Examining the impact of educational reforms on schooling and competences in PIAAC

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1. Introduction

Recent surveys on cognitive skills show that competences are positively correlated with schooling and parental background. However, the institutional differences across countries mediate the relationship between these variables, thus affecting the degree of inequality in the distribution of competences as well as the gradient of competences on employment probability and earnings. We intend to exploit existing datasets to explore the association between alternative measures of human capital and the institutional framework characterising different countries. Our main finding is that institutional changes that induce more schooling in the population are associated to higher level of cognitive competences (namely literacy and numeracy), even taking into account their demographic and social origins. Besides effects on educational inequalities among the cohorts affected, educational reforms may also exert intergenerational effects and change the educational distribution among future generations. Jerrim and MacMillan (2015) using cross-country data argue that educational attainment of the parents is among the main factors of intergenerational mobility and that income inequality plays an important role for the transmission of advantage from parents to children. However, research exploiting the staggered roll-out of educational reforms within countries finds little intergenerational impact of reform-induced increases of parental education (Black et al, 2005; Oreopolous et al, 2006). In our setting we can not explore intergenerational issues as the intergenerational educational process is only measured with respect to schooling and does not report information on competences in the parent generation.

Two main caveats are in order before presenting our results. The first one is the choice of the outcome variables. While there is a large literature on the effect of institutions on schooling, either measured by years of schooling or by the share of population attaining a specific degree, there is more limited evidence on their effect on competences, mainly obtained by student surveys (Hanushek and Woessman 2011). Very little is known about whether reforms are correlated to competences in the adult population. Hanushek et al. (2015) show that adult competences are a better measure of human capital, being correlated to individual earning and providing a larger explanatory power than schooling. Cappellari et al. (2017) discuss the potential endogeneity of both schooling and competences: when using reforms as instruments, they show that schooling affect wages via numerical skills.

The second caveat is the definition and measurement of what is generally classified as educational reform. OECD (2019) provides a comprehensive analysis of the recent policy discourse in the educational debate, which is mostly focused on responsibility division among institutional layers.[1] More generally, it is quite difficult to determine the boundaries of what the term "educational reform" includes. Some reforms are easy to define (for example, raising the years of compulsory schooling) and to measure in their impact (for the same example, measuring the fraction of compliant students). Other reforms are more difficult to define (for example, raising the qualification requirement of teachers) and even harder to measure (for the same example, measuring

[1] OECD (2019) collects education policy priorities by official document reading and by interviewing relevant actors. From the evidence collected in the report, three priorities appear more prevalent among the review of OECD countries:
a) tackling unclear or unbalanced division of responsibility between national and local authorities and schools (indicated in 32 national education system reviews)
b) improving teacher qualifications, skills and training (31 national education system reviews)
c) defining national education priorities and goals (27 education systems).

the fraction of compliant teachers), especially when the final outcome is unspecified by the policy makers, who often use vague terms like "improving the quality of education".

In this chapter, we try to address both issues, providing evidence on the association between reforming activities of governments, and educational outcomes in the adult population. The reforming activities of governments is captured by collecting information on institutional changes, as already done in Braga et al (2013) and Braga et al (2020). The next section discusses the advantages and limits of such approach. The educational attainment in the adult population is obtained from the survey microdata of the Programme for the International Assessment of Adult Competencies (PIAAC; OECD 2013) and is measured by two alternative indicators: years of schooling (for most countries derived from the highest educational attainment), and numeracy (measured by the scores of survey respondents in cognitive tests). The third section describes our outcome variables and discusses the matching of individual data with the reform timing. The fourth section discusses the association between reforms and outcomes and the fifth section concludes.

2. Educational reforms

As measure of educational reforms, we exploit the dataset created by Braga et al (2013). The dataset is built by identifying all policy interventions occurred in Europe over the last century (1929-2000). The reforms affect various dimensions of education, covering pre-primary education, expansion of compulsory education and comprehensiveness, teachers' qualification, school autonomy and accountability, university autonomy and selectivity and students' funding. While it is generally possible to identify the "sign" of the reform (whether it is inclusive or exclusive, i.e. augmenting or reducing school participation), it is impossible to assess the impact of each reform, since the size and/or the coverage are often unknown in the original source (mostly various issues of the Eurydice annual report). By counting the number and the orientation of reforming activity one can infer the goals of the policy maker, without being able to identify his/her effectiveness. We take the degree of activism in policy making as indicative of the orientation of governments, a sort of revealed preference approach.[2] In addition, we can also consider the sign, because the original database classifies with a positive sign inclusive policies, and with a negative sign policies that were restricting the access to schooling.

