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# How returns to skills depend on formal qualifications: Evidence from PIAAC

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# HOW RETURNS TO SKILLS DEPEND ON FORMAL QUALIFICATIONS: EVIDENCE FROM PIAAC

**OECD Education Working Paper No. 163**

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This working paper has been authorised by Andreas Schleicher, Director of the Directorate for Education and Skills, OECD.

An earlier version of this paper was presented at the 3rd PIAAC (Programme for the International Assessment of Adult Competencies) International Conference in Madrid in November 2016.

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# Abstract

Using PIAAC (Programme for the International Assessment of Adult Competencies) data for 21 countries, we study interrelationships between formal qualifications, cognitive skills, and labour market outcomes, focusing on comparisons between less and intermediate-educated adults (i.e. between adults with a degree below the upper secondary and at the upper secondary level). Less-educated adults tend to have lower cognitive skills than intermediate-educated adults, yet both groups are internally heterogeneous. In country-specific individual-level regressions, cognitive skills partly explain the lower occupational status of less-educated adults, but cross-national variation in their disadvantage remains substantial after accounting for skills.

Country-level regressions show that the remaining disadvantage increases with the aggregate skills gap and with the internal homogeneity of the two educational groups. We further show that the association between skills and occupational attainment is weaker among the less educated than among the intermediate group. These findings are consistent with the idea that employers statistically discriminate on the basis of formal qualifications.



# Résumé

À l'aide des données de l'évaluation PIAAC (Programme pour l'évaluation internationale des compétences des adultes) en provenance de 21 pays, nous étudions les interrelations entre les qualifications formelles, les compétences cognitives et les résultats du marché du travail, en mettant principalement l'accent sur les comparaisons entre les adultes possédant un niveau d'instruction intermédiaire et ceux moins instruits (c'est-à-dire entre les adultes diplômés du deuxième cycle de l'enseignement secondaire et ceux qui possèdent un diplôme inférieur à ce niveau d'enseignement). Les adultes moins instruits tendent à avoir des compétences cognitives moins développées que les adultes possédant un niveau d'instruction intermédiaire. Toutefois, les deux groupes sont intrinsèquement hétérogènes. Dans les régressions à l'échelle des individus spécifiques aux différents pays, les compétences cognitives expliquent en partie la plus faible performance professionnelle des adultes moins instruits. Cependant, à l'échelle internationale, leur moins bonne performance demeure significative, même si l'on tient compte des niveaux de compétences.

Les régressions à l'échelle des pays montrent que le désavantage qui subsiste s'accroît avec l'écart de compétences global et l'homogénéité intrinsèque aux deux groupes. Nous démontrerons que la corrélation entre les compétences et la réussite professionnelle est plus étroite parmi les adultes au niveau d'instruction intermédiaire que parmi ceux moins instruits. Ces résultats sont cohérents avec l'idée que les employeurs établissent une discrimination statistique sur la base des qualifications formelles.

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# How returns to skills depend on formal qualifications: Evidence from PIAAC

## Introduction

Returns to skills are important for both individuals and society (OECD, 2013). At the individual level, labour market returns to skills in terms of occupational attainment (and associated differences in earnings and employment security) are a crucial determinant of life chances (Barone and van de Werfhorst, 2011; Hanushek et al., 2015; van de Werfhorst, 2011). On the societal level, labour market returns to skills may encourage individual and societal investments in skills. They are also central to normative discussions about the legitimacy of labour market inequalities.

Yet, skills are difficult to observe, not only for social scientists working with survey data, but also in everyday life. Several theories in sociology and labour economics therefore stress the importance of formal qualifications as proxies for (or "signals" of) skills (Bills, 2003; Spence, 1973). One of the primary questions in this literature is how employers infer the likely skills and productivity levels of (potential) employees from formal qualifications and other easy-to-observe worker characteristics. This very idea of "signalling" suggests that the association between skills and formal qualification might be central to how skills are rewarded on the labour market.

The link between formal qualifications and skills might be especially important for understanding the labour market disadvantage of less-educated adults, commonly defined as adults with less than upper secondary education. Less-educated adults are experiencing great difficulties on today's labour markets across all advanced economies (Abrassart, 2013; Gesthuizen, Solga and Künster, 2011; OECD, 2016). They face higher risks of unemployment than their better-educated counterparts. When they do find employment, it tends to be in low-status occupations characterised by meagre wages and low job security. Hence, improving the labour market prospects of less-educated adults is a prime challenge for countries that want to maintain social cohesion and avoid excessive social inequalities.

Previous research also shows the labour market disadvantage of less-educated adults differs considerably across countries. In this paper, we want to provide new insights into why it differs. We focus on two possible causes of this cross-country variation:

1. *Country variation in the skills of less-educated adults*: One possible reason why less-educated workers may fare better in some countries than in others is that the skills of the group vary across countries (Heisig and Solga, 2015; OECD, 2013; Park and Kyei, 2011). In particular, we would expect less-educated adults to achieve somewhat better labour market attainment in countries where they have higher levels of skills.
2. *Country variation in the association between skills and formal qualification*: Less-educated adults might further experience different levels of labour market disadvantage because of country differences in how well formal qualifications predict (or "inform" about) individual skills - that is, because of country

differences in the signalling value of formal qualifications. When less-educated adults have very low skills compared to other educational groups or when they are very homogenous in their skill distribution, their formal qualifications send a strong negative signal to employers, potentially exacerbating their labour market disadvantage above and beyond any direct, individual-level effects of skills.

In this paper, we seek to disentangle these two sources of country variation in the labour market disadvantage of less-educated adults. By providing high-quality, internationally comparable measures of cognitive (general) skills, the Programme for the International Assessment of Adult Competencies (PIAAC) supplies unique opportunities for our analysis.[1]

In a first step, we provide evidence on the distribution of cognitive skills among less-educated adults. While often perceived as a homogeneous, adversely selective group (e.g. Solga, 2002), we find that the distribution of cognitive skills among less-educated adults is actually quite heterogeneous, with considerable shares of the less educated demonstrating substantial levels of competence in the PIAAC assessment. We further show that the relationship between skills and formal qualifications varies considerably across countries, both with respect to the skills gaps between less- and intermediate-educated adults and with respect to the internal homogeneity of these groups, and that both aspects are systematically related to the extent of external differentiation (or tracking) and vocational orientation of (upper) secondary education. This supports the notion that the signalling value or the "skills transparency" of educational degrees is much higher in some countries than in others (Andersen and van de Werfhorst, 2010).

We then use insights from our analysis of the association between qualifications and skills to better understand country variation in the labour market disadvantage of less-educated adults relative to adults with intermediate qualifications. In the main part of our analysis, we focus on differences in occupational attainment and find that adjusting for differences in cognitive skills (by including the latter in country-specific, individual-level regressions) partly accounts for the labour market disadvantage of less-educated adults and reduces country-to-country variation in its size. At the same time, the skills distribution of the two groups continues to have an effect, even after controlling for cognitive skills at the individual level: the disadvantage of less-educated adults grows as the skills differential between less- and intermediate-educated adults increases and as these groups become internally more homogeneous. These findings are consistent with

[1] We compare 21 of the 24 countries that participated in the first round of PIAAC. We exclude Australia, Cyprus, and the Russian Federation because of concerns about data quality (Cyprus and the Russian Federation) and because no public use-file is available (Australia).

