2001, Castillo-Climent 2010).

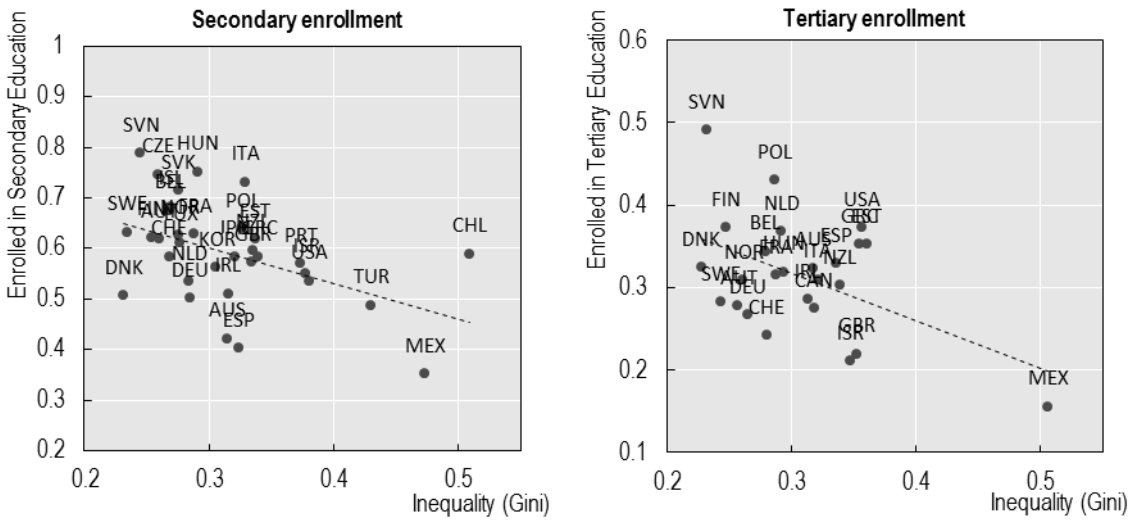
38. One explanation is that, while eliminating one source of bias, exploiting within country variation dramatically lowers estimates' precision when variables either display high stability over time, or (as the stock of human capital) trend in one direction. This concern is even more serious given the high volatility of growth rates measured at short horizons (e.g. 5 years), and the likelihood that human capital is measured with substantial errors (De la Fuente and Domenech, 2000; Cohen and Soto, 2007). When variables are highly persistent, lagged levels can be weak instruments for first differences, so that the (first difference) GMM panel data estimator is likely to be severely biased in short panels. With System GMM, identification therefore relies on lagged first differences having some explanatory power for levels, which might not be the case of available measures of human capital. One further source of bias in GMM estimates arises from (cross-country) parameter heterogeneity (Lee, Pesaran and Smith, 1997).

39. To address these issues, previous OECD research (Bassanini and Scarpetta, 2002; Arnold et al, 2011) carefully re-constructed high quality, yearly education data and looked at an error correction (ECM) version of the underlying growth model, estimated using Pooled Mean Group (PMG) techniques developed by Pesaran, Shin and Smith (1999). This approach allows to deal with parameter heterogeneity and to separately estimate short- and long-run coefficients for each growth determinant. The results suggest that across 21 OECD countries human capital has a robust, positive and significant impact on long run growth. Those data and approach could not be used in the present analysis, however, due to the lack of yearly data on inequality for a large enough number of OECD economies.

4. Inequality, social mobility and human capital accumulation

40. Across OECD countries, income inequality is negatively associated with average educational attainment. Figure 4 displays a simple cross-country correlation between the share of population enrolled in upper secondary (left panel) and tertiary education (right panel) and the Gini coefficients of disposable income inequality.

Figure 4. Inequality and enrolment rates across OECD countries, 2010



Note: The graph is obtained combining OECD data on the number of students enrolled (by age class and level of education) with data on population by age class. The ratio of Upper secondary enrolled is computed relative to the population aged 15-19 (20-24 for the ratio of tertiary enrolled). The two ratios are computed in 2010. Inequality (captured by the Gini coefficient) is measured when individuals were aged 10-14, that is in 2005 (left panel) and 2000 (right panel). Both regression coefficients are statistically significant at the 1% level of confidence.

Sources: see Annex 3.

41. While consistent with early cross-country analyses (e.g. Perotti 1996, Deininger and Squire, 1998) such a simple correlation is not in itself confirmation of the human capital accumulation theory (theory b above). To test this, it is necessary to see whether the sign and strength of the relationship between inequality and education varies across individuals depending on their socio-economic background. More generally, results based on cross-country variation (including the so-called "Gatsby Curve", which plots the relationship between inequality and earnings mobility in a subset of OECD economies) are likely to suffer from biases induced by observed and unobserved time invariant country-specific confounding factors.

42. The analysis in this section exploits individual-level survey data (from the OECD Adult Skills Survey, PIAAC) to estimate whether the link between educational attainments and inequality depends on parents' educational background (PEB, a proxy for socio-economic background) while exploiting within country variation to account for time-invariant observed and unobserved country characteristics.

43. To exploit such variation in a cross-sectional survey as PIAAC, the exercise exploits differences in human capital attainments across age cohorts (within a country). More specifically, individuals are pooled by 5-year age groups (indexed with *t*), and each group is assigned the measure of inequality in their country at the time they were aged between 10 and 14.[25] The baseline empirical equation is:

$$HC_{i,t,c} = \boldsymbol{\beta_1}\mathrm{PEB}_{i,t,c} * Ineq_{t,c} + \boldsymbol{\beta_2}\mathrm{PEB}_{i,t,c} + \theta \mathrm{X}_{i,t,c} + \mu_t + \mu_c + \epsilon_{i,t,c}$$

25 . For example, the exercise assumes that educational outcomes of individuals born in 1966-70 informs about schooling decisions taken around 1980. Hence, in the statistical analysis the outcomes of those individuals can be related to Ineq_{1980}. Following this reasoning, outcomes of the cohorts (1966-70, 1971-75, …, 1991-95) were related to inequality measured in (1980, 1985, …, 2005, which correspond to *t* in equation 2).

where *HC* is a measure of human capital for individual *i* in country *c*, *PEB* is a set of three indicators for her parent educational background being "Low", "Medium" or "High", and *Ineq* is an index of inequality in the country.[26] In this specification, the three parameters in β_2 measure average educational outcomes of individuals with different parental background, while those in β_1 capture whether such averages vary with the extent of income inequality in the country. This procedure allows running panel regressions (country c, period t) accounting for country fixed effects (μ_c) and common shocks (μ_t). Hence, the parameters β can be estimated accounting for time-invariant country determinants that might bias simple cross-country estimates. This would be the case, for example, if inequality is correlated with the quality of the educational system, or with other policies and institutions that affect educational outcomes. (For a detailed description of the other variables considered and of the estimation approach, see Annex 3).

44. This approach measures the degree of inter-generational educational persistence in terms of average outcome differences by individuals in the three groups (and to anticipate the results reported below, unsurprisingly it finds the persistence to be strong). However, crucially, it also allows (changes in) inequality to affect individuals with different PEBs differently. So, for example, if the most important effect of higher income inequality is to increase the incentives to invest in education, higher disparities should be associated with increased achievements, irrespective of individual background. On the other hand, evidence that achievements decline with rising inequality and this effect is stronger among the poor would support the idea that, interacting with financial market imperfections, inequality significantly lowers the opportunities of education and upward social mobility of disadvantaged individuals.[27]

45. This section tests for these alternatives using three different sets of outcomes (further evidence is provided in Annex 3):

- The first is the probability of attaining tertiary education, a measure of the *quantity* of human capital accumulated by the individual.
- The second is an index of skill proficiency, capturing *cognitive ability* and therefore also accounting for the quality of achieved education.
- The third measure is an index of the probability of employment, so moving beyond education to explore the impact of inequality on *labour market opportunities*.

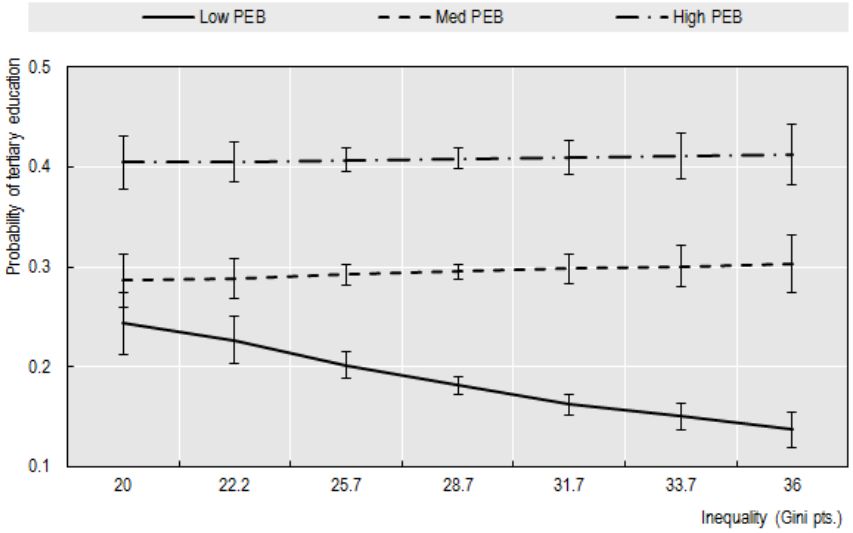
46. The results of all three approaches indicate that widening income disparities lowers the outcomes of individuals from low socio-economic backgrounds, but do not affect those of medium and high background individuals. As in the case of growth regressions, therefore, they strongly support the idea that higher inequality lowers the opportunities of education (and social mobility) of disadvantaged individuals in the society, an effect that dominates the potentially positive impacts through incentives.

26 . The variable is defined as follows. An individuals is assigned a Low PEB if neither parent has attained upper secondary education; a Medium PEB if at least one parent has attained secondary and post-secondary, non-tertiary education; and a High PEB if at least one parent has attained tertiary education.

27 . Studies of social mobility across OECD countries (Causa and Johansson, 2009 and OECD, 2010) provide broad support to the idea that students' achievements strongly depend on parents' education. The proposed exercise aims at extending these results determining whether mobility declines as inequality increases. Confirmation of this hypothesis would contribute to explaining why, when looked at in a cross section of advanced countries, inequality and social mobility are negatively correlated (D'Addio 2007; Corak 2013).

47. The first evidence supporting the negative effects of inequality on opportunities refers to the probability of graduating from university. In Figure 5, each line indicates the average predicted probability of tertiary education by PEB as a function of inequality (measured in Gini points).[28]

Figure 5. Average probability of tertiary education by parental educational background and inequality



Note: the graph reports the average predicted probability that individuals from poor, medium and high family (educational) background attain tertiary education, as a function of the degree of inequality (Gini points). Low PEB: neither parent has attained upper secondary education; Medium PEB: at least one parent has attained secondary and post-secondary, non-tertiary education; High PEB: at least one parent has attained tertiary education. Dotted lines represent baseline probabilities for each group. The bars indicate 95% confidence intervals. The values of the Gini coefficient in the X-axis represent percentiles of the underlying distribution on inequality indexes. In particular the 25th (25.7), the median (28.67), and the 75th (31.7).