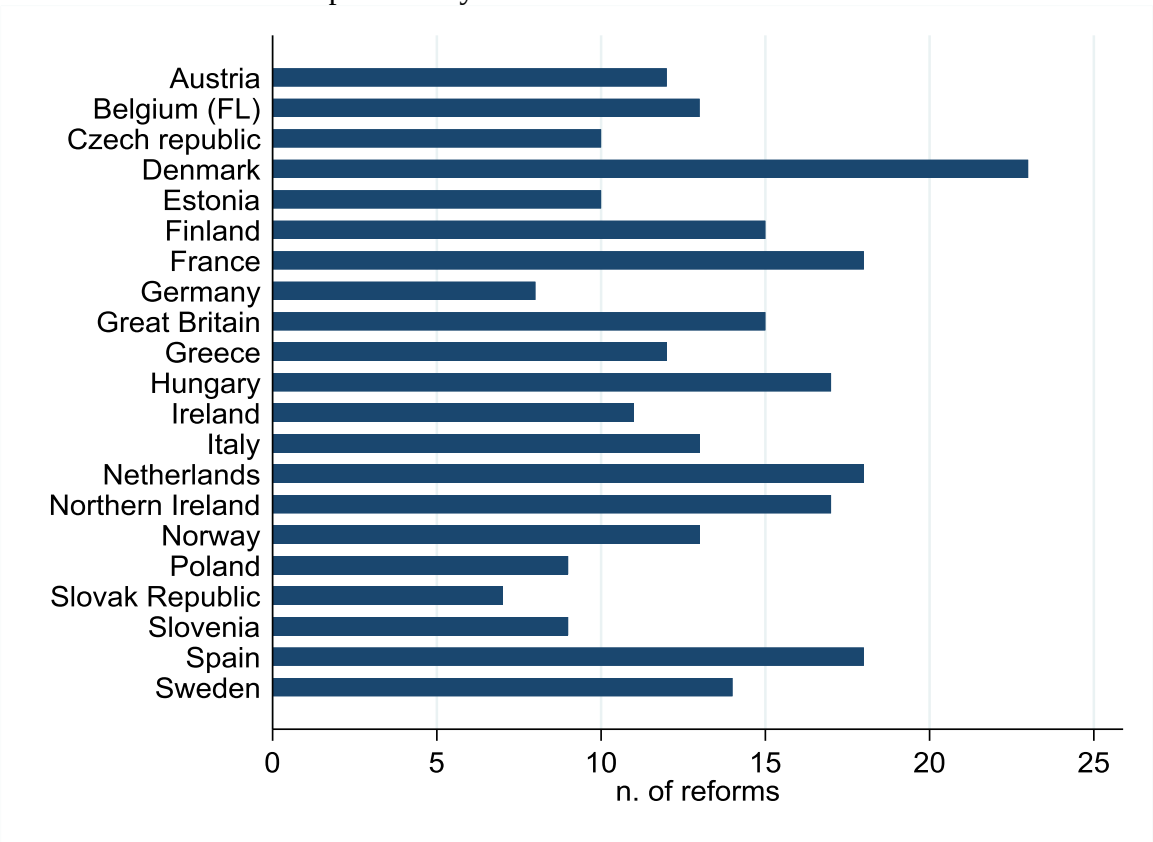
In Braga et al (2013), these reform indicators were matched to various waves of different datasets in order to increase the precision of estimated impact on the distribution of years of schooling.[3] On the contrary, in the present chapter we match the indicators to a unique cross-section collected in 2012, interpreted as a pseudo-panel. In Figure 1, we plot the countries available in PIAAC for which we have information on reforming activity in education. The graph shows that some countries (like Denmark) were more active than other (notably Germany and Slovakia) in repeatedly modifying their educational systems. More illuminating is Figure 2, showing the interventions by domain of action, where we can observe that the two most impacted areas are the duration of compulsory education and the regulation of university autonomy, even though the latter regulation waves typically occurred later in time. Teachers' qualification is also a frequent domain of intervention, while student financing at tertiary level remains in the background (not surprisingly, since in the European context most universities are public and almost free). Finally, in Figure 3, we group reforms by stages of education, separating compulsory (primary and secondary plus pre-primary, which is compulsory in few cases) from non-compulsory (tertiary education). This graph confirms

[2] An alternative (and opposite) interpretation could consider the fragmentation of policy action, due to government instability. However these indices are built over a large sample of countries and years, thus making this hypothesis less reliable.

[3] Braga et al (2013) include the European Social Survey (ESS), European Union Statistics on Income and Living Conditions (EUSILC), the International Adult Literacy Survey (IALS) and International Social Survey Programme (ISSP).

that more active countries in reforming their educational systems (notably the Nordic countries and the Netherlands) were such in all domains.

Figure 1 – Number of reforms per country



Notes: only "expansionary" reforms (i.e., in a positive direction) matched to PIAAC cohorts