Note by Turkey:

The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Turkey recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Turkey shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union:

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the idea that employers treat educational credentials as proxies or "signals" of (hard-to-observe) skills. When the skills gap is large and when educational groups are relatively homogeneous, formal qualifications send a stronger signal about actual skills, potentially amplifying statistical discrimination on the basis of formal qualifications (Aigner and Cain, 1977; Solga, 2002). Findings tend to be less clear when we consider the percentile rank of less- and intermediate-educated adults in the distribution of monthly earnings.

In a final step, we explore another potential implication of the signalling story, namely that labour market returns to skills differ by formal qualifications. We find that the association between skills and labour market attainment in terms of occupational status tends to be weaker among the less educated than among workers with intermediate formal qualifications. The pattern is similar, although somewhat less conclusive, for the earnings rank. This suggests that low formal qualifications constitute a barrier that prevents workers with nonetheless relatively high levels of skills from fully converting their skills into success on the labour market. Again, this seems consistent with the idea that employers treat formal qualifications as crucial signals in the hiring process or that higher formal qualifications are a key entry requirement to the upper segments of the labour market for other reasons (e.g. because "meritocratic" selection criteria mandate preselection on the basis of educational achievements) (Bills, 2003).

## The distribution of skills among less- and intermediate-educated adults

We begin by analysing the distribution of skills among less and intermediate-educated adults. Less-educated adults are defined as persons whose highest degree is at the lower secondary level or below (International Standard Classification of Education [ISCED] Levels 0 to 2; see OECD, 1999). Intermediate-educated adults have completed upper secondary or non-tertiary post-secondary education (ISCED Levels 3 and 4). We exclude respondents with a tertiary degree (ISCED Levels 5 and 6) from the analysis, as they rarely compete for the same kinds of jobs as less-educated adults. We further restrict the analysis to persons aged 16 to 54 who were not enrolled in full-time education at the time of interview. The upper age threshold ensures that our analysis of labour market outcomes is not affected by cross-national differences in early retirement dynamics. We exclude persons who obtained their highest degree in a different country than where they took part in PIAAC. We provide further details on our analytic sample and on the measures used in Annex A.

Figure 1 depicts the distribution of numeracy skills among adults with low formal qualifications (dark blue lines) and intermediate formal qualifications (light orange lines) for the 21 countries in our sample.[2] We show ten lines for each group, corresponding to the ten plausible values provided by PIAAC to account for the uncertainty of individual competence estimates (OECD, 2013). Reassuringly, differences across the ten plausible values are generally quite small.

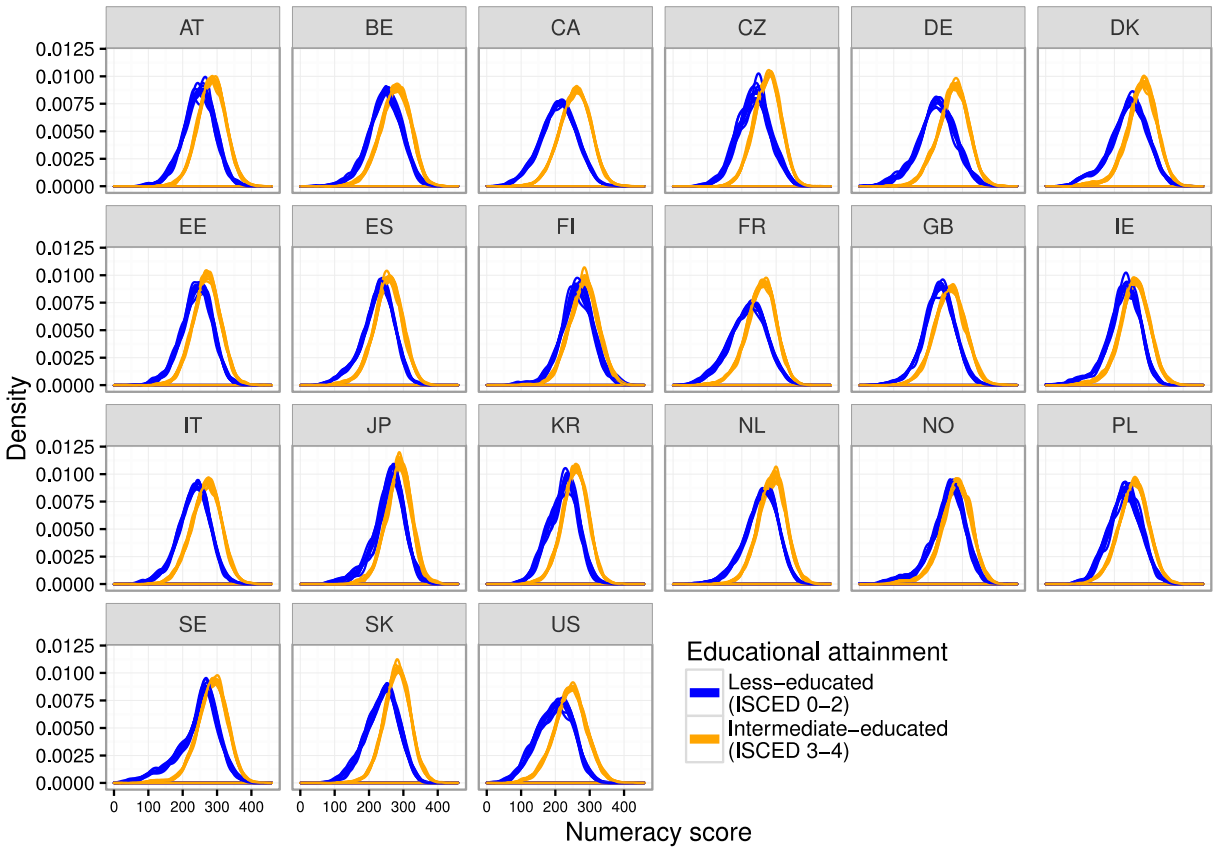
Figure 1 clearly shows that the distribution of numeracy skills among the less educated tends to be quite heterogeneous, with scores ranging from below 100 to 300 and above in most countries. To make this more concrete, a numeracy score of 300 means that an adult falls into the middle of proficiency Level 3. Adults performing on this level "can successfully complete complex tasks that require an understanding of mathematical information that may be less explicit (…). They have a good sense of number and space

[2] Results are broadly similar for literacy skills (available upon request).

(…) and can interpret and perform basic analyses of data and statistics in texts, tables, and graphs." (OECD, 2013:78) By contrast, adults with numeracy skills below 176 points score below proficiency Level 1. They "can only cope with very simple tasks set in concrete familiar contexts where the mathematical content is explicit and that require only simple processes such as counting; sorting; performing basic arithmetic operations with whole numbers or money, or recognising common spatial representations." (OECD, 2013:79)

Unsurprisingly, intermediate-educated workers have on average higher numeracy skills, with the majority of adults in this group scoring between 150 and 350 points in most countries. At the same time, there clearly is considerable overlap between the skills distributions of the two educational groups. In all countries, a substantial part of the less educated outperforms the lower-performing members of the intermediate-educated group.