Source: see Annex 3.

48. Consistent with the large evidence of significant inter-generational educational persistence, the estimated probability of graduating from university is highest for individuals who have highly educated parents – just over 40% of them receive tertiary education, compared to an average of around 30% of those who have parents with middle levels of educational background.

49. However, the graph also shows that the probability of tertiary education decreases with inequality, but only in the case of low PEB individuals. Based on the underlying estimates, an increase in inequality of around 6 Gini points (corresponding to the US - Canada income inequality differential in 2010) would lower the probability of individuals with parents of low educational background being in tertiary education by around 4 percentage points.[29] On the other hand, inequality does not have any impact

28. In this case, parental education background is measured based on father's education. The results obtained using rather mother's or both parents' education are very similar.

29 . This amounts to more than one-fifth of the baseline probability of tertiary education attainment of Low PEB individuals (18%), and more than one-third of the probability differential relative to Medium PEB individuals.

on the probability of graduating from tertiary education in the case of individuals with medium or high family background.[30]

50. The same results qualitatively hold if focusing on alternative measures of the quantity of education. For example, inequality is found to increase the probability of obtaining at most a lower secondary degree, and lower the number of years of completed schooling; as in the previous case, both results hold for low parental education background individuals only (see Annex 3 for further details).

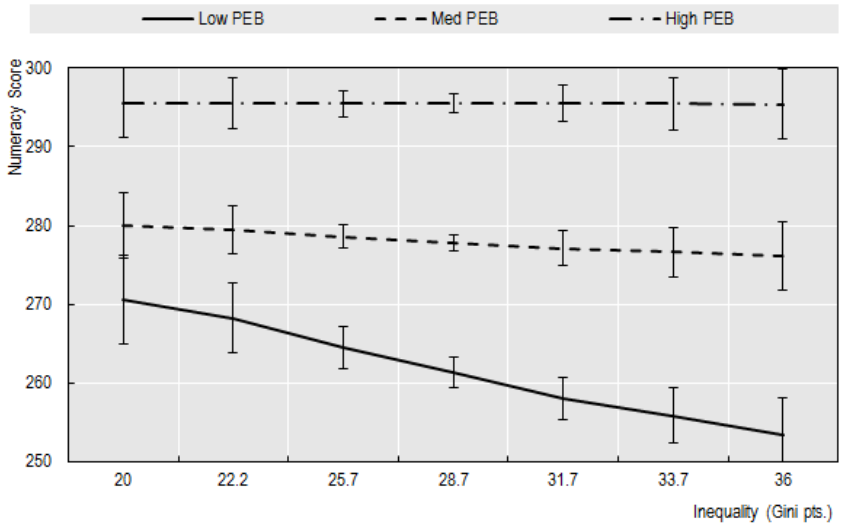
51. The second evidence about the effects of inequality on human capital is obtained by looking at test scores. Several recent studies showed that measuring educational achievements through skill differences (e.g. based on international tests scores in literacy, science and math) dramatically improves our ability to explain variations in long-run growth across countries (see e.g. Hanushek and Woessmann 2012). Being interested in the potential mechanisms behind the inequality-growth nexus, it is therefore important to confirm that inequality has a differential impact on educational achievements using such alternative human capital measures.

52. The PIAAC survey provides a measure of the numeracy and literacy skills. One obvious concern in the context of the present analysis is to what extent these measures actually reflect skills acquired while in education, given that skills are likely to depreciate with age, and might be complemented by those accumulated at work. These concerns are addressed both empirically and based on previous results suggesting that PIAAC skills largely reflect those accumulated while studying (see Annex 3 for a discussion).

53. Figure 6 reports the average predicted numeracy score by father's educational background as a function of inequality (Using literacy scores as a measure of the quality of human capital delivers very similar findings). As in the previous case, Figure 6 shows that numeracy scores decrease with inequality in the case of individuals from low background. In contrast, average scores of more advantaged individuals are unaffected by widening income inequality. According to these estimates, an increase in inequality of around 6 Gini points is associated with a lower numeracy score of low background individuals by around 6 points. This is a significant amount – it accounts for nearly 40% of the gap between their average predicted numeracy score (261) and that of individuals with medium parental backgrounds.

30 . The same results qualitatively hold if focusing on alternative measures of the quantity of education, as the probability of obtaining at most a lower secondary degree, or the number of years of schooling. The analysis shows no significant gender differences in these patterns. See Annex 3 for further details.

Figure 6. Average numeracy score by parent educational background and inequality



Note: the graph plots the average predicted numeracy score for individuals from low, medium and high family (educational) background, as a function of the degree of inequality (Gini points) in the country at the time they were around 14 years old. Low PEB: neither parent has attained upper secondary education; Medium PEB: at least one parent has attained secondary and post-secondary, non-tertiary education; High PEB: at least one parent has attained tertiary education. Dotted lines represent baseline probabilities for each group. The bars indicate 95% confidence intervals. The values of the Gini coefficient in the X-axis represent percentiles of the underlying distribution on inequality indexes. In particular the 25th (25.7), the median (28.67), and the 75th (31.7).

Source: see Annex 3.

54. In principle, these results might simply be a consequence of the previous one, whereby a lower amount of skills just reflects the lower quantity of education. However, the results hold even if conditioning the estimates on the level of formal education, therefore insulating the estimates from the negative consequences of inequality on the quantity of education. Hence, low background individuals see their skills decrease as inequality rises even when they are compared with higher backgrounds individuals with the same amount of formal education. This suggests that part of their lower proficiency can be traced to a worse "quality" of the educational track (e.g. they attended worse quality schools/universities) or to a lower amount of effort (e.g. hours) while studying.

55. The third evidence suggesting that higher inequality lowers the amount of opportunities available to disadvantaged individuals in the society emerges from looking at their labour market outcomes. In particular, PIAAC allows an analysis of the probability of *not* being employed, on average, over the working life.[31] As in the case of educational outcomes, this probability significantly increases as inequality increases in the case of low background individuals, rising by around 3 percentage points (or 20% of their baseline probability of non-employment) as inequality widens by 6 Gini points. Again, the corresponding probabilities for richer individuals are unaffected by inequality (see Figure A3.5 in Annex 3 for more results and details).

31. Each individual is asked to report the number of years spent in paid employment (experience), and the number of years since she left the educational system (potential experience). This information allows computing the fraction of time spent out of employment (a measure of the probability of not being employed) over the working life.

Box 2. The long-run aggregate implied effects

The analysis above suggests that higher inequality may lower the inflows of human capital in an economy, as low background individuals see their educational outcomes worsen. A permanent increase in inequality has therefore the potential to lower the stock of human capital, although this process would be gradual. How would these (long run) changes affect aggregate output? Answering this question requires to first evaluate the impact of lower attainments on aggregate human capital, which in turn depends on the relative weight of low background individuals in the population.

Based on the most recent wave of the PISA survey, whose focus is on individuals aged around 15 and sample size allow for more precise measurement than PIAAC, in 2012 the share of Low PEB students varied significantly across OECD countries. It ranged from over 40% in Portugal, Turkey or Mexico, to around 20% in Italy, Spain and Germany and 10% in Australia, France and the US. In Nordic countries, the UK or Canada it was at, or below, 5%. These figures mean a larger impact of inequality on skills developments in the former than in the latter set of countries. For example, the 6.6 points fall in Numeracy scores of low PEB individuals would translate, in the long run, in a lower proficiency of the working age population, as measured by PIAAC scores, of almost 3 points in Portugal or Turkey (6.6 times 40%), as opposed to around 1.5 points in Italy and Spain, and less than 1 point in other countries. Similarly, the number of years of schooling would decrease by nearly 0.2 in the first set of countries, but only 0.1 in the second.

The lower quantity and quality of human capital would in turn affect aggregate output (what follows is based on works that, unlike the present one, did estimate a positive impact of inequality on growth; see the end of Section 3 for a brief discussion of the possible reasons behind the discrepancies in the empirical literature). One recent paper by Hanushek and Woessmann (2012) estimated the sensitivity of growth to human capital quality looking at skill proficiency across countries. The results indicate that, other things equal, a one standard deviation increase of individual student performance translates into higher annual growth rates of 2.0 percentage points. The inequality-induced fall in PIAAC proficiency score computed above for the case of Portugal or Turkey (3 points) represents around 7% of a standard deviation. Based on the estimates by Hanushek and Woessmann (2012), then, inequality might knock 0.12 percentage points off average annual growth in such countries (and 0.06 per cent in Italy and Spain).

A similar procedure can be applied to the case of human capital quantities (e.g. years of schooling), whose impact on growth is in general estimated to be much weaker. The in-depth analysis by Arnold et al (2011) concludes that increasing average schooling by one year would raise long run per capita GDP by around 8%. Based on the changes in years of schooling computed in the previous paragraph, then, higher inequality would be associated with GDP per capita being around 1.5% lower in Portugal or Turkey, and 0.4% lower in Italy or Spain, in the long run.

5. Concluding remarks

56. This paper contributes to a large empirical literature estimating the impact of inequality on growth. Drawing on harmonised data covering the OECD countries over the past thirty years, the econometric analysis suggests that income inequality has a sizeable and statistically significant *negative* impact on growth, and that redistributive policies achieving greater equality in disposable income has no adverse growth consequences. Moreover, it suggests that it is inequality at the bottom of the distribution that hampers growth. Additional analysis based on OECD PIAAC data suggests that one key channel through which inequality negatively affects economic performance is through lowering investment opportunities (particularly in education) of the poorer segments of the population.

57. These findings have relevant implications for policymakers concerned about slow growth and rising inequality. On one hand it points to the importance of carefully assessing the potential consequences of pro-growth policies on inequality: focusing exclusively on growth and assuming that its benefits will automatically trickle down to the different segments of the population may undermine growth in the long run inasmuch as inequality actually increases. On the other hand it indicates that policies that help limiting or – ideally – reversing the long-run rise in inequality would not only make societies less unfair, but also richer. In particular, the present analysis highlights the importance of two pillars of a policy strategy for tackling rising inequalities and promoting equality of opportunities.

58. One policy avenue to reduce inequality involves reforms to tax and benefit policies. Recent OECD work has focused on top incomes (Förster *et al*. 2014). As top earners now have a greater capacity to pay taxes than before, governments may consider re-examining their tax systems to ensure that wealthier individuals contribute their fair share of the tax burden. This aim can be achieved in several different ways – not only via raising marginal tax rates on the rich but also improving tax compliance, eliminating or scaling back tax deductions which tend to benefit high earners disproportionally, and reassessing the role of taxes on all forms of property and wealth, including the transfer of assets. Broadening the tax base by closing loopholes in the current tax code has the potential to raise both efficiency and equity. This is particularly the case for the taxation of capital income, which is highly concentrated among wealthy households and represents a significant fraction of their total income. The unequal tax treatment of income from different asset classes increases inequality in some cases and distorts the allocation of capital.