Figure 2 - Number of reforms by area of intervention

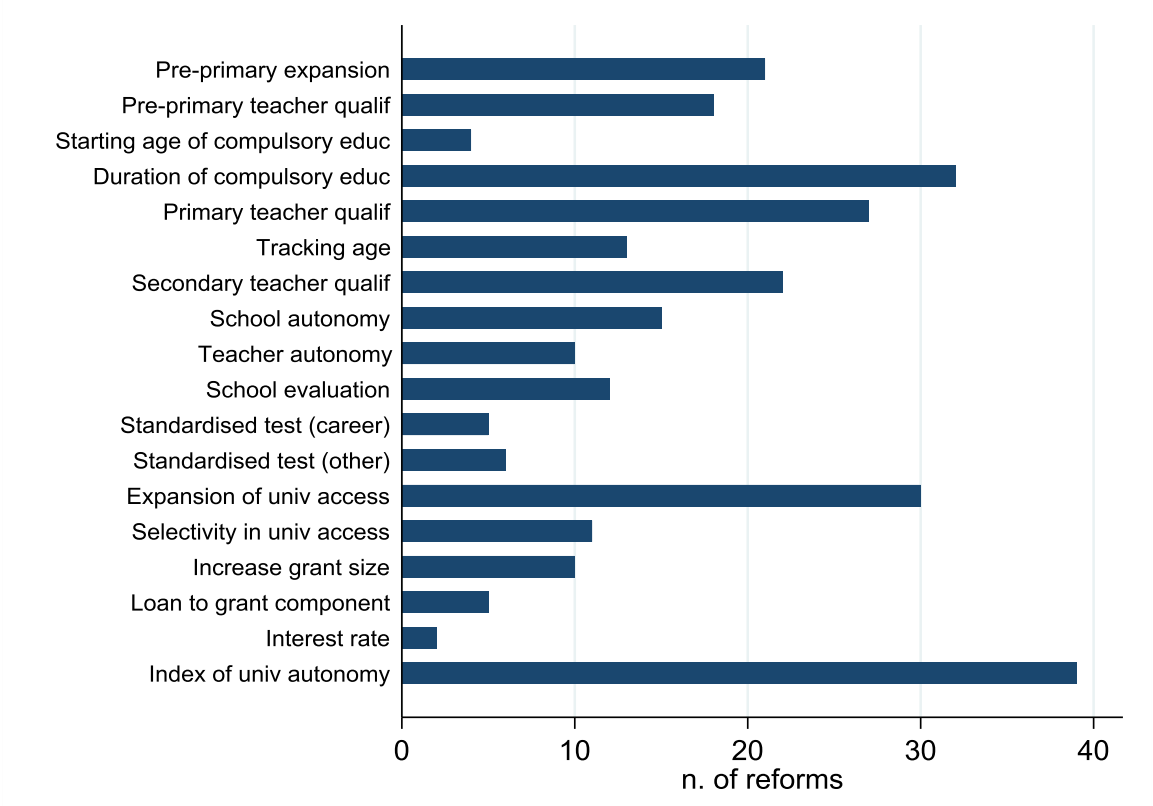
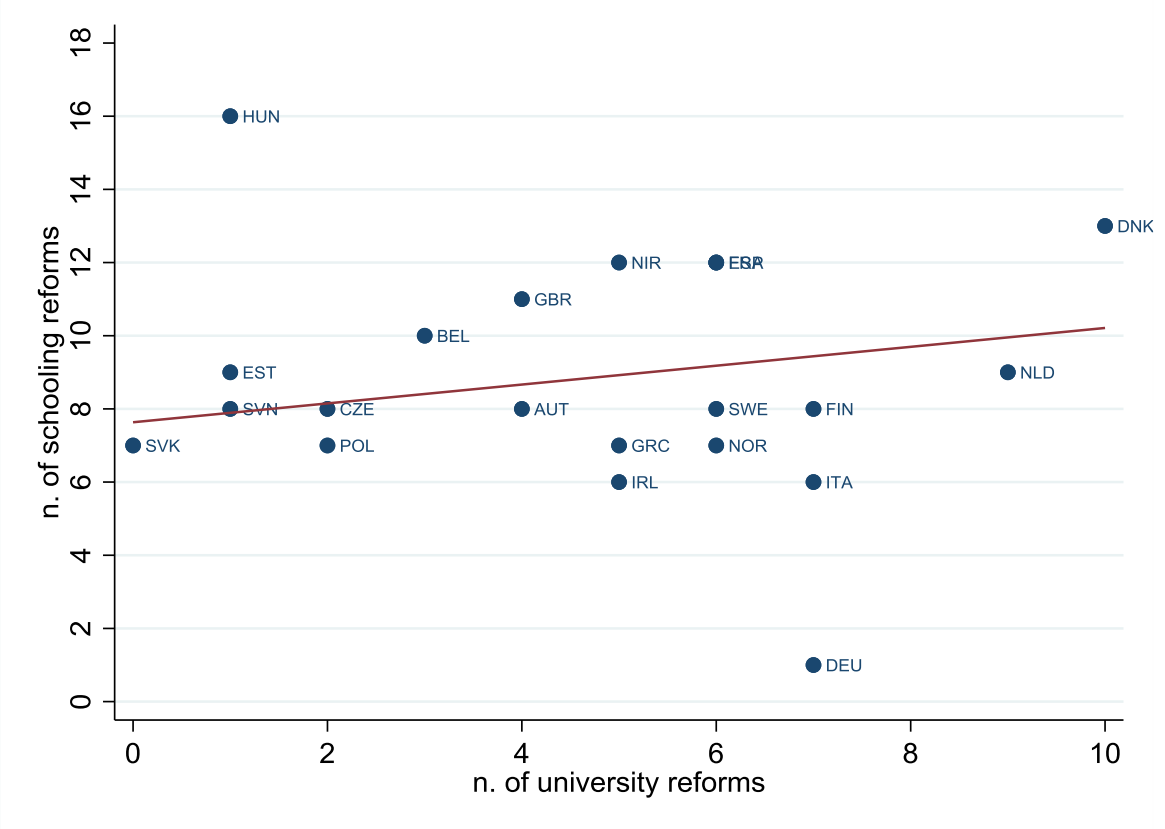


Figure 3 – Activism of countries in the main areas of education



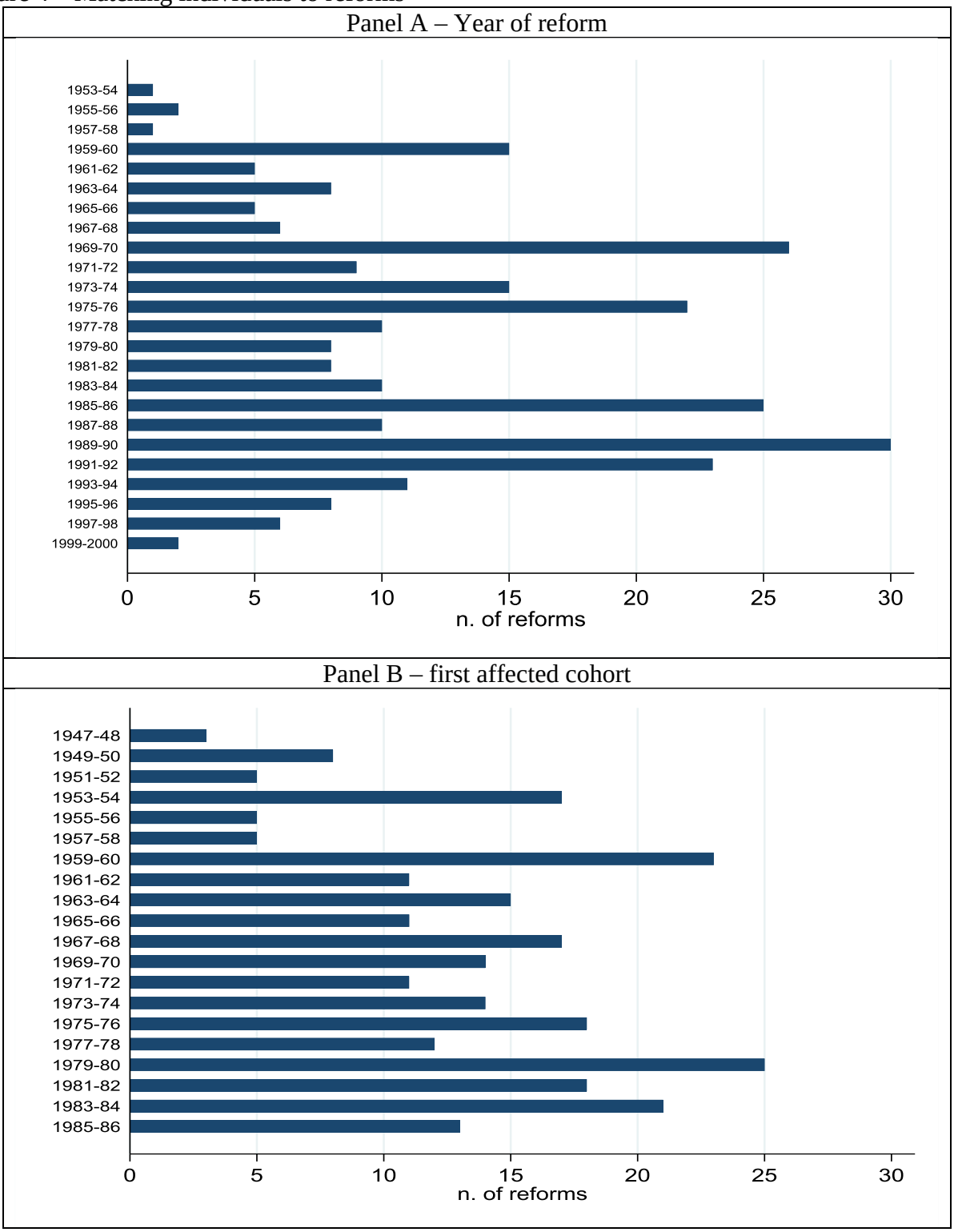
Note: linear fit excludes outliers (Hungary and Germany)