**Figure 1. Distribution of numeracy skills among less- and intermediate-educated adults**




*Note*: Countries ordered alphabetically; see Table 1 for country codes. Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. ISCED = International Standard Classification of Education.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

These results suggest that differences in general skills partly account for the labour market disadvantage of less-educated adults. Yet, the considerable within-group variation visible in Figure 1 also raises the question if, and to what extent, higher general skills enable adults with low formal qualifications to avoid marginalisation and attain desirable

positions on the labour market. Before we examine these issues in greater detail, we take a more systematic look at cross-national differences in the distribution of cognitive skills among less- and intermediate-educated adults.

## The relationship between skills and formal qualifications

Table 1 reports the means and within-group standard deviations of numeracy skills for the two educational groups in the 21 countries in our sample. There is considerable cross-country variation in the average numeracy skills of less-educated adults and in the internal homogeneity of the group. The average numeracy score for adults with less than upper secondary education ranges from 194.2 points in the United States to 262.3 points in Finland, with a cross-country standard deviation of 15.5 points. On average, less-educated adults in Finland thus score higher than their American counterparts by considerably more than one proficiency level (the intermediate proficiency Levels 1 to 4 each have a range of 50 points).

**Table 1. Means and standard deviations of numeracy scores by educational attainment**

| | | Less-educated adults (ISCED0-2) | | Intermediate-educated adults (ISCED3-4) | | Numeracy gap |
|---|---|---|---|---|---|---|
| | Country codes | (1) Mean | (2) SD | (3) Mean | (4) SD | (3) – (1) |
| Austria | AT | 247.8 | 44.8 | 282.4 | 39.9 | 34.6 |
| Belgium | BE | 246.6 | 46.8 | 275.8 | 43.4 | 29.2 |
| Canada | CA | 222.0 | 51.7 | 261.8 | 45.0 | 39.8 |
| Czech Republic | CZ | 239.8 | 44.6 | 273.6 | 37.6 | 33.8 |
| Denmark | DK | 249.1 | 51.8 | 280.8 | 43.5 | 31.7 |
| Estonia | EE | 241.3 | 44.1 | 269.3 | 40.5 | 28.0 |
| Finland | FI | 262.3 | 47.0 | 279.8 | 44.4 | 17.5 |
| France | FR | 216.8 | 52.9 | 254.7 | 43.6 | 38.0 |
| Germany | DE | 221.2 | 51.5 | 269.6 | 44.8 | 48.4 |
| Ireland | IE | 227.8 | 47.1 | 255.8 | 45.9 | 28.0 |
| Italy | IT | 232.1 | 45.9 | 267.3 | 43.1 | 35.2 |
| Japan | JP | 258.6 | 44.6 | 285.3 | 37.9 | 26.8 |
| Korea | KR | 222.7 | 43.0 | 257.5 | 37.7 | 34.8 |
| Netherlands | NL | 252.7 | 50.1 | 285.8 | 41.3 | 33.2 |
| Norway | NO | 252.8 | 53.9 | 277.1 | 47.6 | 24.3 |
| Poland | PL | 230.6 | 46.6 | 253.0 | 44.3 | 22.4 |
| Slovak Republic | SK | 237.0 | 46.5 | 280.7 | 39.5 | 43.7 |
| Spain | ES | 227.9 | 45.6 | 254.8 | 41.1 | 26.9 |
| Sweden | SE | 248.5 | 54.3 | 283.0 | 44.7 | 34.5 |
| United Kingdom | UK | 230.9 | 50.2 | 264.0 | 47.2 | 33.1 |
| United States | US | 194.2 | 51.8 | 243.9 | 48.4 | 49.7 |
| Mean | | 236.3 | 48.3 | 269.3 | 42.9 | 33.0 |
| SD | | 15.5 | 3.4 | 11.9 | 3.1 | 7.6 |

*Note*: Multiple imputation estimates (10 imputations/plausible values). Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. Numeracy gap is the difference in mean numeracy skills between intermediate- and less-educated adults. Survey weights applied. ISCED = International Standard Classification of Education. SD = Standard deviation.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

The internal heterogeneity of the less educated similarly differs across countries. In some countries, the less educated are a relatively homogeneous group. For example, the estimated within-group standard deviations are 43.0 for Korea and 44.6 for Japan. In other countries such as Norway or Sweden, the less educated are much more heterogeneous, with estimated within-group standard deviations of 53.9 and 54.3 points, respectively. In the most homogeneous countries, the middle 95% (i.e. excluding the 5% at each end of the distribution) of the less educated thus fall into a range that is approximately 40 points narrower than in the least homogeneous countries (recall that the middle 95% of a normally distributed variable cover a range of approximately four standard deviations).

Column 3 of Table 1 shows that country variation in mean numeracy scores is somewhat smaller for intermediate-educated adults (see the cross-country standard deviations at the bottom of the table). Yet it clearly remains considerable, with the average numeracy skills of the intermediate-educated group ranging from 243.9 points in the United States to 285.8 in the Netherlands (cross-country SD = 11.9 points). The within-group standard deviation of numeracy skills ranges from 37.6 points in the Czech Republic to 48.4 points in the United States.

The final column in Table 1 illustrates that cross-country differences in the mean numeracy skills of less- and intermediate-educated adults translate into considerable variation in the gap between the two groups. In Finland, a mere 17.5 points separate the typical intermediate-educated from the typical less-educated worker. In Germany and the United States, the difference is almost three times as large, at 48.4 and 49.7 points, respectively.

The results presented so far underline that less-educated adults are a heterogeneous group that includes individuals with only rudimentary numeracy skills as well as adults with relatively high levels of skills that should render them fit for today's labour markets. In addition, they suggest that the "skills transparency" of education systems (Andersen and van de Werfhorst, 2010) differs considerably across countries. There are countries where the skills gap between less- and intermediate-educated adults is large and where these groups are internally homogeneous, rendering educational credentials strongly predictive of an individual's actual skills. In other countries, the gap is smaller and within-group differences are large so that a person's formal qualifications convey much less information about her actual skills. As we further explore below, such cross-country differences in the signalling value of educational degrees may moderate the importance of formal qualifications for labour market attainment.

To better understand why skills transparency varies across country we study its relationship with two aspects of secondary education: the extent of tracking (also called external differentiation) and the vocational orientation of (upper) secondary education (Bol and van de Werfhorst, 2013; Heisig and Solga, 2015). The United States and Canada are examples of countries with low levels of external differentiation and a weak vocational orientation. In both countries, lower and upper secondary education takes place within a comprehensive single track and vocational programmes play a marginal role. On the other end of the spectrum we find countries such as Germany or Austria where children are allocated to different tracks at relatively early ages and where a large proportion of students at the upper secondary level attend vocational programmes.

Figure 2 shows scatterplots of the skills gap between less- and intermediate-educated adults against two widely used measures of external differentiation and vocational

orientation (Bol and van de Werfhorst, 2013).[3] We cannot include Estonia in this analysis because the index of external differentiation is not available for this country. To improve the cross-country comparability of the estimated skills gap, we ran country-specific linear regressions of numeracy skills on an indicator for having intermediate qualifications for sex, age, foreign-birth/foreign-language status, and parental education. Another reason why we control for these covariates is that we are interested in the skills gap as a measure of how much information a person's formal qualifications (an easy-to-observe proxy) provide about his/her skills (a hard-to-observe characteristics that employers are ultimately interested according to the signalling account). After adjusting for these other readily-observable individual characteristics, our measure captures the additional information contained in a person's formal qualifications more closely.[4]

Figure 2 relates the estimates of the adjusted skills gap from the country-specific regressions (i.e. the coefficient estimates on the intermediate qualifications dummy) to the education system variables. The graphs in the top row depict the bivariate relationships between the numeracy gap and the measures of external differentiation (panel I) and vocational orientation (panel II), respectively. Panel I suggests that the numeracy gap is larger in countries with stronger tracking in secondary education and panel II that it is smaller in countries that put greater emphasis on vocational programmes in upper secondary education. Neither relationship reaches statistical significance, however.