59. However, the present paper suggests that it is even more important to focus on inequality at the bottom of the income distribution. Government transfers have an important role to play in guaranteeing that low-income households do not fall further back in the income distribution. This is not only restricted to cash transfers. Other important elements of this pillar are policies to promote and increase access to public services. This concerns services such as high-quality education or access to health. Such measures smooth inequality stemming from cash incomes immediately, but they furthermore constitute a longer-term social investment to foster upward mobility and create greater equality of opportunities in the long run.

60. Many social policies are aimed at poverty alleviation. The analysis in this paper suggests, however, that it is not just poverty (i.e. the incomes of the lowest 10% of the population) that inhibits growth. Instead it suggests that policymakers need to be concerned about the bottom 40% more generally -- including the vulnerable lower middle classes at risk of failing to benefit from the recovery and future growth. Anti-poverty programmes will not be enough.

61. The other major set of policy insights from the current paper concerns the links between inequality and human capital. The evidence strongly suggests that high inequality hinders the ability of individuals from low economic background to invest in their human capital, both in terms of the level of education but even more importantly in terms of the quality of education. This would imply that education policy should focus on improving access by low-income groups, whose educational outcomes are not only worse on average from those of middle and top income groups, but also more sensitive to increases in inequality. However, the performance of disadvantaged individuals might not respond significantly to policies aimed at lowering the direct private costs of, in particular, tertiary education (e.g. tuition costs, or the availability of grants). The adverse impact of inequality may, in fact, still operate via the differential effects of foregone earnings on schooling decisions in different segments of the income distribution; through its effect on the allocation of parental inputs in children's human capital production, or on the ability of parents to select optimal schooling environments (e.g. neighbourhoods). Policy needs therefore to take account of the fact that low socio-economic groups in unequal societies are likely to have underinvested in formal education. Accordingly, strategies to foster skills development must include improved job-related training and education for the low-skilled (on-the-job training) and better access to formal education over their working lives

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ANNEX 1. ADDITIONAL TABLES AND FIGURES

Table A1.1 Trends in real disposable household income by income group, pre-crisis and post-crisis period

	Average annual change, in percentages					
	Pre-crisis (mid-1980s to 2007/08)			Post-crisis 2007/08 - 2011/12		
	Total population	Bottom decile	Top decile	Total population	Bottom decile	Top decile
Australia	3.6	3.0	4.5	0.8	1.6	-0.5
Austria	1.3	0.6	1.1	1.5	-0.8	1.3
Belgium	1.1	1.7	1.2	0.4	2.2	-1.5
Canada	1.1	0.9	1.6	0.8	0.4	0.3
Chile	1.4	1.8	1.2	2.7	4.9	2.7
Czech Republic	2.7	1.8	3.0	0.2	-0.6	0.0
Denmark	1.0	0.7	1.5	0.3	-0.5	0.6
Estonia	-	-	-	-1.8	-4.5	-1.5
Finland	1.7	1.2	2.5	1.2	1.5	1.0
France	1.2	1.6	1.3	0.3	-1.3	1.7
Germany	0.9	0.1	1.6	0.4	0.0	0.8
Greece	1.5	1.8	1.3	-8.3	-12.7	-9.0
Hungary	0.6	0.4	0.6	-1.3	-5.2	-1.6
Iceland	-	-	-	-6.6	-6.4	-9.7
Ireland	3.6	3.9	2.5	-4.2	-10.2	-4.1
Israel *	2.3	0.8	2.8	0.5	1.5	-0.8
Italy	0.8	0.2	1.1	-1.5	-3.9	-0.8
Japan	0.3	-0.5	0.3	-0.9	-1.7	-0.4
Korea	-	-	-	1.3	0.6	0.9
Luxembourg	2.2	1.5	2.9	-0.9	-1.2	-1.8
Mexico	1.4	0.8	1.7	-2.4	-4.9	-1.7
Netherlands	1.4	0.5	1.6	-1.4	-1.6	-3.0
New Zealand	1.5	1.1	2.5	-0.5	-0.9	-2.2
Norway	2.3	1.4	2.7	0.9	0.0	0.6
Poland	-	-	-	2.9	3.3	1.5
Portugal	2.0	3.6	1.1	-2.3	-1.9	-3.7
Slovak Republic	-	-	-	4.2	1.8	4.6
Slovenia	-	-	-	-0.5	-0.6	-0.6
Spain	3.1	3.9	2.5	-3.6	-12.9	-1.4
Sweden	1.8	0.4	2.4	2.5	0.7	3.8
Switzerland	-	-	-	-	-	-
Turkey	0.5	0.8	0.1	1.0	0.1	1.3
United Kingdom	2.1	0.9	2.5	-0.9	-0.9	-0.3
United States	0.9	0.1	1.5	0.2	-1.3	0.9
OECD-27	1.6	1.3	1.8	-0.5	-1.8	-0.7

Note: Income refers to disposable household income, corrected for household size and deflated by the consumer price index (CPI).

Panel A: Average annual changes are calculated over the period from 1985 to 2008, with a number of exceptions: 1983 was the earliest year for Austria, Belgium, and Sweden; 1984 for France, Italy, Mexico, Turkey and the United States; 1986 for Greece, Finland, Luxembourg, and Norway; 1987 for Ireland; 1991 for Hungary; 1992 for the Czech Republic; 1995 for Australia and Portugal and 1996 for Chile. The latest year for Chile was 2006; for Denmark, Hungary, and Turkey it was 2007; and for Japan 2006. Changes exclude the years 2000 to 2004 for Austria, Belgium, Ireland, Portugal and Spain for which surveys were not comparable.

Panel B: Average annual changes are calculated over the period from 2007 to 2011, with a number of exceptions: 2006 was the earliest year for Chile; 2008 for Australia, Germany, Finland, France, Israel, Mexico, Norway, New Zealand, Sweden and United States. The latest year for Japan was 2009; for Austria, Belgium, United Kingdom and Ireland it was 2010; and for Australia, Hungary, Korea, Mexico, Netherlands and United States it was 2012. Information on data for Israel: http://dx.doi.org/10.1787/888932315602.

Table A1.2 Recent trends in different income inequality measures

	Gini coefficient			S90/S10 income share ratio			Income share in total income						Palma ratio		
							Bottom 10%	Bottom 20%	Bottom 40%	Top 40%	Top 20%	Top 10%			
	2007	2010	2011	2007	2010	2011	2011 or latest available year, percentages						2007	2010	2011
Australia	0.336	0.334	0.324	9.3	8.9	8.5	2.9	7.3	19.8	63.0	39.7	24.4	1.33	1.30	1.23
Austria	0.269	0.269	0.282	5.7	6.1	7.1	3.1	8.4	22.4	59.6	36.7	22.2	0.95	0.94	0.99
Belgium	0.277	0.264	..	6.5	5.8	..	3.6	8.9	22.9	58.4	35.1	20.8	0.98	0.91	..
Canada	0.318	0.319	0.316	8.5	8.6	8.5	2.8	7.6	20.4	62.2	39.2	24.2	1.20	1.21	1.18
Chile	0.511	0.510	0.503	29.5	30.1	26.5	1.5	4.3	12.5	75.3	56.4	40.9	3.43	3.41	3.26
Czech Republic	0.257	0.258	0.256	5.3	5.6	5.5	4.0	9.7	24.3	57.8	35.5	21.6	0.90	0.90	0.89
Denmark	0.246	0.252	0.253	5.1	5.3	5.3	4.0	9.7	24.0	57.5	34.7	21.0	0.85	0.87	0.87
Estonia	0.312	0.317	0.323	8.0	8.9	9.1	2.6	7.2	19.7	63.1	39.3	23.6	1.15	1.16	1.20
Finland	0.270	0.265	0.261	5.8	5.6	5.5	3.9	9.5	23.7	58.2	35.5	21.5	0.96	0.93	0.91
France	0.293	0.303	0.309	6.8	7.2	7.4	3.4	8.5	21.6	61.5	39.7	25.5	1.09	1.14	1.18
Germany	0.287	0.286	0.293	6.7	6.7	6.9	3.4	8.6	22.2	60.5	38.1	23.7	1.04	1.04	1.07
Greece	0.335	0.338	0.335	10.7	11.0	12.6	1.9	6.3	18.8	63.4	39.7	24.4	1.30	1.32	1.30
Hungary	0.272	0.272	0.290	6.0	6.0	7.3	3.1	8.2	21.7	60.3	37.2	22.5	0.98	0.95	1.04
Iceland	0.283	0.246	0.251	6.5	5.6	5.6	3.7	9.7	24.4	57.5	34.7	20.9	1.04	0.84	0.86
Ireland	0.303	0.313	0.302	6.9	8.4	7.7	3.0	8.1	21.3	61.3	38.2	23.3	1.12	1.16	1.10
Israel	0.371	0.376	0.377	13.4	13.6	12.5	2.0	5.7	16.6	66.5	42.1	25.6	1.62	1.62	1.55
Italy	0.313	0.321	0.321	9.0	10.5	10.2	2.4	7.1	20.0	62.4	39.3	24.4	1.16	1.21	1.22
Japan	0.329	0.336	..	10.3	10.7	..	2.3	6.5	18.9	63.7	40.0	24.4	1.25	1.30	..
Korea	0.312	0.310	0.307	10.0	10.5	10.2	2.2	6.8	20.2	61.4	37.5	22.3	1.13	1.12	1.10
Luxembourg	0.276	0.271	0.276	6.1	5.8	5.9	3.7	9.0	22.6	59.5	36.5	22.0	0.99	0.94	0.97
Mexico	0.475	0.466	0.482	26.8	28.5	30.5	1.2	3.9	12.5	73.9	52.9	36.7	2.80	2.66	2.93
Netherlands	0.295	0.283	0.278	7.1	6.6	6.6	3.4	8.9	22.9	59.2	36.8	22.7	1.10	1.02	0.99
New Zealand	0.330	0.324	0.323	8.3	8.3	8.0	3.1	7.7	20.2	63.0	40.1	24.7	1.30	1.24	1.22
Norway	0.250	0.249	0.250	5.9	6.0	6.1	3.4	9.2	24.3	57.0	34.3	20.5	0.85	0.84	0.85
Poland	0.317	0.307	0.304	8.3	7.9	7.7	3.1	7.9	21.1	61.4	38.4	23.5	1.20	1.13	1.11
Portugal	0.364	0.345	0.341	10.6	9.4	9.9	2.7	7.2	19.6	63.9	41.8	26.7	1.54	1.39	1.36
Slovak Republic	0.246	0.263	0.261	5.2	6.1	5.8	3.5	9.0	23.2	58.5	35.1	20.5	0.83	0.90	0.88
Slovenia	0.241	0.246	0.245	5.3	5.4	5.3	3.7	9.4	24.1	57.1	33.8	19.6	0.80	0.82	0.81
Spain	0.306	0.334	0.344	8.4	12.1	13.8	1.8	6.0	18.3	64.3	40.5	24.6	1.10	1.27	1.34
Sweden	0.259	0.269	0.273	5.8	6.1	6.3	3.4	8.7	22.7	59.0	35.9	21.8	0.89	0.94	0.96
Switzerland	..	0.298	0.289	..	7.3	6.9	3.3	8.5	22.0	60.2	37.4	23.0	...	1.10	1.04
Turkey	0.409	0.417	0.412	14.5	16.1	15.2	2.1	5.6	16.0	69.0	47.4	31.7	1.94	2.03	1.99
United Kingdom	0.341	0.341	0.344	9.8	10.0	9.6	2.9	7.5	19.7	64.0	42.2	27.6	1.37	1.37	1.40
United States	0.378	0.380	0.389	15.1	15.9	16.5	1.7	5.4	16.3	67.5	44.3	28.4	1.65	1.66	1.74
OECD	0.314	0.314	0.315	9.3	9.6	9.6	2.9	7.7	20.6	62.1	39.3	24.4	1.26	1.25	1.26