The timing of the reforms varies over the last century, as it can be grasped from panel A of Figure 4. We can identify two clear waves of educational reformism, one occurred under the pressure of student protest at the end of the '60s, and a second one occurred under the pressure of budget cuts and/or transition to market economies occurred during the '90s. However, the timing of the reform does not necessarily coincides with the distribution of the affected birth cohorts. Once again following Braga et al (2013), we assume that the each reform hit the cohort born n years earlier, where $n = 3$ for pre-primary, $n = 6$ for primary, $n = 10$ for secondary and $n = 15$ for tertiary (in order to account for anticipation and expectation effects).[4] This is our main identification assumption for understanding the impact of reforms on outcomes, consisting in the idea that two adjacent birth cohorts experience almost identical environments and only differ in their exposure to a specific reform: in facts cohorts born in country i in year t are confronted with cohorts born in the same country in year $t + 1$, and not with cohorts born in country j in year t.

The distribution of the relevant populations by birth cohorts and number of reforms experienced is given by panel B of Figure 4. It shows that earlier cohorts experienced a rather stable institutional environment up to the end of the baby-boom generation, after which reforming the educational systems became widespread. The generation born one decade later (1979-80) were the most affected by the activism of governments.

[4] In other words, a reform fostering the university enrolment introduced in 1968 is assumed to affect all cohorts born after 1953, and so on.

Figure 4 – Matching individuals to reforms



3. Individual educational outcomes

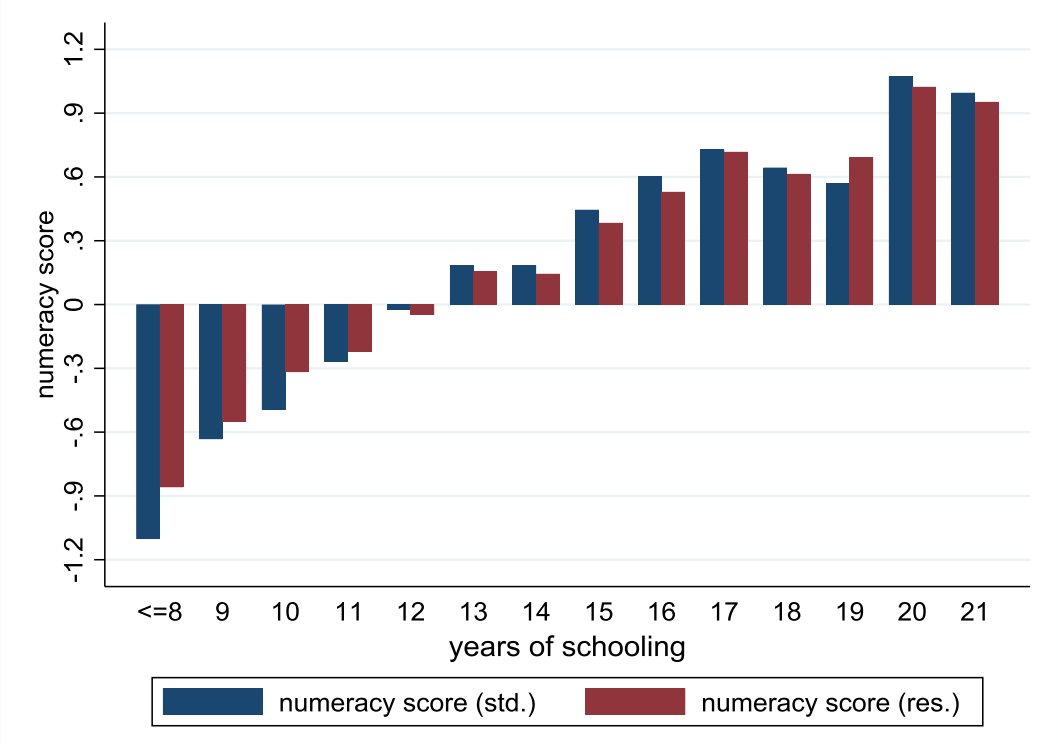
The PIAAC survey rounds we consider were conducted between 2011 (1st round) and 2017 (3rd round) in 39 countries (34 OECD member countries and 5 partner countries). The survey measures adults' proficiency in key information-processing skills -literacy, numeracy, and problem solving - and gathers information on their family background and educational careers. In what follows, we

focus our attention on numeracy; evidence on other dimensions of cognitive ability, such as literacy, goes in the same direction of the one discussed below.