Much clearer findings emerge when we consider the partial relationships between the education system characteristics and the numeracy gap, that is, when the respective other feature of secondary education is held constant (panels III and IV).[5] We now find relatively strong evidence that higher levels of external differentiation are associated with larger and higher levels of vocational orientation with a smaller, numeracy gap. The marked differences to the bivariate case are due to the fact that external differentiation and vocational orientation are strongly positively correlated ($r = .68$ in the sample of 20 countries used in Figure 2), yet have opposing effects on the numeracy gap. Hence, their effects are suppressed when the respective other predictor is not controlled.

While it is difficult to establish causal relationships between the two features of secondary education systems and the skills gap, there are several pathways through which such relationships might plausibly operate (unfortunately, none of them can be tested more directly using the PIAAC data). In particular, the finding is consistent with the idea that ability-related tracking reinforces pre-existing differences between low- and higher-

[3] Values refer to the early-/mid-2000s. For further details, see Annex A and Bol and van de Werfhorst (2013).

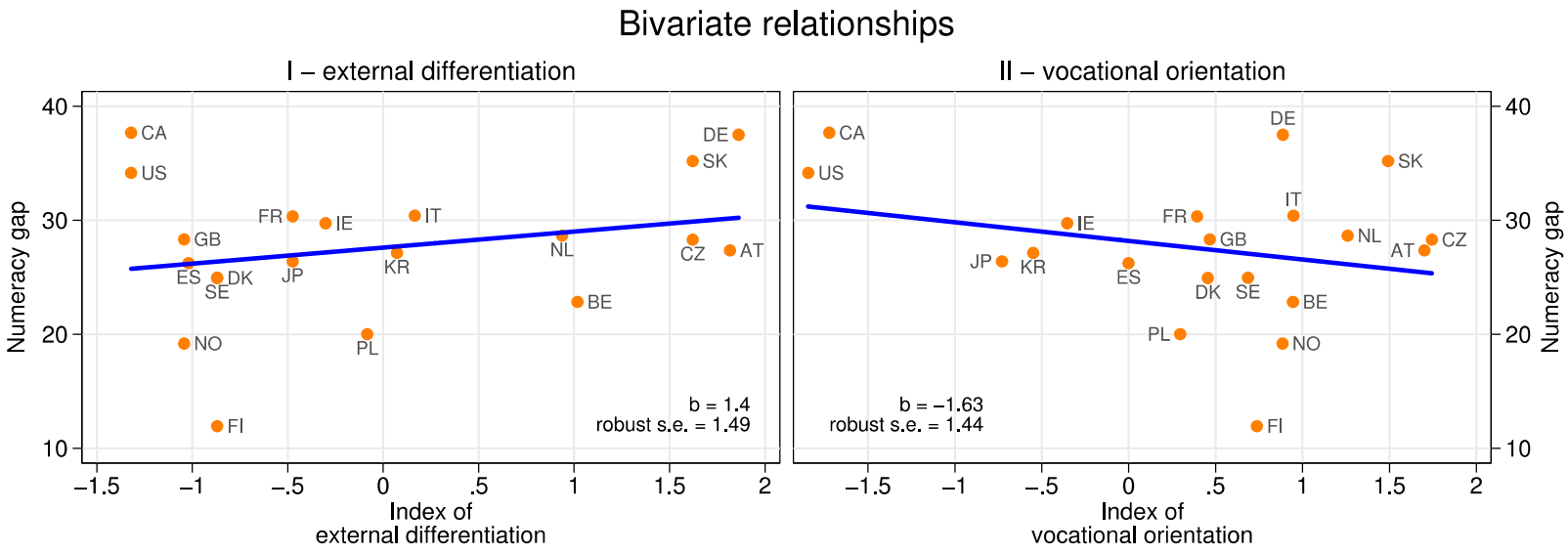
[4] Parental education might be more difficult to observe than the other characteristics but there is evidence suggesting that employers infer class background from other worker characteristics such as name, school attended, and leisure activities (Jackson, 2009). In any case, all results reported in this paper are very similar if we omit parental education from the control variables used in adjusting the skills gap and the internal homogeneity measures introduced below.

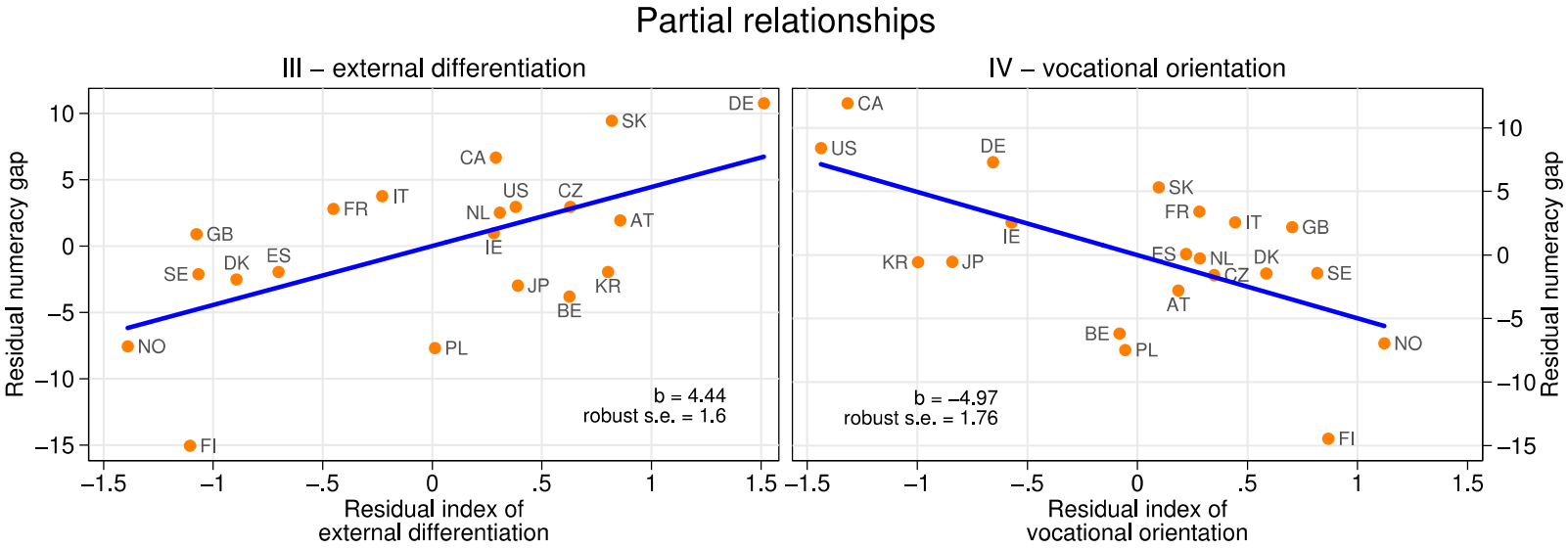
[5] The graphs plot the residuals from auxiliary regressions of the numeracy gap and the focal education system characteristic (i.e. external differentiation in panel III and vocational orientation in panel 4) on the respective other education system variable. According to the Frisch-Waugh-Lovell theorem, the linear relationship between these residualised measures is identical to the relationship estimated using conventional multiple regression with both education system measures included simultaneously (Davidson and MacKinnon, 2004: Chapter 2). The reported standard errors are based on this conventional regression.