Note: Data shown for 2007 refer to 2006 for Chile and Japan; 2008 for Australia, France, Germany, Israel, Mexico, New Zealand, Norway, Sweden and the United States. Data for 2010 refer to 2009 for Chile, Hungary, Japan, New Zealand and Switzerland. Data for 2011 refer to 2012 for Australia, Finland, Hungary, Korea, Mexico, the Netherlands and the United States. 2011 data for the United Kingdom are provisional. 2011 data for Austria are not comparable to earlier years. The OECD average for 2007 includes 2009 data for Switzerland. The OECD average for 2011 includes 2009 data for Japan and 2010 data for Belgium.

Income distribution data refers to the total population and are based on equivalised household disposable income, i.e. disposable income adjusted for household size. TheS90/S10 income share ratio refers to the ratio of average income of the top 10% to the average income of the bottom 10% of the income distribution. The Palma ratio is the ratio of the share of the top 10% to the bottom 40%. Information on data for Israel: http://dx.doi.org/10.1787/888932315602.

Source: OECD Income Distribution Database (IDD).

ANNEX 2. SYNTHESIS OF LITERATURE REVIEW

Table A2.1 Summary of main cross-country reduced-form studies on inequality and growth

Authors	Sample	Data structure	Distribution	Measure of inequality	Income inequality data set	Estimation method	Effect of inequality on growth
Alesina and Rodrik (1994)	46/70 countries 1960-1985	Cross-section	Income, Land	Gini coefficient	Jain Fields	OLS, 2SLS	*Income*: Negative for the whole sample; Negative in democracies and non-democracies; Insignificant when income and land inequality are considered simultaneously; *Land*: Negative for the whole sample
Persson and Tabellini (1994)	56 countries 1960-1985	Cross-section	Income	Share of the fourth quintile	Paukert	OLS, 2SLS	Negative for the whole sample; Negative in democracies and insignificant in non-democracies
Clarke (1995)	74/81 countries 1970-1978	Cross-section	Income	Gini., Coef. of var., Theil, 4th quintile sh.	UN Social indicators	OLS, WLS, 2SLS	Negative for the whole sample; Negative in democracies and non-democracies
Perotti (1996)	67 countries 1960-1985	Cross-section	Income	Share of the 3th and 4th quintiles	Jain Lecaillon	OLS, WLS	Negative for the whole sample; Insignificant when regional dummies are added; negative in democracies and non-democracies; negative in rich and insignificant in poor countries
Birdsall and Londono (1997)	43 countries 1960-1992	Cross-section	Income, land and Human capital	Gini coefficient	Deininger and Squire	OLS	*Income*: Negative for the whole sample; Insignificant when income, land and human capital inequality are considered simultaneously; *Land and human capital*: Negative for the whole sample, even when income, land and human capital inequality are considered simultaneously
Deininger and Squire	66/87 countries	Cross-section	Income, Land	Gini coefficient	Deininger and Squire	OLS	*Income*: Negative for the whole sample; Insignificant when regional dummies are added; *Land*: Negative for the whole sample; Insignificant in democracies and negative in non-

Authors	Sample	Data structure	Distribution	Measure of inequality	Income inequality data set	Estimation method	Effect of inequality on growth
(1998)	1960-1992						democracies; Insignificant in rich and negative in poor countries
Li and Zou (1998)	46 countries 1960-1990	Panel	Income	Gini coefficient	Deininger and Squire	FE, RE	Positive for the whole sample
Deininger and Olinto (2000)	31/60 countries 1966-1990	Panel	Income, Land	Gini coefficient	Deininger and Squire	System GMM	*Income*: Positive when income and land inequality are considered simultaneously; *Land*: Negative for the whole sample
Forbes (2000)	45 (mid-high inc) countries 1966-1995	Panel	Income	Gini coefficient	Deininger and Squire	First-diff GMM	Positive in high and mid-income countries
Barro (2000)	84 countries 1965-1995	Panel	Income	Gini coefficient	Deininger and Squire	3SLS	Insignificant for the whole sample; Positive in rich and negative in poor countries
Castellò and Domenéch (2002)	67/83 countries 1960-1990	Cross-section	Income, Human capital	Gini coefficient	Deininger and Squire, Barro and Lee	OLS	*Income*: Negative for the whole sample; Insignificant when regional dummies are added; Positive when income and human capital inequality are considered simultaneously; *Human Capital*: Negative for the whole sample, even when income and human capital inequality are considered simultaneously
Banerjee and Duflo (2003)	45 countries 1965-1995	Panel	Income	Gini coefficient	Deininger and Squire	Kennel regressions	Negative effect on growth resulting from changes in inequality in any direction
Knowles (2005)	40 countries 1960-1990	Cross-section	Income	Gini coefficient	Deininger and Squire	OLS	Negative for the whole sample; Insignificant for high/mid-income countries and negative for low-income countries; Insignificant for gross-income and negative for expenditures

Authors	Sample	Data structure	Distribution	Measure of inequality	Income inequality data set	Estimation method	Effect of inequality on growth
Voitchovsky (2005)	21 (developed) countries 1975-2000	Panel	Income	Gini coefficient; 90/75 and 50/10 ratios	Luxembourg Income Study	System GMM	Insignificant considering aggregate inequality; Positive at the top of inequality distribution; Negative at the bottom of inequality distribution
Castellò (2010)	102/56 countries 1960-2000	Panel	Income, Human capital	Gini coefficient, Distribution of education by quintiles	UNU-WIDER Luxembourg Income Study	System GMM	*Income*: Negative for the whole sample; Negative for poor and positive for rich countries; *Human Capital*: Negative for the whole sample; Negative for poor and inconclusive for rich countries
Ostry, Berg and Tsangarides (2014)	90 countries 1960-2010	Panel	(Market and disposable) Income	Gini coefficient	SWIID	System GMM,	Look at both net inequality and redistribution (the difference between market and disposable income inequality). Inequality is estimated to have a negative effect on growth, redistribution is not significant.
Halter, Oechslin and Zweimuller (2014)	90 countries 1966-2005	Panel	Income	Gini coefficient,	Deininger and Squire, UNU-WIDER	System GMM, First-diff GMM	First-diff GMM: positive link in whole and in sub-samples by income. System GMM: positive in rich and negative in poor countries

Source: adapted and updated from Cunha Neves P. and S. Tavares Silva (2014)

Table A2.2 Summary of main studies on intermediate theoretical mechanism

Authors	Mechanism	Sample	Data structure	Measure of inequality	Income inequality data set	Estimation method	Assessment of relevance of tested mechanism
Persson and Tabellini (1994)	Political economy (Fiscal policy)	13/43 countries 1960–1985	Cross-section	Income Share of the fourth quintile	Paukert	OLS 2SLS	Rejection
Alesina and Perotti (1996)	Political economy (Socio-political Instability)	71 countries 1960–1985	Cross-section	Income Share of the third and fourth quintiles	Jain Lecaillon	2SLS	Acceptance
Perotti (1996)	Credit market imperfections	62 countries 1960–1985	Cross-section	Income Share of the third and fourth quintiles	Jain Lecaillon	OLS 2SLS	Ambiguous result
Perotti (1996)	Political economy (Fiscal policy)	49/27 countries 1960–1985	Cross-section	Income Share of the third and fourth quintiles	Jain Lecaillon	OLS 2SLS	Rejection
Perotti (1996)	Political economy (Socio-political Instability)	64 countries 1960–1985	Cross-section	Income Share of the third and fourth quintiles	Jain Lecaillon	OLS 2SLS	Acceptance
Deininger and Squire (1998)	Credit market imperfections	52/81 countries 1960–1992	Cross-section	Land Gini coefficient	Deininger and Squire (1996)	OLS	Acceptance
Svensson (1998)	Political economy (Socio-political Instability)	101 countries 1960–1985	Cross-section	Income Ratio between the share of income by the poorest 40% to the richest 20%	Paukert	OLS	Acceptance
Sylwester (2000)	Political economy (Socio-political Instability)	52 countries 1960–1992	Cross-section	Income Gini coefficient	Deininger and Squire (1996)	3SLS	Acceptance (short-run); Rejection (long-run)

Authors	Mechanism	Sample	Data structure	Measure of inequality	Income inequality data set	Estimation method	Assessment of relevance of tested mechanism
Barro (2000)	Saving	84 countries 1965–1995	Panel	Income Gini coefficient	Deininger and Squire (1996)	OLS	Rejection
Keefer and Knack (2002)	Socio-political instability	56/89 countries 1970–1992	Cross-section	Income, Land Gini	Deininger and Squire (1996)	OLS	Acceptance

Source: adapted from Cunha Neves P. and S. Tavares Silva (2014).

ANNEX 3. ESTIMATING THE INEQUALITY, SOCIAL MOBILITY AND GROWTH NEXUS: TECHNICAL ANNEX

A3.1 Introduction

62. This Annex provides background information and estimation details on the empirical exercises summarized in the main text. Section A3.2 describes the methodology and the data used in cross-country growth regressions (section 3 in the main text). Section A3.3 illustrates the approach taken to investigate the link between inequality and educational mobility (section 4 in the main text) and discusses several additional results.

A3.2 The impact of inequality on growth

A3.2.1 The growth equation

63. Mankiw et al (1992) showed how empirical growth equations similar to the one analysed in the paper can be derived from a neoclassical (Solow, 1956) growth model augmented in order to take into account human capital as a factor of production. They start from a constant return to scale production function as:

$$Y(t) = K(t)^{\theta} H(t)^{\beta} (A(t)L(t))^{1-\theta-\beta} \qquad \text{(A3.1)}$$

where *Y*, *K* and *H* are output, physical and human capital respectively, *L* is labour, A is labour augmenting technology and θ and β are the partial elasticities of output with respect to physical and human capital. As in the Solow model, L and A grow exogenously at rates n and g, respectively: $L(t)= L(0)e^{nt}$ and $A(t)=A(0)e^{gt}$. The number of effective units of labour *A(t)L(t)* then grows at rate $n+g$. Physical capital depreciates at rate δ.