We are interested in assessing whether and which of these reforms were effective in:
a) raising individual schooling,
b) improving cognitive competences,
since these two variables capture different dimensions of individual human capital. There are other dimensions (like technological ablities, problem solving or non-cognitive skills) that could be investigated, but unfortunatey information on these dimensions is scattered and not available for all countries. By matching existing survey data with our measures of educational reforms, we identify 21 countries (those reported in Figure 1) for which we select the population aged between 25 and 65.

There are some problems when using raw values of these variables that need to be accounted for. The first issue is that years of schooling are a time invariant measure, while cognitive skills decline with age. As a consequence, when using a single cross-section, one should control for the effect of individual age on skills.[5] In addition, years of schooling and cognitive skills are positively correlated, but causation may go in both directions: more educated individuals possess a higher level of competences, but also smarter (and more competent) individuals may stay in schools longer.[6]

Figure 5 – Numeracy by years of schooling, with and without demographic controls



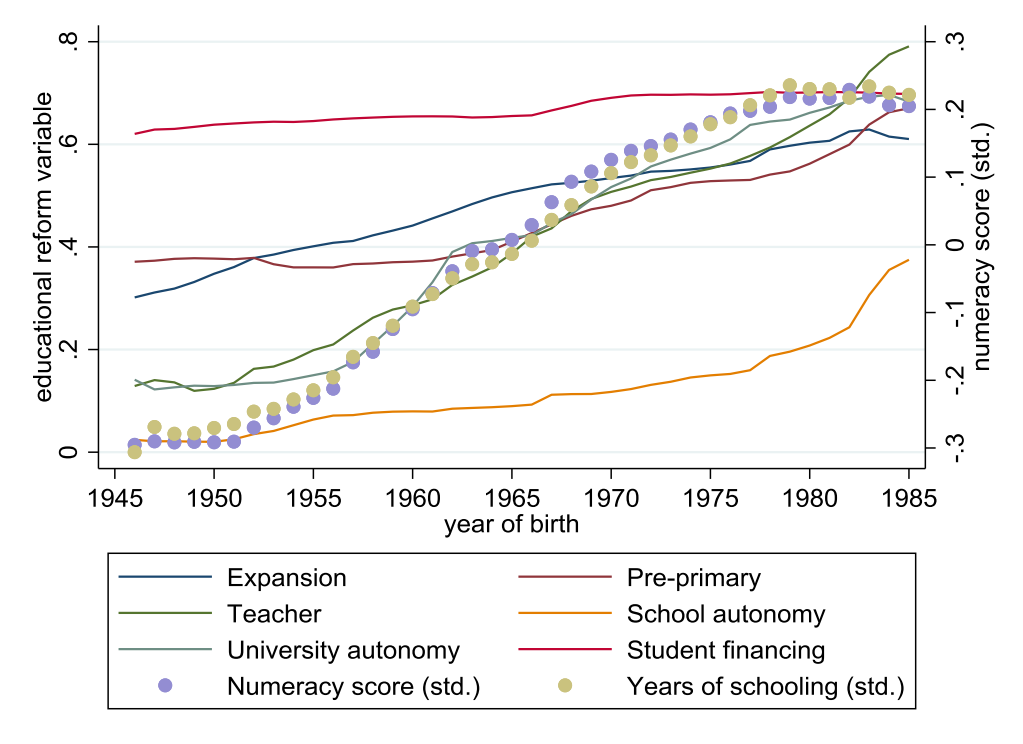
We look at the relationship between the human capital variables in Figure 5. The idea behind this exercise is that there exists a "structural" relationship between education and numeracy, such as education increases (in a causal sense) the numerical competences in the population. The structural

[5] The simplest way to "clean" the effect on age on cognitive skills is regressing individual competences on age and age square, and take the residual of such regression

[6] Using the same dataset, Cappellari et al (2017) claim the existence of a recursive structure, where reforms affect schooling, which raises cognitive skills, that cause higher earnings.

mechanisms stems from the fact that by staying longer at school individuals learn more and improve their skills. There are two alternative (and non-causal) interpretations that may well account for a positive gradient of numeracy with schooling. First, individuals may be characterised by a heterogeneous degree of intrinsic ability, which co-determines education and competences. The positive gradient would then just be a reflection of intrinsic ability. Second, younger individuals could be characterised by higher education (due to upward secular trends in education) and higher numeracy (due to age related decay in numeracy). In this event, the positive gradient would just be an age effect. Disentangling between causal and non-causal interpretations is beyond the scope of this chapter. Still, it is interesting to verify how strong the association between the two variables is. Indeed the graph indicates the existence of a strong association between the two variables. Also, the gradient is virtually unaffected by considering numeracy after correcting it for age effects,[7] which suggests that the uncovered correlation is not just an artifact of differences in human capital between age groups. Finally it is worth noting how the gradient is not constant along the educational distribution, but there is a jump in numerical competences among individuals who have attained a PhD, corresponding to 20 years of schooling or more.

Figure 6 – Reform summary indices



Note: all series plotted are 5-year moving averages

Eventually, schooling is permanent but increases over birth cohorts, as a consequence of increasing scholarisation in the population, and this may introduce spurious correlation between reforming activity and education. In Figure 6, we consider the historical evolution of educational reforms and the trends in human capital accumulation. To achieve this, we plot 5-year moving averages of both reform indicators (grouped by domain of intervention) and human capital indicators by birth cohorts. The left axis measures cumulated reform intensity on a 0-1 scale, while the right axis reports human capital variables (years of schooling and numeracy) measured in standard deviation

[7] The blue bar reports the standardised values of numeracy (i.e. after subtracting its mean and dividing by the standard deviation, in order to have a new variable with zero mean and unitary standard deviation), while the red bar exhibits the residuals from a regression over age, age squared, and country fixed effects.

units.[8] Looking first at the human capital variables, we can appreciate the remarkable increase that has occurred throughout the post-World War II era. This evolution takes on a logistic shape, with a slow increase in the first ten years, an acceleration in the baby boomers cohorts and a final slow down phase for the cohorts born after the mid-1970s. Interestingly, the pattern is very similar across the two human capital variables considered. However, while for years of education the pattern can be clearly interpreted as an upper trend in attainment, for numeracy an interpretation based on a (negative) logistic decay with age may well account for the evidence. Upward trends over birth cohorts also characterise the reform indices in general, but the slope is not as steep as for the human capital variables, which suggest that reforms alone cannot explain the increase in average attainment over the period. Behavioral factors such as peer effects and intergenerational spillovers may have reinforced an amplified the institutional impulse.