ability students by allocating them to different learning environments and depriving low-performing students of positive stimulation (Heisig and Solga, 2015). In tracked systems, the lowest ability students will often cluster in the lowest track. Higher-ability students, by contrast, attend mid-tier tracks such as the German Realschule that are designed to prepare them for completing education with intermediate qualifications, or even upper-tier tracks geared towards preparation for tertiary education. A second, related explanation is stronger sorting on the basis of ability or achievement. In tracked systems, external gatekeepers such as teachers and school principals play a crucial role in the allocation of students to educational programmes. Compared to comprehensive or "choice-driven" systems (Jackson, Jonsson and Rudolphi, 2012), such external selection should limit the extent to which low-performing students can choose more ambitious programmes and thereby eventually obtain higher educational degrees.

As for the role of vocational orientation in upper secondary education, smaller numeracy gaps are consistent with the idea that vocational options and thus participation in upper secondary education increase the learning efforts of low-ability students, including those who eventually remain less educated (Heisig and Solga, 2015; Soskice, 1994). Moreover, emphasis on occupation-specific skills in upper secondary education plausibly reduces investment (in terms of teaching/learning time, etc.) in general skills in upper secondary education and might thus reduce the low-intermediate gap in the kinds of (general cognitive) skills assessed in PIAAC (Heisig and Solga, 2015).

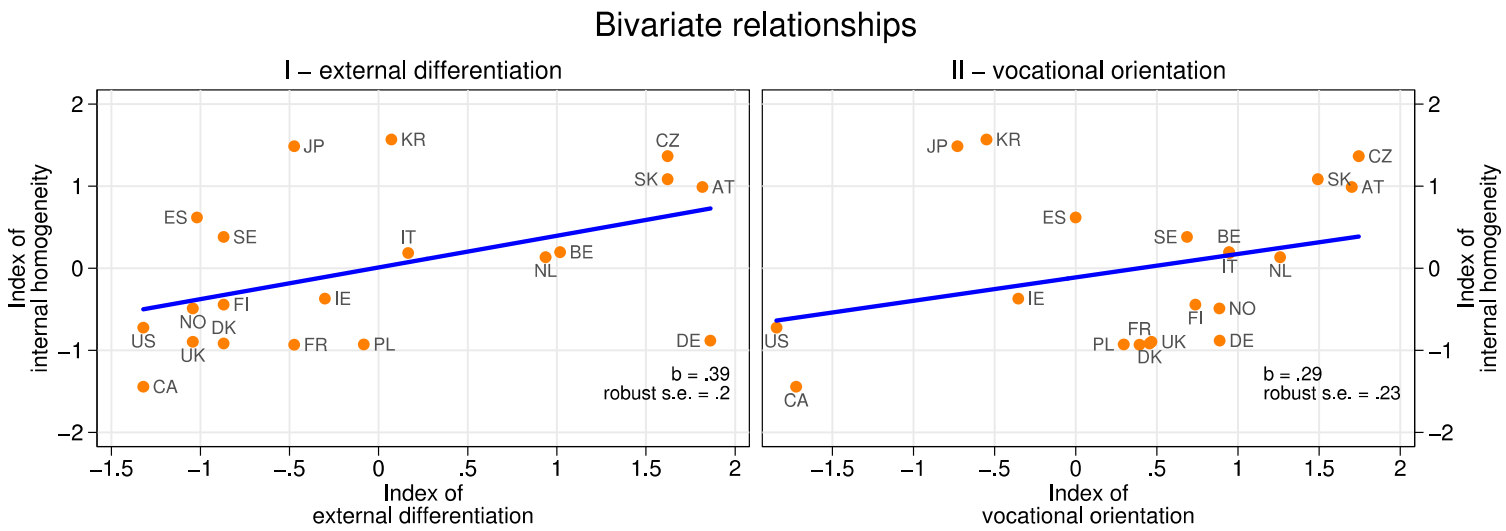
**Figure 2. Secondary education systems and the numeracy gap between less- and intermediate-educated adults**

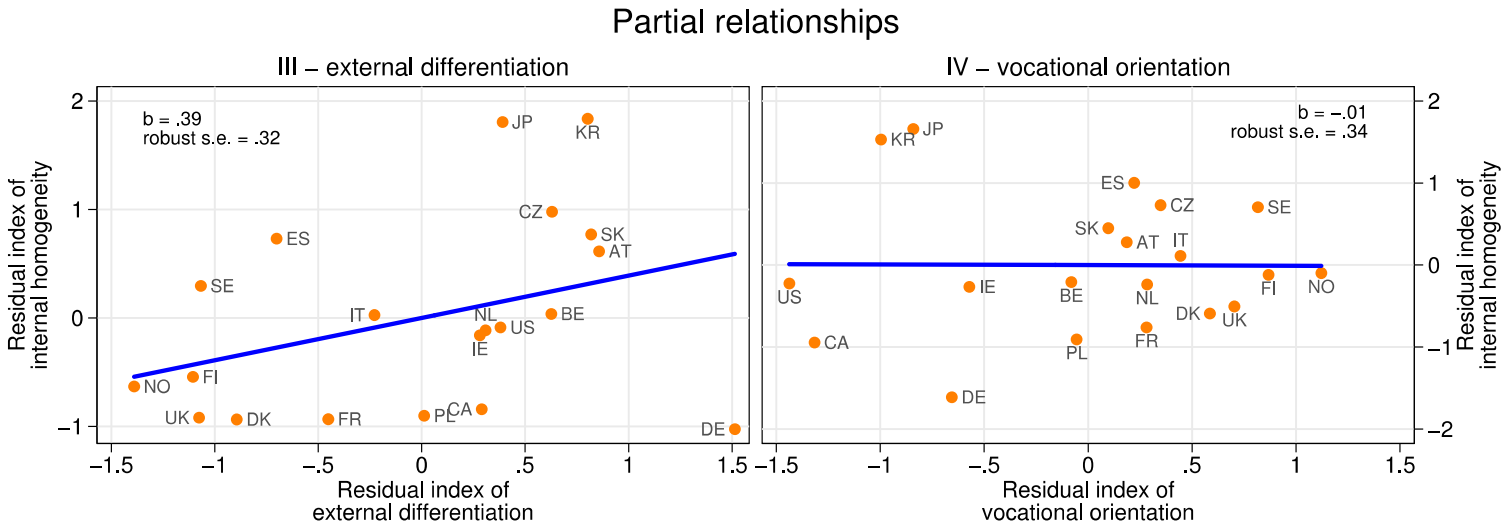





*Note*: See Table 1 for country codes. Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. Numeracy gaps estimated using country-specific linear regressions with controls for sex, age, foreign-birth/foreign-language status and parental education. Partial relationships are relationships between the residuals from auxiliary country-level regressions that regress the numeracy gap and the focal education system variable on the respective other education system variable. Indices external differentiation and vocational orientation taken from version 4 of the Education Systems Data Set by Bol and van de Werfhorst (2013). Index of external differentiation is based on age of first selection into different tracks (reverse coded), number of tracks available at age 15, and length of tracked education as a proportion of the total duration of primary and secondary education. Values for these variables refer to 2003 (age of first selection and number of tracks at age 15) and 2002 (length of tracked curriculum) or the closest year available. Index of vocational orientation is based on the proportion of students in upper secondary education who are enrolled in a vocational program, as provided in two sources: OECD (OECD, 2006 Table C2.5) and UNESCO's online database (http://data.uis.unesco.org/). Values refer to 2004 (OECD) and 2006 (UNESCO).
*Source*: Authors' calculations based on OECD (2012*), Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