64. Let s_k and s_h be the fraction of income invested in physical and human capital, respectively. Defining quantities in (A3.1) in terms of unit of effective labour input *A(t)L(t)* ($y = Y/AL$, $k = K/AL$, and $h = H/AL$) the evolution of the economy is then determined by:

$$\dot{k}(t) = s_k\, y(t)\, (n + g + \delta)\, k(t) \qquad \text{(A3.2)}$$

$$\dot{h}(t) = s_h\, y(t)\, (n + g + \delta)\, h(t) \qquad \text{(A3.3)}$$

Under the assumption that $\alpha+\beta<1$ (i.e. of decreasing returns to reproducible factors), this system of equations can be solved to obtain steady-state values of k^* and h^* defined by

$$k^* = \left(\frac{s_k^{1-\beta} s_h^{\beta}}{n + g + \delta}\right)^{1/(1-\theta-\beta)} \qquad \text{(A3.4)}$$

$$h^* = \left(\frac{s_k^{\theta} s_h^{1-\theta}}{n + g + \delta}\right)^{1/(1-\theta-\beta)} \qquad \text{(A3.5)}$$

Substituting A3.4 and A3.5 into the production function and taking logs yields the expression for the steady-state output in intensive form. The latter can be expressed either as a function of s_h (investment in human capital) and the other variables or as a function of h^* (the steady-state stock of human capital) and the other variables (Mankiw et al., 1992). From an empirical point of view, the choice between the two depends on the nature of available data. In this paper human capital is proxied by the average years of education of the working age population and thus the expression is in terms of human capital stock (h). Thus, the steady-state path of output y^* can be written as:

$$ln\left(\frac{Y(t)}{L(t)}\right)^* = lnA(0) + gt + \frac{\theta}{1-\theta-\beta}\ln s_k + \frac{\beta}{1-\theta-\beta}\ln h^* - \frac{\theta+\beta}{1-\theta-\beta} ln\,(n+g+\delta) \quad \text{(A3.6)}$$

65. Let y^* be the steady state level of output in efficiency units and $y(t)$ its value at time t, then the transitional dynamics to the steady state can be expressed as:

$$\frac{\partial ln\, y}{\partial t} = \lambda\,[\ln y^* - \ln y]$$

where $\lambda = (n+g+\delta)\,(1-\theta-\beta)$ is the rate of convergence. For example, if $\theta = \beta = 1/3$, and $n+g+\delta = 0.06$ then the convergence rate would equal 0.02. This implies that the economy moves halfway to steady state in about 35 years. Under the assumption that $\theta+\beta < 1$ (i.e. decreasing returns to reproducible factors), this equation implies that lny approaches lny^* exponentially,

$$\ln y(t) - \ln y^* = e^{-\lambda t}\,[\ln y(t-s) - \ln y^*]$$

which can be rewritten to have an expression for the growth of income:

$$lny(t) - lny(t-s) = (1-e)^{-\lambda s}(lny^* - lny(t-s)) \quad \text{(A3.7)}$$

Substituting y^* from A3.6 (with $\phi(\lambda) = (1-e)^{-\lambda s}$):

$$ln\,y(t) - ln\,y(t-s) = -\phi(\lambda)lny(t-s) + \phi(\lambda)\frac{\theta}{1-\theta-\beta}\ln s_k + \phi(\lambda)\frac{\beta}{1-\theta-\beta}\ln h^* - \phi(\lambda)\frac{\theta+\beta}{1-\theta-\beta} ln\,(n+g+\delta) \quad \text{(A3.8)}$$

66. Hence, in a Solow model output growth is a function of the initial level of income and of the ultimate determinants of the steady state. This implies that estimating an equation as (A3.8) would allow inferring the impact of each growth determinant on the subsequent pattern of growth.[32] This is because, the coefficient $\hat{\alpha}$, estimated on lagged output in equation (1), allows recovering the speed of convergence: $\hat{\lambda} = -\ln(1-\hat{\alpha})/s$, with s=5. Moreover, the coefficient estimated on a given growth determinant X (call this coefficient γ, as in the case of inequality in (1)) allows computing the impact of such determinant on the steady state level of output ($\widehat{\Delta lny^*} = -(\hat{\gamma}/\hat{\alpha}) * \Delta X$). Exploiting these two estimates and equation A3.7

32 . Empirically, such equation has been adapted to assess the relevance of a variety of growth determinants, allowing for different specifications of the functional form; see section A3.2.2 for a precise definition of the variables and specification considered here.

one can, for example, calculate the implied effect of a change in inequality on long-run (i.e. 25-year) growth.

67. The figures discussed in Section 3.2, for example, are obtained from the coefficients estimated in the first column of Table 1. Based on those estimates, a 1 Gini point reduction in inequality would increase the steady state level of per capita GDP by 5.7% ($\Delta \ln y^* = -(\hat{\gamma}/\hat{\alpha}) * (-1) = 0.0569$). Differentiating A3.7 yields an expression for the percentage change in GDP at year *t* (which is *s* years ahead of the current period) as a function of $\Delta \ln y^*$: $\Delta \ln y(t) = (1-e)^{-\hat{\lambda}s}(\Delta \ln y^*)$. Finally, the estimated speed of convergence is $\hat{\lambda} = -\ln(1-\hat{\alpha})/5 = 0.029$. These estimates imply that a 1 Gini point reduction in inequality would increase GDP per capita by 3% after 25 years (with a gain in average growth of nearly 0.12% per year). These values also imply that GDP would cover slightly more than half of the distance from the new steady state over the same horizon.[33]

68. Since its beginning in the early 1990s, the empirical growth literature has extended equation A3.8 to account for a variety of long run growth determinants (as public and social capital, trade openness, financial development, quality of institutions etc.). Early works focussing on the role of inequality include Persson and Tabellini (1994) and Alesina and Rodrik (1994).

69. Moreover, equation A3.8 can be estimated for any time interval. Because inequality indicators are not measured at high frequency across countries, the present application will exploit five-year intervals (i.e. s=5). This allows using a dynamic fixed-effect (DFE) specification estimated with GMM methods, accounting for a country-specific component in the error term, which is a likely source of bias in early cross-country regressions of long run per capita GDP growth on inequality.

70. However, DFE specifications typically impose homogeneity of all slope coefficients, and homogeneity of the rate of convergence appears to be at odds with data for OECD countries (Bassanini and Scarpetta, 2002). Pesaran and Smith (1995) show that, under slope heterogeneity, GMM (and simple Least Square Dummy Variable) dynamic fixed effect estimates of the speed of convergence are usually affected by a downward heterogeneity bias. Accordingly, Arnold et al (2011) rather looked at an error correction (ECM) version of equation A3.8, using Pooled Mean Group (PMG) estimators which allow the speed of convergence to the steady state differ across countries. This is a realistic approach, as both exogenous (i.e. Solow) and endogenous (i.e. Uzawa-Lucas) growth models imply that the speed of convergence to the steady state differs across countries because of cross-country heterogeneity in population growth, technical change and progressiveness of the income tax. Moreover, the approach permits to discriminate between growth theories by glancing at the estimated parameters. In fact, for plausible values of the parameters, the Solow model implies a much slower speed of convergence to the steady state than that implied by the Lucas model (the paper concludes that the estimated speed of convergence is compatible with endogenous growth theories). As mentioned, this empirical approach could not be taken in the case of present analysis due to the lack of time series variation in inequality data.

33 . The country-specific implied effects shown in Figure 3 are obtained using the same estimated coefficients and equation. The only difference is that for each country, the impact on growth was obtained cumulating the effects of each of the four 5-year changes in inequality observed between 1985 and 2005. Hence, for example, $\Delta Ineq_{1985-90}$ induces a shift in lny^* which affects the growth of GDP during 20 years ($\Delta \ln y(2010) = (1-e)^{-20\hat{\lambda}}\Delta \ln y^*(\Delta Ineq_{1985-90})$ while $\Delta Ineq_{2000-05}$ only affects GDP during 5 years ($\Delta \ln y(2010) = (1-e)^{-5\hat{\lambda}}\Delta \ln y^*(\Delta Ineq_{2000-05})$. Hence earlier shifts would have a larger impact on GDP at the end of the period than subsequent shifts of the same magnitude.

A3.2.2 The empirical model and data

71. The baseline regression considered in the analysis augments the above estimating equation including inequality among the determinants of steady state income. It is estimated empirically exploiting a newly assembled (unbalanced) panel of data covering OECD countries over the period 1970-2010. More specifically, the baseline estimating equation is

$$lny_{i,t} - lny_{i,t-s} = \alpha lny_{i,t-s} + \gamma Ineq_{i,t-s} + \beta_1 HC_{i,t-s} + \beta_2 Inv_{i,t-s} + \mu_i + \mu_t + \epsilon_{i,t-s} \quad (1)$$

72. In the baseline specification:

- inequality is measured by a Gini coefficient. The Gini coefficient is an index of inequality based on the comparison of cumulative proportions of the population against cumulative proportions of income they receive, and it ranges between 0 in the case of perfect equality and 1 in the case of perfect inequality. The analysis will also focus on measures capturing income disparities at the top/bottom of the distribution. More specifically, denote average disposable income in the country as $\bar{Y}$, and the mean disposable income of the nth decile as $\bar{y}_n$, then bottom inequality is measured as: $BI = \bar{Y}/\bar{y}_n$ (for n<5). Vice versa, top inequality is measured as $TI = \bar{y}_n/\bar{Y}$ (for n>7).

  The main source of the inequality data is the OECD-IDD dataset.[34] The dataset contains a number of standardised indicators based on the central concept of "equivalised household income", i.e. the total income received by the households adjusted for household size with an equivalence scale. Income data refer to cash income – excluding imputed components such as home production and imputed rents. This includes earnings (broken down into those of the household head, of the spouse and of other household members); self-employment income; capital income (rents, dividends and interest). The figures for public transfers and household taxes are also included, which allow to distinguish "market" and "disposable" income (measured after taxes and transfers). The analysis assumes the household as the unit within which income sources are pooled and equally shared. The income attributed to each person is adjusted for household size based on a common equivalence elasticity (the square root of household size) that does not distinguish between adults and children and implies that economic needs increase less than proportionally with the household size. Data for most countries are drawn from household surveys which may also be affected by under-reporting (especially at the top and bottom of the distribution) and do not allow to accurately measure income at the upper-end of the distribution. While satisfactorily covering the last part of the period 1970-2010, the IDD presents more missing values in the early sub-periods and has therefore been integrated with information from the publicly available set of Key Figures from the LIS (Luxembourg Income Study) database.[35]

- Output is measured by the log of real GDP per capita in country *i* and year *t* ($lny_{i,t}$) expressed in 2005 US$ at purchasing power parity. The analysis exploit five-year intervals (i.e. s=5), so that the left hand side variable measures 5-year growth rates of per capita GDP. Source: OECD Annual National Accounts[36].

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34 See http://www.oecd.org/social/income-distribution-database.htm.