4. The effects of educational reforms

The evidence depicted in Figure 6 suggests the existence of positive association between reforming activity of government and educational attainment in the population. Before investigating this association in greater details, we would like to make clear that we cannot claim pure causation going from reform to education, since reforms could have been introduced as a policy response to behavior already observed in the relevant population. Consider for example an increase in the years of compulsory education. This typically occurred under the pressure of teachers and opinion leaders, in a situation where a fraction of students was already compliant (and therefore unaffected by the reform), while the treated would be the students that would have not continued to stay in school had not it been made compulsory. However, such a clear-cut situation does not always exist, and the beneficiaries of the reforms are not always easy to identify. In the absence of (clearly detectable) exogenous variations in the policy stance of governments, and without the possibility to restrict the set of potentially treated students, we limit ourselves to claim the existence of association between reforms and educational attainment, both at the mean of the distribution as well as in its dispersion. Our presumption is that a reform raising the mean and reducing the dispersion in the outcome variables is effective in including more individuals in the social and economic dimensions of life.

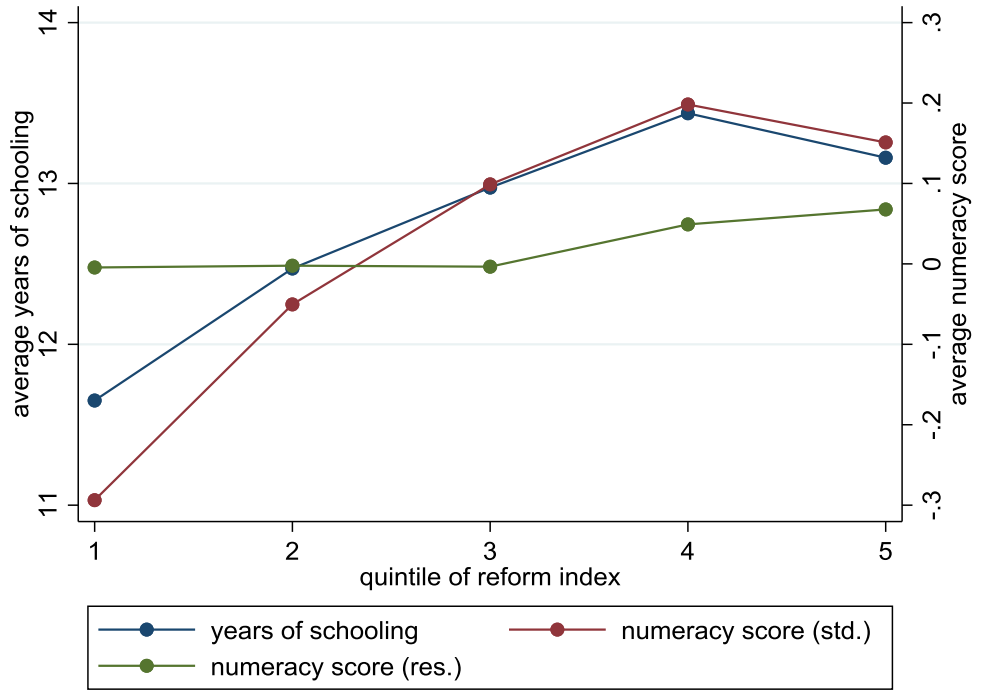
We begin our discussion of the results in Figure 7A, which represents our main findings. We plot years of schooling and numeracy against an index of intensity of educational reforms. The index is obtained by progressively cumulating the reform indices described in section 2 over birth cohorts within countries. Within a country, different birth cohorts are matched to different values of the index depending on how intense the reform activity of that country has been up to the year in which a cohort can be potentially affected by the reform. Over time, reform activity typically assumes the form of educational expansions, which we record as an increase of the reform index. In some cases, reforms had the opposite direction and implied a limitation of educational supply or access, which we record as a decumulation of the reform index. The index obtained by accumulating or decumulating the reform indicator is then grouped in quintiles. The outcome variables on the vertical axis of the graph are the average of the outcomes by quintiles, averages being calculated over countries and birth cohorts. We consider two outcomes, namely years of schooling and the standardised numeracy score.[9]

[8] In this exercise, we do not consider the residualised indicator of numeracy because it does not covary with the birth year by construction, as the year of birth is part of the control variables deployed in the regression model used for generating the residuals.

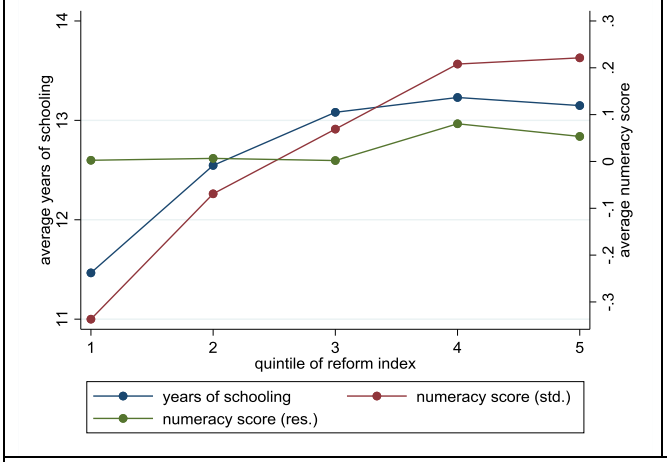
[9] In doing so, it is important to take into account that while years of schooling are presumably not subject to life cycle changes for the adult population, the same does not apply to numeracy scores due to the decay of competences with age, implying that the competences of older cohorts will be underestimated due to the decay. Since older cohorts will typically be observed at the early stages of educational expansions, the decay of competences with age will lower any