**Figure 3. Secondary education systems and internal homogeneity of less- and intermediate-educated adults**






*Note*: See Table 1 for country codes. Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. Index of internal homogeneity is based on a country-level factor analysis of the residual within-group standard deviations of literacy and numeracy among less- and intermediate-educated adults (for details, see Heisig, forthcoming). Partial relationships are relationships between the residuals from auxiliary country-level regressions that regress the numeracy gap and the focal education system variable on the respective other education system variable.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

In Figure 3, we explore how external differentiation and vocational orientation are related to the internal homogeneity of adults with low and intermediate formal qualifications, as captured by a measure that we constructed using the PIAAC data: the index of internal homogeneity (Heisig, forthcoming). The index is based on the residual standard deviation of numeracy and literacy skills among less- and intermediate-educated adults, after accounting for sex, age, foreign-birth/foreign-language status and parental education (i.e. it is based on four standard deviations per country, one for each combination of educational group and skill domain). Because the four measures turn out to be highly correlated, both across skill domains and across educational groups, we ran a factor analysis of the group- and domain-specific standard deviations to construct a one-dimensional summary measure. We reverse -coded the factor scores so that higher values correspond to greater homogeneity (i.e. smaller within-group standard deviations of skills).

The graphs in the top row of Figure 3 (panels I and II) suggest that both external differentiation and vocational orientation are associated with greater internal homogeneity of less- and intermediate-educated adults. However, the relationship is somewhat stronger and statistically significant (at the 10% level) only for the external differentiation index (the two-tailed p-value is .076). The partial relationships in the bottom row suggest that the apparent effect of vocational orientation is spurious: When external differentiation is held constant, the association between vocational orientation and the homogeneity measure becomes essentially zero (panel IV). By contrast, accounting for country differences in vocational orientation hardly alters estimated effect of external differentiation (panel III). The coefficient estimate no longer reaches statistical significance (b = .39, s.e. = .32), but this reflects a loss of precision (due to the rather strong correlation between the indices of external differentiation and vocational orientation noted above) rather than an attenuation of the point estimate.

Again, this country-level analysis is not sufficient for establishing a causal relationship between external differentiation and the internal homogeneity of less- and intermediate-educated adults with respect to general skills. However, the idea that educational tracking leads to more compressed skills distributions within educational groups clearly has some plausibility. As noted above, tracked systems typically restrict individual choice of schools and educational programmes more than do comprehensive systems (Jackson et al., 2012). In fact, the most prominent argument for tracking is that it creates more homogeneous student populations and thereby makes it easier to tailor curricular content and other aspects of instruction to the academic abilities of students.

## Cognitive skills and the labour market disadvantage of less-educated workers

We now examine if cross-national differences in the distribution of general skills across the two educational groups are related to differences in their relative labour market attainment. We focus on differences in terms of occupational status in the current or last job. Information on the last job is available for respondents who did not work at the time of interview, but had left their last job no more than five years before. Occupational status is measured using the International Socio-Economic Index of Occupational Status (ISEI; Ganzeboom, De Graaf and Treiman, 1992), assigned on the basis of one-digit International Standard Classification of Occupations (ISCO; 2008 revision) codes.

We analyse occupational status rather than unemployment because it is less sensitive to overall macroeconomic conditions, which varied substantially across the countries in our sample when PIAAC was conducted. We also prefer occupational status to (log) earnings

because the latter are known to depend on a variety of institutional factors that are difficult to control given the limited degrees of freedom available at the country level (Koeniger, Leonardi and Nunziata, 2007; OECD, 2014). However, we provide results for an individual's percentile rank in the distribution of monthly earnings in Annex B (and briefly discuss them in the text). Differentials in earnings ranks likely are less sensitive to cross-national differences in wage-setting institutions and other contextual factors than earnings differentials: These institutions might not as strongly affect how many "steps" two workers are apart as they affect the magnitude of the steps, that is, the relative earnings increase associated with being one step (e.g. one percentile) further up in the earnings distribution.

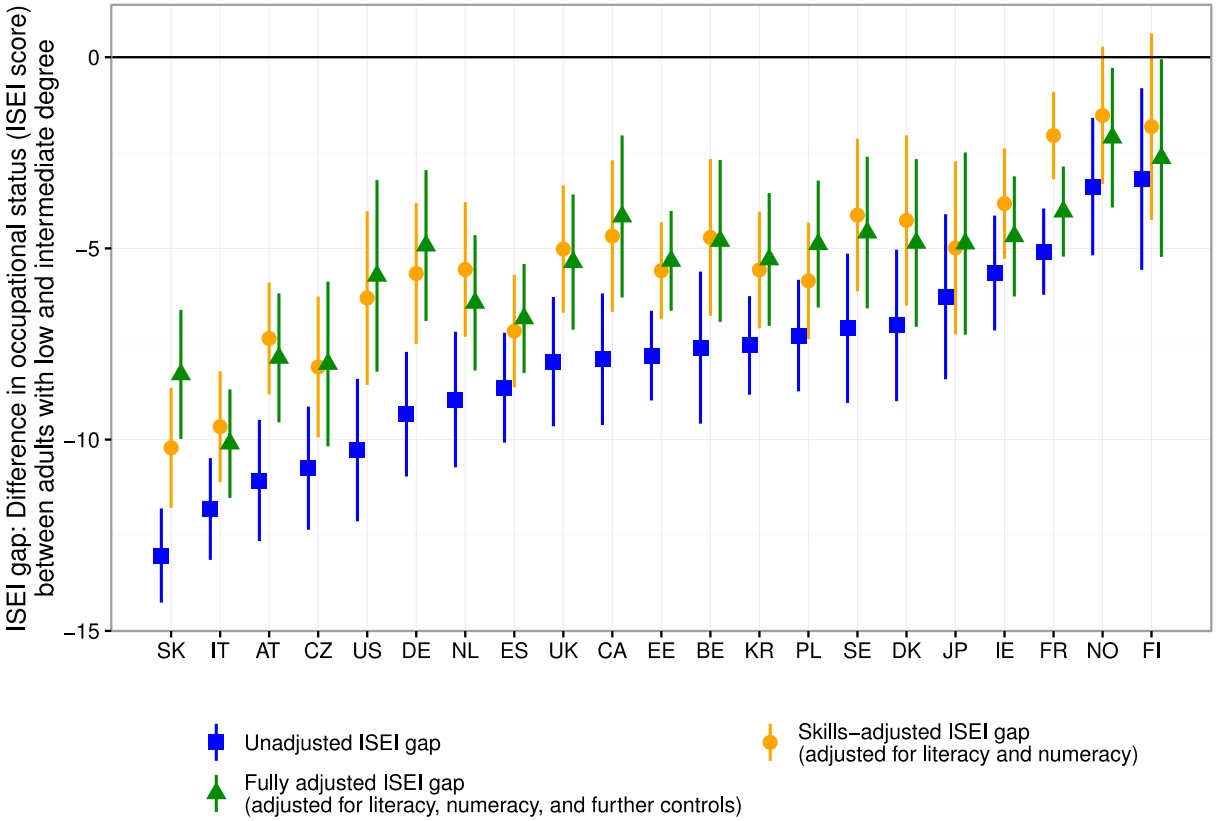
Figure 4 shows three variants of the ISEI gap between less- and intermediate-educated adults across the 21 countries in our analysis. All estimates are based on country-specific regressions of occupational status on an indicator for being less-educated and different sets of additional predictor variables. Blue squares represent the unadjusted ISEI gap (i.e. the gap based on empty models without any controls). The skills-adjusted ISEI gap (orange circles) is adjusted for differences in literacy and numeracy skills. The fully adjusted gap (green triangles) is additionally adjusted for a set of further control variables (sex, potential work experience, foreign-birth/foreign-language status, parental education and self-employment). Vertical lines depict 95% confidence intervals.