35 See http://www.lisdatacenter.org/data-access/key-figures/

36 The data can be downloaded at http://dotstat.oecd.org/Index.aspx.

- Physical capital is proxied by the ratio of real non-residential fixed capital formation to real GDP expressed in 2005 US$ at purchasing power parity. Source: OECD Annual National Accounts

- Human capital is measured by average years of schooling of the working age (15-64) population. The baseline specification focuses on the level of such variable (as in recent works on inequality and growth, see e.g. Halter et al. 2014), but considering a log transformation, which would be consistent with the derivation in section A3.2.1, did not change the results. The data are sourced from the latest (2013) version of the widely used Barro and Lee dataset.[37] In general, the quality of available cross country data on human capital has been shown to be relatively poor (De la Fuente and Domenech, 2013). The high quality education data re-constructed by Arnold et al (2011) are however only available for a subset of OECD countries and could not be used in the present analysis, as they imply a substantial reduction in the sample size.

73. Panel data allow estimating the empirical link between inequality and growth accounting for country and period fixed effects (μ_i, μ_t). The baseline specification does not, on the other hand, account for the last term in A3.7, cumulating population growth, capital depreciation and technological progress ($n+g+\delta$). The paper focuses on a simplified specification for several reasons. First, since sample size is already limited by the availability of inequality statistics, and especially since panel estimation requires a large number of observations, this simple specification helps maximize the degrees of freedom. Second, within country variation population growth is unlikely to differ a lot within countries (capital depreciation is assumed constant and technological growth is unobserved). Third, the adopted model is the one typically used to estimate the effect of inequality on growth (see e.g. Perotti 1996; Forbes, 2000; Halter et al 2014).

A3.3 Inequality, social mobility and human capital investment

74. This section further describes the data and methodology used to test the relevance of the human capital accumulation channel. It discusses several additional results not reported in the main text.

A3.3.1 Evidence from PIAAC: Data and empirical specification

75. The data are sourced from the OECD Programme for the International Assessment of Adult Competencies (PIAAC), a survey administered to representative samples of the working age (15-64) population in 24 OECD countries between 2010 and 2011 (for more details, see OECD, 2013). They include a rich battery of questions covering demographic characteristics (age, gender, place of residence, religion), working history, educational attainments as well as a direct measure of skill proficiency in three domains: literacy, numeracy, and problem solving in technology-rich environments. PIAAC measures each of the three skill domains on a 500-point scale. For each individual, the data therefore allow measuring educational outcomes both in terms of formal attainments (e.g. highest degree obtained) and in terms of actual skills (e.g. numeracy score). They also report the level of education and main occupation of parents, which allow constructing a measure of Parental Education Background (PEB). The variable is defined as follows. An individual is assigned a Low PEB if neither parent has attained upper secondary education; a Medium PEB if at least one parent has attained secondary and post-secondary, non-tertiary education; and a High PEB if at least one parent has attained tertiary education.

76. The main drawback of the survey is that it lacks variation over time. To gain such variation, the exercises will exploit differences in human capital attainments across age cohorts within a country. Individuals are pooled by 5-year age groups (indexed with *t*), and each group is assigned the measure of inequality in their country at the time they were aged between 10 and 14. For example, the exercise

[37] The data can be downloaded at http://www.barrolee.com/data/dataexp.htm

assumes that educational outcomes of individuals born in 1966-70 informs about schooling decisions taken around 1980. Hence, in the statistical analysis the outcomes of those individuals can be related to Ineq1980 Following this reasoning, outcomes of the cohorts (1966-70, 1971-75, …, 1991-95) were related to inequality measured in (1980, 1985, …, 2005). These latter years are captured by the index *t* in the estimated equation (2):

$$HC_{i,t,c} = \beta_1 \mathrm{PEB}_{i,t,c} * Ineq_{t,c} + \beta_2 \mathrm{PEB}_{i,t,c} + \theta \mathrm{X}_{i,t,c} + \mu_t + \mu_c + \epsilon_{i,t,c} \ .$$

77. The vector β_2 captures the degree of intergenerational persistence in educational outcomes *HC* (the "educational achievement gradient"), while β_1 measures whether such gradient varies with the extent of income inequality within a country. As mentioned, one advantage of (2) is that the relevant parameters in β_1 and β_2 can be estimated accounting for time-invariant country determinants that might bias cross-country estimates. This would be the case, for example, if inequality is correlated with the quality of the educational system, or with other policies and institutions that affect educational outcomes.

78. Clearly, the identification of the two parameters of interests hinges on several assumptions. One is that individuals (and their families) do actually take the relevant educational choices when aged around 14, so that, if it matters at all, inequality is appropriately measured. Another important assumption is that changes in country-level inequality between 5-year intervals are not driven by unobserved shocks that also affect attainments of individuals in subsequent cohorts. The relevance of this concern will be partially assessed in the empirical section, testing the robustness of the core results to controlling for country-specific trends in human capital achievements and inequality, and for occupation-specific and country-specific rates of skills depreciation, and allowing for country-year dummies to account for unobserved shocks that are specific to different country-cohort pairs (for example, shocks due to the introduction of country-specific educational policies affecting some but not all cohorts).

79. Other individual characteristics that are likely to be relevant for educational choice taken at earlier age are used as controls (in matrix *X*); these include gender, parents' immigration status, whether the individual speaks native- or foreign language and the region of residence. Proficiency scores in problem solving will be used as a proxy for individual ability. Because the exercise assumes a role for measured inequality in the country at earlier ages, individuals born abroad are excluded from the analysis.

A3.3.2. Inequality, background and educational attainments

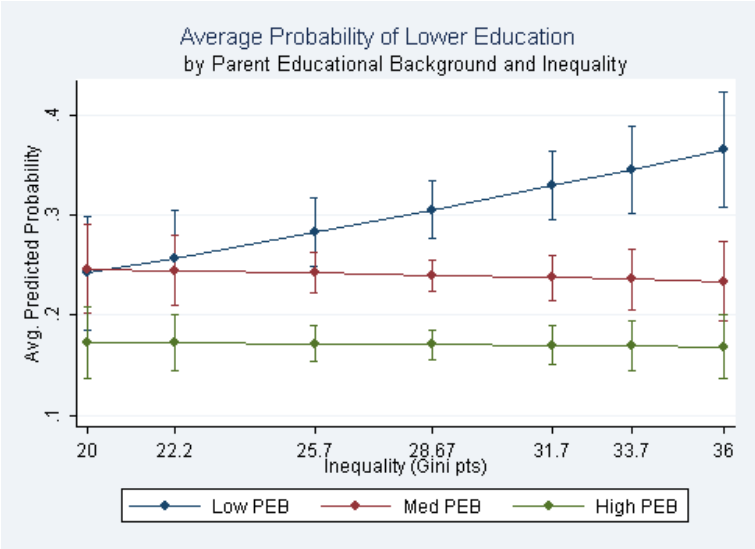
80. The link between inequality, familiar background and educational attainments is assessed in two complementary ways: estimating an ordered probit model for the highest level of formal education achieved, and estimating a linear regression for the number of completed years of schooling.

81. **Attainment probability**: in the case of the ordered probit, the dependent variable ($HC_{i,t,c} = EDU_{i,t,c}$) takes three ranked values: Low if the individual reports having attained less than lower secondary education, Medium in case of upper secondary education and High in case of tertiary education).[38]

[38] An ordered probit can be derived form a latent variable model $y^* = X\beta + \epsilon$ where y^* is unobserved and the error term is normally distributed. The latent continuous variable would in this application measure the individual propensity to achieve higher education. While this is unobserved, we assume that there exist threshold levels in the support of y^* that determine *observable* changes in education attainment. These cut points α_1 and α_2 are therefore such that y=Low if $y^*<\alpha_1$, y=Med if $\alpha_1<y^*<\alpha_2$, and y=High if $y^*>\alpha_2$. The parameters β and the cut points α can be estimated by maximum likelihood.

82. In this framework, the estimated parameters β_1 and β_2 allow predicting the average probability of achieving each educational level by parental education background *and* inequality level (i.e., at different levels of inequality). The main text shows that higher inequality lowers the probability of tertiary education by individuals from low background. Inequality is also associated to a significant increase in the probability that they attain at most lower secondary education (Figure A3.1). This probability is predicted to increase, on average, by nearly 5 percentage points (from 28.2% to 32.9%) following an interquartile (25th-75th) increase in inequality. However, there does not seem to be an association between inequality and the attainment probability of richer individuals.

Figure A3.1 Probability of lower secondary education (or less) by Parent Educational Background and inequality



Note: the graph reports the average predicted probability that individuals from poor, medium and high family (educational) background do not reach Upper secondary education, as a function of the degree of inequality (Gini points). Low PEB: neither parent has attained upper secondary education; Medium PEB: at least one parent has attained secondary and post-secondary, non-tertiary education; High PEB: at least one parent has attained tertiary education. Dotted lines represent baseline probabilities for each group. The bars indicate 95% confidence intervals. The values of the Gini index in the X-axis represent percentiles of the underlying distribution on inequality indexes. In particular the 25th (25.7), the median (28.67), and the 75th (31.7).

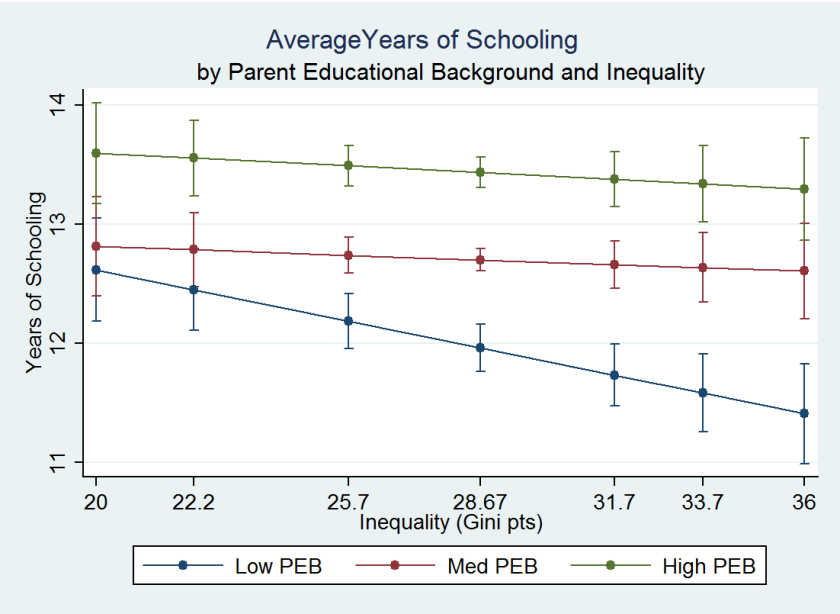
83. **Years of schooling:** A summary measure of the above mentioned changes in the level of formal education is given by the count of years of schooling (YS). Table A3.1 reports results obtained estimating (1) when $HC_{i,t,c} = YS_{i,t,c}$. Results in column 1 report the baseline estimates for the vector β_2, indicating that higher in inequality is negatively (and significantly) related to average schooling by low background individuals, while the link is not significant in the case of medium or high background individuals (as in the case of attainment probabilities).