Figure 7 – Impact of reforms onto schooling and competences (means), by intensity of reforming activity

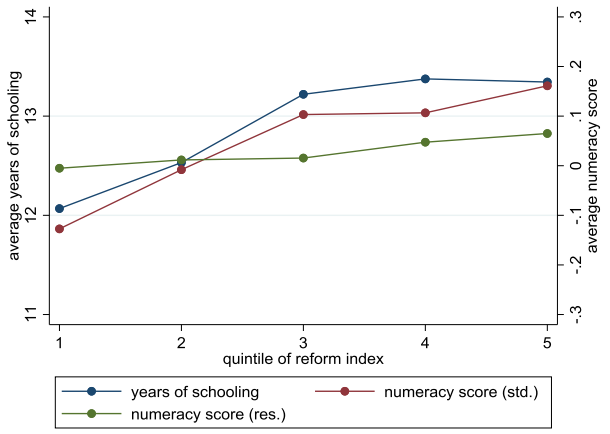
Panel A – All reforms



Panel B – School reforms



Panel C – University reforms



Note: observations are grouped by "cumulative" reform variables - cumulative reform variables are computed by adding 1 each time there is a reform and by subtracting 1 each time there is a "negative" reform (very few, <10% of reforms) - residuals are computed after a regression of standardised numeracy score on quadratic age polynomial and country fixed effects - All PIAAC observations are used to compute residuals (also those younger than 25) in order to capture the age profile of skills.

Panel A of Figure 7 considers all the reforms recorded in our data in conjunction without distinguishing between the educational levels at which each reform takes place. The graph shows a clear gradient between the intensity of educational reforms and human capital accumulation. Comparing cohorts in the lowest quintile of educational reforms with those in the highest, average educational attainment increases by two years. Also, the same comparison indicates a sizeable

positive association between educational expansions and competences. To account for this possibility, we also show in the graph average numeracy by reform quintiles after filtering out the effect of age through regression analysis.

increase of numerical competences, of about 40% of a standard deviation. Thus the countries that have exerted a more intense reforming activity (see Figures 1 and 3, that identify the group of Nordic countries and the Netherlands) are also characterised by more educated and competent populations. Notice that such a claim is based on within-country variation, due to matching birth cohorts to the year when a reform takes place.

In each case we can observe a tendency towards concavity of the relationship, indicating that the marginal effectiveness of educational reforms decreases with the level of human capital. Looking at the competences-reforms profile after removing age effects reveals a flatter relationship, that is higher competences in the bottom quintiles (mostly populated by older cohorts) and lower proficiency in the top quintiles (mostly populated by younger cohorts), consistently with the idea that competences are subject to decay with age.

In Panels B and C of Figure 7, we distinguish educational reforms according to the educational level in which they impact, namely schooling reforms (panel B) vs university reforms (panel C). Perhaps the most notable difference relative to panel A emerges for university reforms in panel C, where we can observe that the numeracy gradient reverts comparing the bottom and the top quintiles after numeracy is purged from the effect of age. This may suggest that most intense reform activity associated with the wave of university expansions of the 1990s has spread the diffusion of university fields characterised by relatively lower levels of numeracy, such as social science, in substitution of more numeracy-oriented fields such as engineering.

The differential impact of reform activities by type of reform is further investigated by breaking down the reform indicator into six categories: four categories refer to reforms of the schooling system (pre-primary education, educational expansions, teachers' management and school autonomy), while two categories attain to university education (university autonomy and students' financing). These six categories are built up by aggregating the 18 policy areas previously discussed in section 2. Without reporting additional graphs for ease of exposition,[10] we find that the greatest impact on educational attainment seems to be exerted by reforms that expanded access to education (including tertiary enrolment), reflecting the greater scope that these may have in increasing years of completed education in comparison with educational expansions at lower levels of the educational system. In turn, schooling reforms appear more effective than teachers' reforms in affecting years of education. Also, all reforms correlate positively with numeracy skills, but the correlation weakens considerably once skills are purged from age effects.