It is evident that less-educated adults tend to work in lower-status jobs than intermediate-educated adults everywhere. The unadjusted ISEI gap is negative and statistically significant in all countries. Its size varies considerably across countries, ranging from -13.0 points in the Slovak Republic to only -3.2 and -3.4 points in Finland and Norway, with an average of -8.0 points. To put these figures in perspective, note that ISEI scores range from 16.5 to 76.2 points, with a standard deviation of 16.4 points in our sample. The ISEI is positively associated with log hourly earnings, with the simple bivariate association ranging from a .6 log point increase in hourly earnings per unit increase in the ISEI in Denmark and Sweden to a 1.5 log point increase in the United States (the average strength of the association across the 21 countries is 1.0 log points).

Differences in literacy and numeracy skills between less- and intermediate adults generally account for a considerable portion of the ISEI gap. In all countries, the skills-adjusted ISEI gap is smaller than the unadjusted one, with the average falling from -8.0 to -5.4 points. Adjusting for skills also reduces cross-country variation in the ISEI gap: whereas the unadjusted gap has a variance of 6.5, the skills-adjusted has one of 5.1, a reduction of approximately 21%. Thus, differences in the distribution of general skills partly explain why the labour market disadvantage of the less educated is larger in some countries than in others. For most countries, adding further control variables has only minor effects on the estimated ISEI gap (France and the Slovak Republic are the two exceptions where the impact is considerable). The direction of the change is inconsistent, with the fully adjusted gap being larger than the skills-adjusted gap in some countries and smaller in others.

Although accounting for general skills at the individual level explains a substantial portion of the ISEI gap between less- and intermediate-educated adults and also reduces cross-country differences in the ISEI gap, even the fully adjusted gap remains substantial and statistically significant in all countries. Moreover, it continues to vary across countries, ranging from -10.1 and -8.3 points in Italy and the Slovak Republic to -2.6 and -2.1 points in Finland and Norway.

**Figure 4. The ISEI gap between less- and intermediate-educated adults across 21 countries**




*Note*: See Table 1 for country codes. Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. ISEI gaps estimated using country-specific linear regressions with an indicator for having low formal qualifications (ISCED Levels 0-2) and varying sets of controls: none (unadjusted ISEI gap); literacy and numeracy skills (skills-adjusted ISEI gap); literacy and numeracy skills, sex, potential work experience, foreign-birth/foreign-language status, parental education, and self-employment (fully adjusted ISEI gap). Vertical lines depict 95% confidence intervals. ISEI = International Socio-Economic Index of Occupational Status.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

In Figure 5, we explore if the remaining cross-national variation in the fully adjusted ISEI gap is related to the skills transparency and the vocational orientation of the education system. As in Figure 2 and Figure 3, we depict bivariate relationships in the top row (panels I to III) and partial relationships in the bottom row (panels IV to VI). Perhaps the most striking result in Figure 5 is that both the skills gap between less- and intermediate adults - we now use the simple average of the literacy and numeracy gaps - as well as the internal homogeneity of these groups are related to the ISEI gap between less- and intermediate-educated adults, even after accounting for general skills at the individual level. The labour market disadvantage of less-educated adults grows as the aggregate skills differential (gap) between less- and intermediate-educated adults increases and as these groups are internally more homogeneous. When the respective other country-level characteristics are held constant (see the partial relationships in panels IV and V in

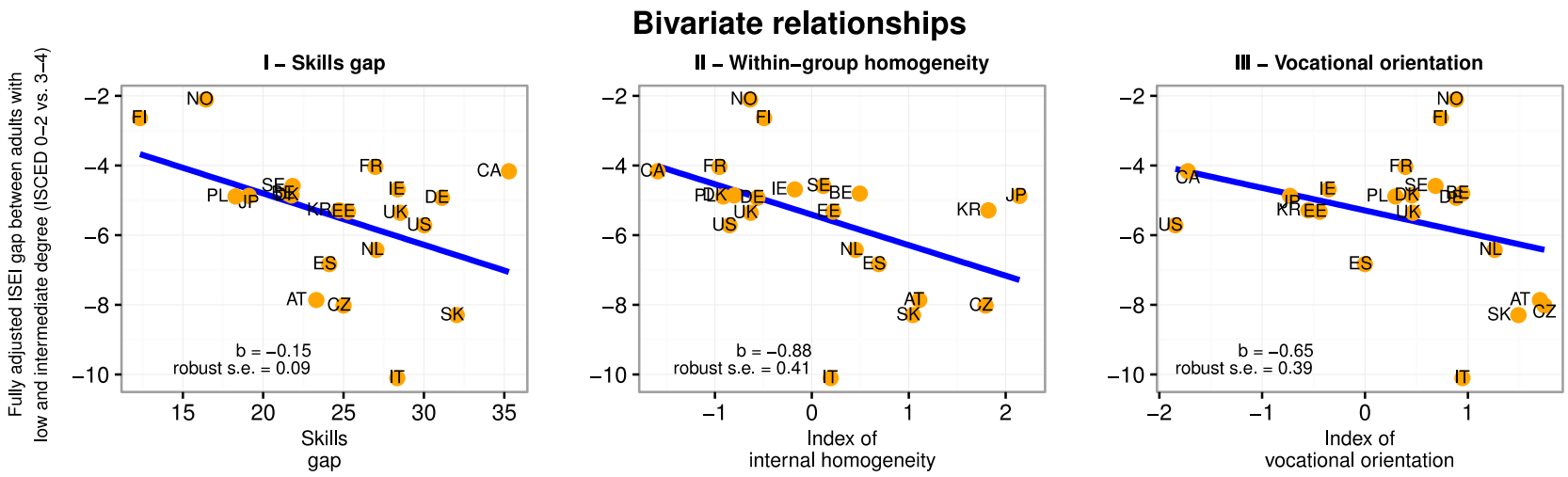
Figure 5), these relationships are clearly statistically significant (the bivariate relationship is significant only for the index of internal homogeneity).