84. The remaining columns correspond to alternative specifications of the control set *X*, which are detailed in the table note. Importantly, the results are robust to accounting for the country's level of development as a potential confounding factor (this is obtained in column 3, augmenting the specification by the interaction between PEB and the log of GDP in the country), and to accounting for possible underlying country-specific trends in inequality and educational achievements (col. 4). Finally, column 5 shows that the effects of inequality on schooling has a disproportionately higher impact on low background

individual relative to high background individual even controlling for the interaction between time (i.e. age cohort) and country dummies.[39]

85. To get a better understanding of the relevance of the estimated coefficients, Figure A3.2 reports the average predicted value of the number of years of schooling by educational background as a function of inequality, using the results from baseline specification (col. 1). According to these estimates, an interquartile (25th-75th) increase in inequality (around 6 Gini points) is associated to a decrease by almost 0.5 years of schooling by low background individuals. This represents more than 50% of the predicted schooling differential with individuals with medium family background.[40]

Figure A3.2 Years of schooling by Parent Educational Background and inequality level



Note: the graph plots the average predicted Average Years of Schooling for individuals from low, medium and high family (educational) background, as a function of the degree of inequality (Gini points) in the country. Marginal effects obtained using estimates in col.1 of Table 3. Low PEB: neither parent has attained upper secondary education; Medium PEB: at least one parent has attained secondary and post-secondary, non-tertiary education; High PEB: at least one parent has attained tertiary education. The bars indicate 95% confidence intervals. The values of the Gini index in the X-axis represent percentiles of the underlying distribution on inequality indexes. In particular the 25th (25.7), the median (28.67), and the 75th (31.7).

39 This flexible specification only allows determining the differential effects of inequality on schooling by PEB, and therefore does not allow to infer the consequences of inequality on overall education (i.e. on the absolute number of years of schooling of each group). However, comparing the results with the baseline regression is informative as to the relevance of potential biases from country-cohort specific confounding factors.

40 Estimating specification (2) allowing for nonlinear effects of inequality (e.g. interacting family background with a quadratic in inequality) reveals a similar overall picture, but suggests that the negative effects of increased income dispersion on education attainment are slightly stronger when inequality is below the median.

A3.3.3 Inequality, background and skills

86. One key element of PIAAC is the skill assessment exercise, consisting in a set of test questions organised into three domains: numeracy, literacy and problem solving.[41] The tests results are used to impute to each participant an indicator of skill proficiency, which is transformed into a scale ranging from 0 to 500. Hence, the survey offers the possibility to estimate model (1) using as dependent variable one of the available measures of skill proficiency. These are a potentially better measure of Human capital than standard indicators of the highest level of formal education attained. One obvious concern, however, is to what extent they actually reflect skills acquired while in education. On one hand, proficiency in literacy and numeracy as accumulated at school is likely to depreciate with age. On the other, skills measured later in life might not just reflect those accumulated at school. These concerns are somehow mitigated by the following considerations. First, if skill depreciation occurs at the same rate for individuals in different countries, its effect would be captured by the time (age cohort) dummies. In some specification this pattern is captured more flexibly allowing for occupation specific depreciation rates (to the extent that current occupation is a good proxy of the average occupation during the working life). More importantly, the specification allows controlling for age-cohort*country dummies, thus accounting for country-specific rates of depreciation.[42]

87. Finally, previous works focusing on the consequences of job-specific training on skills as measured by PIAAC did not find any significant relation, suggesting that they largely reflect those accumulated while studying (OECD, 2014 – Employment outlook).

88. **Numeracy score:** Table A3.2 reports the coefficients obtained when estimating (1) using numeracy scores as a measure of individual skills. Results in column 1 report the baseline estimates for the vector β_2, indicating that higher in inequality is negatively (and significantly) related to proficiency by low background individuals, while the link is not significant in the case of medium or high background individuals. The remaining columns correspond to alternative specifications of the control set X, which are detailed in the table note. In particular, the core results are unaffected by controlling for country-specific trends in human capital achievements and inequality, and for occupation-specific and country-specific rates of depreciation (cols. 4-6). Allowing for country-year dummies implies, in particular, that the specification in col. 6 also accounts for unobserved characteristics that are specific to different country-cohort pairs (for example, due to the introduction of country-specific educational policies affecting some but not all cohorts).

89. The above findings are robust, albeit slightly lower in magnitude, to conditioning the estimates on the actual level of education attained (col. 7). This amounts to comparing individuals with different backgrounds but having attained the same degree, therefore insulating the estimates from the negative consequences of inequality on education attainments. The results suggest that at least part of the lower proficiency by low PEB might be due to a worse "quality" of the educational track (e.g. they attended worse quality schools/universities) or to a lower amount of effort (e.g. had less time to devote to studying).

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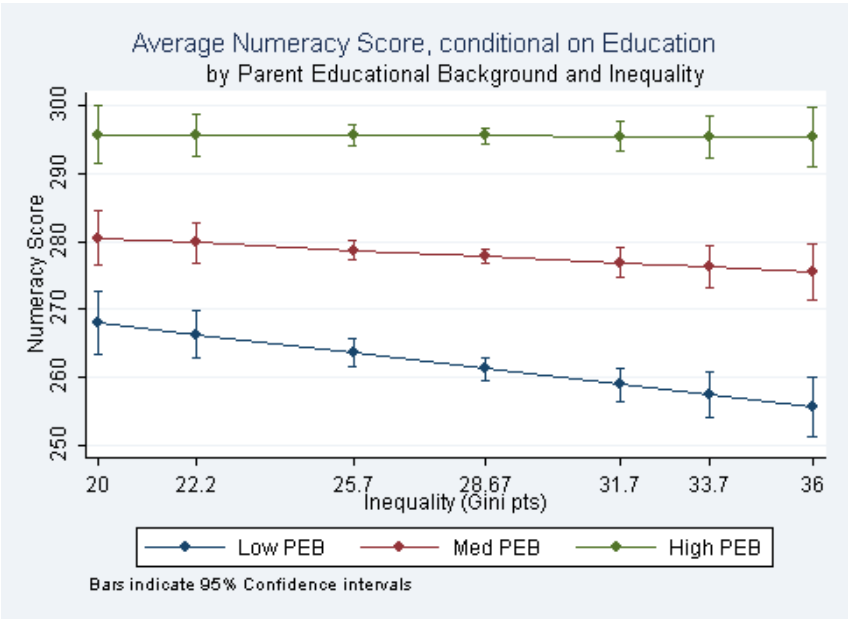
41 Problem solving can only be taken on computers and those who refuse or cannot use a PC are excluded. As a consequence, the number of missing values in problem solving is relatively high in many countries (on average about 10% across all participating countries but up to over 20% in some).

42 Because inequality varies at the country-year level, this specification only allows estimating its differential effect on average skills by PEB group. For example, it allows determining whether increasing inequality lowers skills by low relative to high PEB individuals. It does not identify, however, the consequences of inequality on overall skill proficiency (i.e. on the absolute level of skills on the high PEB individuals). However, comparing the results with the baseline regression is informative as to the relevance of potential biases from country-specific depreciation rates.

Finally, the core results are robust to accounting for proxy of unobserved individual ability (cols. 8 and 9). Following (OECD, 2014 – Employment outlook) such proxy is represented by cognitive skill variables as measured in PIAAC.

90. The main text shows that higher inequality lowers numeracy scores based on the results from the baseline specification (col. 1). Figure A3.3 plots the average predicted numeracy score by educational background using the specification in col. 6, which conditions the estimates on the actual level of education attained. It therefore shows that, even when they are compared with higher backgrounds individuals having obtained the same degree, low background individuals see their skills decrease with inequality (albeit at a slower pace than in the unconditional case). This suggests that part of their lower proficiency can be traced to a worse "quality" of the educational track (e.g. they attended worse quality schools/universities) or to a lower amount of effort (e.g. had less time to devote to studying).

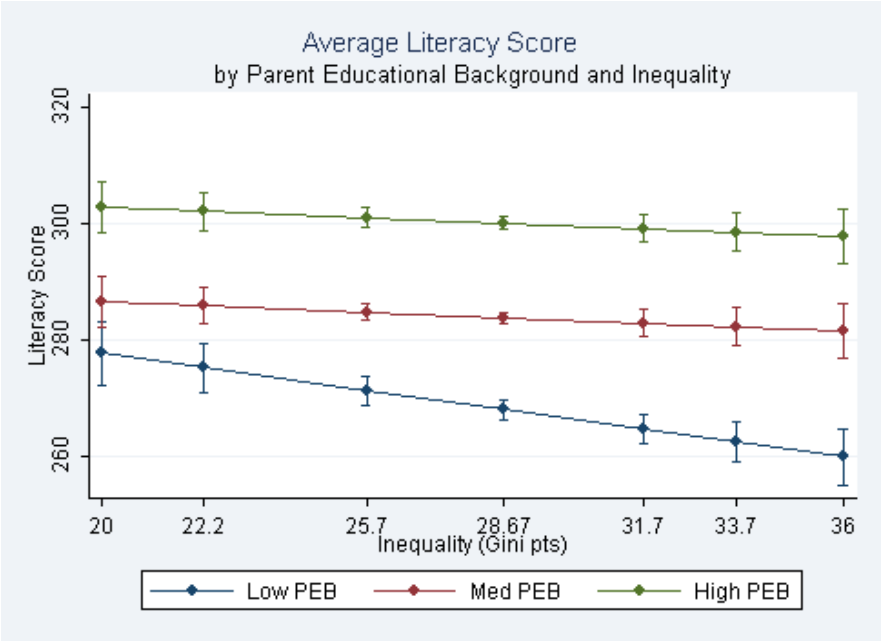
Figure A3.3 Numeracy scores, Family background and Inequality



Note: the graph plots the average predicted numeracy score for individuals from low, medium and high family (educational) background, as a function of the degree of inequality (Gini points) in the country at the time they were around 14 years old. Marginal effects obtained using estimates in Table A3.2, col. 7 (i.e. conditioning the degree of formal education). Low PEB: neither parent has attained upper secondary education; Medium PEB: at least one parent has attained secondary and post-secondary, non-tertiary education; High PEB: at least one parent has attained tertiary education. Dotted lines represent baseline probabilities for each group. The bars indicate 95% confidence intervals. The values of the Gini index in the X-axis represent percentiles of the underlying distribution on inequality indexes. In particular the 25th (25.7), the median (28.67), and the 75th (31.7).

91. **Literacy score:** Table A3.3 reports the coefficients obtained when estimating (1) using literacy scores as a measure of individual skills. Figure A3.4 reports the average predicted literacy score by educational background as a function of inequality, using the baseline specification (col. 1). The results are very similar to those discussed in the case of numeracy. An interquartile (25th-75th) increase in inequality is associated to a lower literacy score of low background individuals by slightly less than 7 points. For comparison, the average predicted differential in literacy score with the Medium PEB group amounts to 15 points.