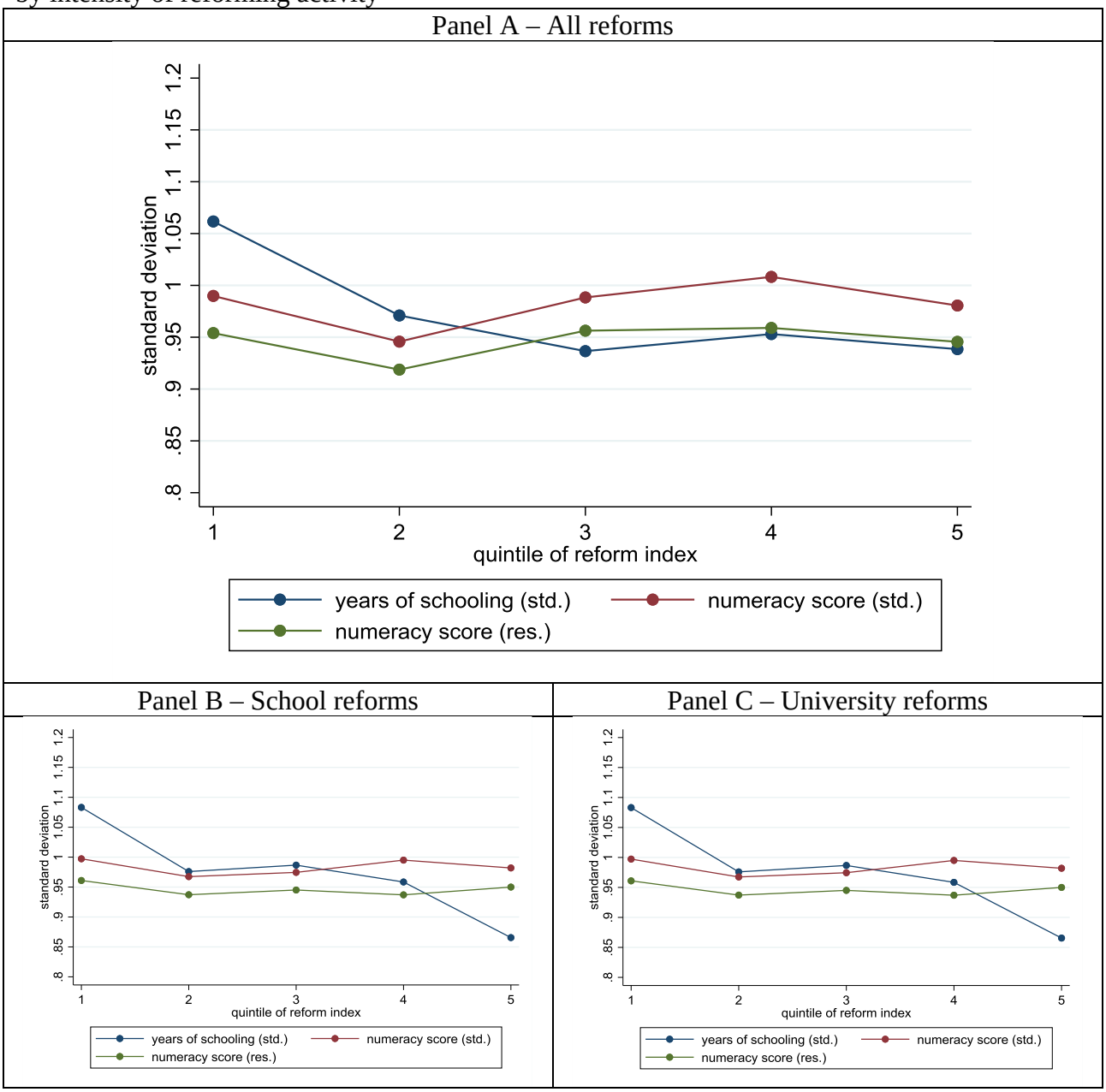
* * *

When we consider the variance of outcomes in the same population cohort as an indicator of policy ineffectiveness, we find that the more active countries obtain a less dispersed distribution of schooling but not of competences. In facts, the evidence discussed so far demonstrates the existence of a relationship between the intensity of educational reforms and the average level of human capital in the population. However, changes in the average attainment may miss the different patterns that this relationship may follow along the educational distribution. To gain a fuller understanding of the impacts of educational reforms, we therefore turn our attention to their relationship with the dispersion of human capital, depicted in Figure 8. Human capital dispersion is measured by the standard deviation of years of education or numeracy within country-by-cohort cells. The graph shows a clear negative relationship between the intensity of reform activity and educational dispersion. This is a mechanical effect due to the fact that the maximum level of education that someone can possibly attain did not change much over time, being stable at about 18 years of education for a full educational cycle from primary school to university completion. Because of this fixed upper limit, educational reforms designed to increase the average attainment are also bound to reduce the dispersion of attainment. Different is instead the case of numeracy dispersion, for which we cannot detect any negative gradient in relationship to educational reforms.

[10] Available upon request from the authors.

If anything, the pattern is weakly increasing, which suggests that the increase in average education induced by the reforms may have implied heterogeneous choices in terms of field of additional studies, with only some individuals impacted by the reform within each cohort-country opting for numeracy-enhancing fields. Moreover, even within numeracy-enhancing fields, there may be heterogeneity in numerical proficiency for any given level of educational attainment, further contributing to the (weakly) increasing pattern depicted in the graph. Overall, the graph accords with the idea that the benefits (returns) of education are heterogeneous in the population. It is also worth noting that there is no much difference between raw and age-conditioned numeracy which suggests that age does not account for much of numeracy dispersion.

Figure 8 – Impact of reforms onto schooling and competences (variance), by intensity of reforming activity



5. Concluding remarks

In this chapter we have shown that educational reforms undertaken in the last century in a large subset of European countries have been effective in raising quantity and quality of human capital in the current adult population. Both years of schooling and cognitive skills are positively associated to the intensity of the reforming activity of governments, which is interpreted as an indicator of political priorities. While the effect at the means of the distribution are easy to identify, less clear is the association with their variances. The dispersion in years of schooling declines with reforms, whereas we do not register identical pattern for cognitive skills.

Given the limited sample sizes of the PIAAC survey, our results can only be taken as suggestive, and a more careful identification of a specific reform and a group of treated people would be required in case of causal statement. However, we believe that our contribution highlights the main methodological problems occurring when aiming to measure the effects of reforms in education.

The first one is that reforms come in swarms, and it is quite difficult to disentangle one from the other. If a government increases the years of compulsory education, it is also likely to ease the transition to subsequent stages of education; similarly, if a government aims to raise the qualification of the teaching profession, it is also likely to give more teaching autonomy to the same teachers. As a consequence, in the present paper we have adopted a shortcut of simply counting the number of reforms. One would have liked to weight them by their impact, but the latter is exactly the unknown variable that what we tried to uncover in the chapter.

The second methodological contribution is that one should not rely on a single outcome variable, typically the (average) years of schooling in the population. We have shown that two correlated dimensions of individual human capital (namely schooling and competences) do react in different ways to the same reforms. Disentangling the two is extremely difficult, unless one can rely on a steady benchmark. But discussing the results on one neglecting the other is conceptually weak.

The third contribution is the identification of the potential effects of reforms using within-country variations associated to (adjacent) birth cohorts. As long as reforms hit individual based on their age, we can always distinguish between a group of treated (those born after the enactment of the reform) and a group of controls (those born before the introduction of the reform). More robust identifications would exploit also geographical differentiation, but in a cross-country comparative analysis these details are impossible to capture.

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