Figure A3.4 Literacy scores, Family background and Inequality



Note: the graph plots the average predicted Literacy score for individuals from poor, medium and high family (educational) background, as a function of the degree of inequality (Gini points) at the time they were around 14 years old. Low PEB: neither parent has attained upper secondary education; Medium PEB: at least one parent has attained secondary and post-secondary, non-tertiary education; High PEB: at least one parent has attained tertiary education. The bars indicate 95% confidence intervals. The values of the Gini index in the X-axis represent percentiles of the underlying distribution on inequality indexes. In particular the 25th (25.7), the median (28.67), and the 75th (31.7).

92. As in the case of growth regressions, these findings seem more supportive of the "opportunity" than the "incentive" arguments raised to explain the sources of the inequality-growth nexus. If higher inequality (e.g. a higher skill wage premium) increased the incentives to invest in education, this should be reflected in increased attainments by at least part of the population. Finding that these are in fact lowered, and that this only happens to the poor, signals that income availability significantly determines the opportunities of education and social mobility.

93. One interesting extension of this exercise consists in checking whether the strength of the link between inequality and educational attainments varies with countries' institutional characteristics or policy setting. This could help shed light on the potential role of policies in offsetting the adverse long-run consequences of widening inequality. The characteristics of education systems and the effectiveness of educational expenditure in levelling the playing field would be examples for capturing such policies.

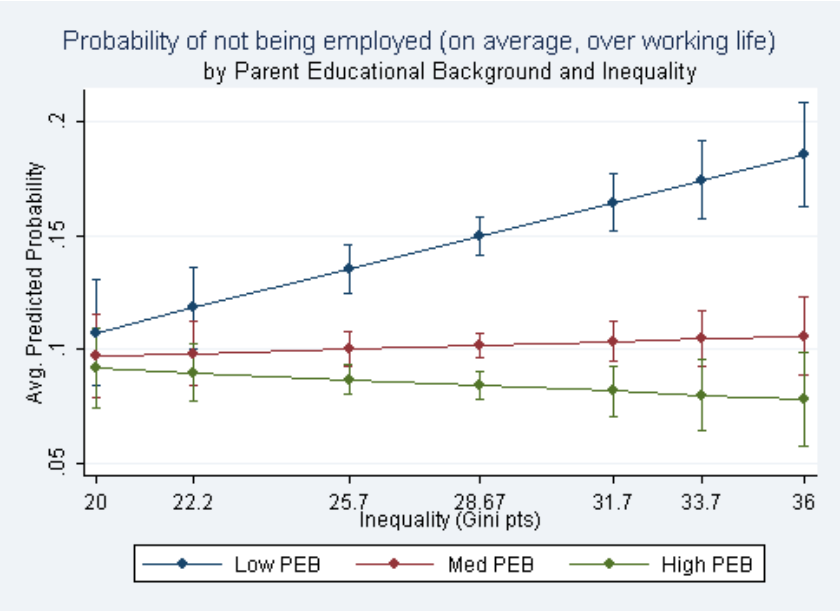
94. OECD countries can be sorted in terms of the private costs of tertiary education exploiting indicator B5 of *Education at Glance*, which captures two dimensions: the costs of tuition and the fraction of students benefitting from public grants (see OECD, 2012). One would expect that the both the degree of intergenerational persistence in education (i.e. the distances between average attainments of High, Medium and Poor PEB individuals) and their sensitivity to inequality to be lower in countries with low costs education (i.e. those with low tuition fees and/or high scholarships availability). In fact, this simple hypothesis is not confirmed by the data, with the corresponding exercise providing inconclusive results. Similar findings are obtained distinguishing countries based on the differences in the distributive impact of Education. The metrics for such classifications were alternative ad-hoc indicators computed in "*Divided we stand*" (chapter 8) such as the income increasing effect of benefits from public education services for the bottom quintiles of the distribution, or the change in the Gini coefficients when the redistributive impact of education is accounted for.

A3.3.4 Inequality, family background and employment probability

95. The information available in PIAAC also allows studying the link between inequality, family background and employment outcomes. In particular, each individual is asked to report the number of years spent in paid employment (experience), and the number of years since she left the educational system (potential experience). This information allows computing the fraction of time spent out of employment (a measure of the probability of not being employed) over the working life.

96. Figure A3.5 reports the average predicted probabilities of not being employed since entry in the labour market for the three groups (Low, Medium and High PEB). According to the estimated coefficients, an interquartile (25th-75th) increase in inequality (6 Gini points) increases by around 3 percentage points the average probability of not being employed of individuals from low background. For comparison, their baseline average predicted probability of not being employed is close to 15%, nearly 5 and 7 points higher than that of individuals from Medium and High PEB, respectively. The graphs again show that the corresponding probabilities for these two latter categories are not affected by inequality.

Figure A3.5 Probability of not being employed over working life



Note: the graph reports the average probability that individuals in each group had *not* been employed between the date they left education and the day of the interview. For each individual, this probability is obtained as follow. First, compute potential experience (PExp) as the difference between the year they left education and that of the interview. Second, compute the difference between potential and actual experience (PExp-Exp). Finally, compute the probability of *not* being employed as NEmp = (PExp - Exp)/PExp. Low PEB: neither parent has attained upper secondary education; Medium PEB: at least one parent has attained secondary and post-secondary, non-tertiary education; High PEB: at least one parent has attained tertiary education. The bars indicate 95% confidence intervals. The values of the Gini index in the X-axis represent percentiles of the underlying distribution on inequality indexes. In particular the 25th (25.7), the median (28.67), and the 75th (31.7).

97. Consistent with this finding, unreported results show that inequality also has a differential impact on the probability of being unemployed at the date of interview, which increases with inequality for Low PEB individuals. The estimates imply that an interquartile (25th-75th) increase in inequality (6 Gini points) raises the average probability of unemployment of individuals from low background by around 3 percentage points. For comparison, their baseline probability of unemployment is around 10%.

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Table A3.1 Years of schooling, Family background and Inequality

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
VARIABLES	Baseline	Ind. ctrls	GDP*PEB dummies	Ctry spec trend	Ctry*year dummy
Ineq X Low PEB	-0.076***	-0.061***	-0.095***	-0.061*	-0.043*
	(0.024)	(0.021)	(0.022)	(0.034)	(0.022)
Ineq X Med. PEB	-0.013	0.004	-0.024	-0.010	0.010
	(0.025)	(0.023)	(0.024)	(0.036)	(0.013)
Ineq X High PEB	-0.019	-0.002	-0.024	-0.019	Ref.
	(0.026)	(0.024)	(0.025)	(0.038)	-
Observations	64,562	64,562	62,315	64,562	64,562
R-squared	0.343	0.390	0.352	0.351	0.360

Note: The dependent variable is the number of years of schooling. All regressions control for Family Background (high/med./low), country and year (age-cohort) dummies. Col.2: Add individual controls (age, gender, region, language, and parents' birthplace). Col. 3: Add the interaction between PEB and Average GDP per capita. Col.4: Adds a country specific trend. Col.5: controls for the interaction country*year (age-cohort) dummies. Cluster adjusted (country*age cohort) standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3.2 Numeracy scores, Family background and Inequality

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
VARIABLES	Baseline	Ind. ctrls	GDP*PEB dummies	Skills depr.	Ctry spec trend	Ctry*year dummy	Formal Education	Ability	Ability & Educ
Ineq X Low PEB	-1.077***	-1.004***	-1.034***	-1.051***	-1.006***	-0.997***	-0.773***	-0.485**	-0.472**
	(0.304)	(0.293)	(0.258)	(0.284)	(0.283)	(0.259)	(0.263)	(0.195)	(0.181)
Ineq X Med. PEB	-0.244	-0.148	-0.141	-0.310	-0.287	-0.271*	-0.307	-0.076	-0.123
	(0.267)	(0.260)	(0.228)	(0.246)	(0.251)	(0.142)	(0.250)	(0.163)	(0.149)
Ineq X High PEB	-0.008	0.057	0.147	-0.005	-0.010	Ref.	-0.024	0.088	0.057
	(0.275)	(0.269)	(0.244)	(0.260)	(0.274)	-	(0.260)	(0.179)	(0.167)
Observations	65,500	65,500	63,253	65,500	65,500	65,500	65,485	51,560	51,547
R-squared	0.177	0.195	0.184	0.250	0.182	0.185	0.285	0.679	0.688

Note: The dependent variable is PIAAC Numeracy score. All regressions control for Family Background (high/med./low), country and year (age-cohort) dummies. Col.2: Add individual controls (age, gender, region, language, and parents' birthplace). Col. 3: Add the interaction between PEB and Average GDP per capita. Col.4: Skills depreciation columns include interactions of age-cohort*occupation (2-digit classification). Col.5: Adds a country specific trend. Col.6: controls for the interaction country*year (age-cohort) dummies. Col 7: accounts for education (3-group dummy). Col. 8: includes problem-solving score (when >0) as a proxy for ability. Col.9: includes both education and ability. Cluster adjusted (country*age cohort) standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A3.3 Literacy scores, Family background and Inequality

	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
VARIABLES	Baseline	Ind. ctrls	GDP*PEB dummies	Skills depr.	Ctry spec trend	Ctry*year dummy	Education	Ability	Ability & Educ
Ineq X Low PEB	-1.110***	-1.013***	-0.996***	-1.073***	-0.795***	-0.780***	-0.843***	-0.510***	-0.503***
	(0.300)	(0.294)	(0.248)	(0.270)	(0.231)	(0.216)	(0.265)	(0.169)	(0.169)
Ineq X Med. PEB	-0.306	-0.210	-0.138	-0.384	-0.081	-0.059	-0.366	-0.125	-0.171
	(0.277)	(0.272)	(0.229)	(0.253)	(0.208)	(0.116)	(0.266)	(0.159)	(0.167)
Ineq X High PEB	-0.312	-0.227	-0.084	-0.305	-0.032	Ref.	-0.326	-0.190	-0.216
	(0.275)	(0.269)	(0.240)	(0.255)	(0.227)	-	(0.269)	(0.159)	(0.169)
Observations	65,500	65,500	63,253	65,500	65,500	65,500	65,485	51,560	51,547
R-squared	0.174	0.180	0.181	0.252	0.181	0.184	0.287	0.718	0.727

Note: The dependent variable is PIAAC Literacy score. All regressions control for Family Background (high/med./low), country and year (age-cohort) dummies. Col.2: Add individual controls (age, gender, region, language, and parents' birthplace). Col. 3: Add the interaction between PEB and Average GDP per capita. Col.4: Skills depreciation columns include interactions of age-cohort*occupation (2-digit classification). Col.5: Adds a country specific trend. Col.6: controls for the interaction country*year (age-cohort) dummies. Col 7: accounts for education (3-group dummy). Col. 8: includes problem-solving score (when >0) as a proxy for ability. Col.9: includes both education and ability. Cluster adjusted (country*age cohort) standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

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