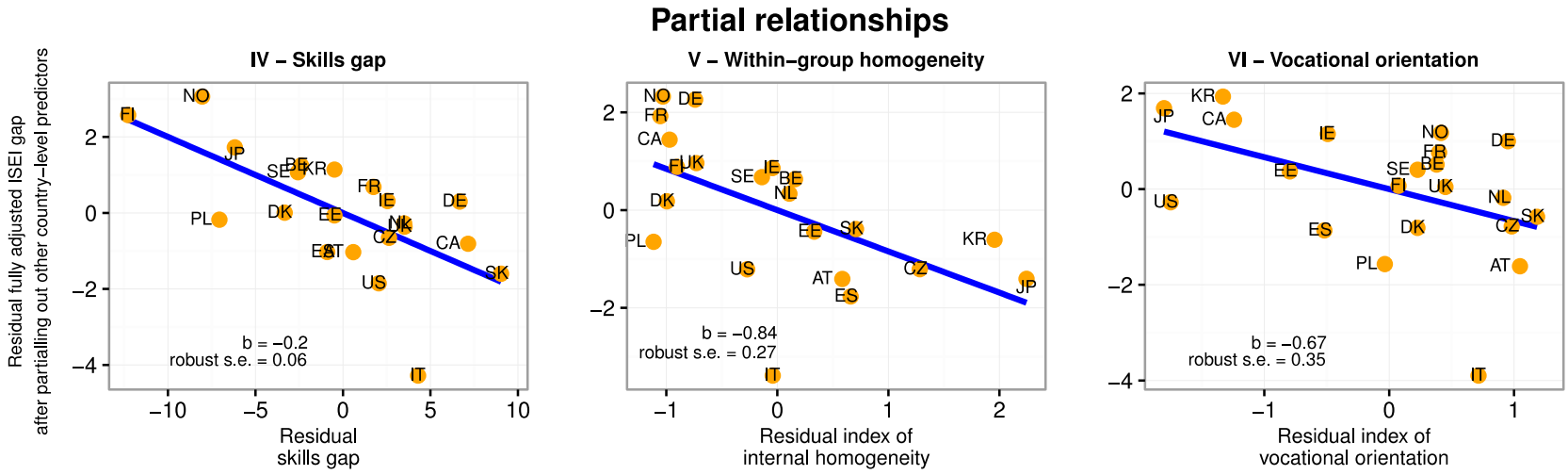
According to panel IV, a unit increase in the skills gap is associated with an increase in the labour market disadvantage of less-educated adults by approximately -.2 ISEI points. This implies a semi-standardised effect of approximately -1.1 ISEI because the cross-country standard deviation of the skills gap is 5.5 points. The effect of the index of internal homogeneity (which is already semi-standardised because the index has a standard deviation of 1 at the country level) is -.84 ISEI points. These are substantial effect sizes, given that the fully adjusted ISEI gap ranges from approximately -10 to -2 points in our country sample.

A sceptical interpretation of these results is that these aggregate-level measures pick up the effects of factors such as non-cognitive skills that were not observed in PIAAC and therefore could not be included in the individual-level regressions for estimating the fully adjusted ISEI gap. However, these unobserved factors could account for the aggregate-level relationship between the skill composition measures and the ISEI gap only to the extent that they are orthogonal to (i.e. linearly independent of) literacy and numeracy skills and to the other covariates included in the individual-level regressions (e.g. parental education).

A plausible alternative interpretation of the result is that the skills distribution of less- and intermediate-educated groups (by shaping the signalling value of educational degrees) influences the labour market disadvantage of less-educated adults above and beyond its direct, individual-level effects. Theories of labour market signalling (Spence, 1973; Weiss, 1995) are a useful framework for understanding why this might be the case. Signalling theory concurs with human capital theory (Mincer, 1970) that more skilled workers are of greater value to employers. However, signalling accounts emphasise that a worker's actual level of skills is difficult to observe for employers. The latter should therefore heavily rely on more readily observable proxies (i.e. "signals") for skills and trainability in hiring, job placement, and promotion decisions (Spence, 1973; Thurow, 1979). Educational degrees, along with other indicators of educational achievement such as grades, are the paradigmatic examples of such signals (Arrow, 1973; Hirsch, 1977; Thurow, 1979; Weiss, 1995).

**Figure 5. Aggregate skills distributions, vocational orientation, and the ISEI gap between less- and intermediate-educated adults**






*Note*: Dots represent fully adjusted ISEI gap between less- and intermediate-educated adults based on country-specific individual-level regressions. Lines are country-level relationships between the ISEI gap and the different predictors. Relationships in the top row are bivariate, bottom row shows partial relationships after accounting for the respective other two predictors. b = estimated regression slope. robust s.e. = robust (HC3) standard error for slope estimate. ISEI = International Socio-Economic Index of Occupational Status.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

The signalling story suggests that the distribution of general skills across less- and intermediate-educated adults can have an aggregate-level effect on their labour market position because employers apply statistical discrimination in hiring decisions: they assess (potential) productivity of applicants based on beliefs about the skills distribution in the applicant's educational group (Aigner and Cain, 1977; Phelps, 1972). When the skills gap is large and/or educational groups are internally homogeneous, formal qualifications are more predictive of an individual's actual skills than in countries with small gaps and large within-group heterogeneity and should therefore play an important role in the employer's assessment of (potential) employees.

The ISEI gap between less- and intermediate-educated adults also seems to increase with the vocational orientation of upper secondary education, even after accounting for the distribution of literacy and numeracy skills at the individual and aggregate levels (see panels III and VI in Figure 5). The partial relationship is significant at the 10% level (two-tailed test), while the bivariate barely misses this threshold. This finding is consistent with previous research (Bol and van de Werfhorst, 2011; Müller and Shavit, 1998; van de Werfhorst, 2011). A plausible interpretation is that intermediate-educated adults have higher levels of occupation-specific skills in countries with a strong vocational orientation, but because such skills are difficult to measure (and PIAAC made no attempt to do so), we cannot examine this explanation directly.

In sum, we find rather strong support for the idea that country differences in the signalling value of formal qualifications and the vocational orientation of upper secondary education are systematically related to the labour market disadvantage of less-educated adults. In Figure A B.1, we explore if this finding is robust to the measure of labour market attainment. We therefore repeated the analyses summarised in Figure 5 with an individual's (percentile) rank in the distribution of monthly earnings (instead of the ISEI) as the dependent variable.[6] Results for the low-intermediate gap in the earnings rank are much less conclusive than for the gap in occupational status. The estimated effects of internal homogeneity and vocational orientation are close to zero and very imprecise. Only for the skills gap do we still find a substantively meaningful negative effect. The partial relationship is estimated at -.18, meaning that the earnings rank differential between less- and intermediate-educated adults increases by .18 percentiles for every unit increase in the skills gap. Even this coefficient estimate does not reach conventional levels of statistical significance, however (t=-1.47, two-sided p-value = .16 with 16 degrees of freedom).

It is not obvious why the country-level relationships are less clear for the earnings rank than for the occupational status (ISEI) gap. One possibility is measurement error. Whereas occupations are relatively clearly defined, precise measures of earnings are more difficult to collect and this may spill over in the measures of earnings rank, especially in countries with low levels of inequality where even slight errors in the reported (or partly imputed) earnings may translate into substantial differences in earnings rank (because distances between percentiles are small). Given the small size of the country-level sample such measurement error could clearly distort the results considerably. Another

[6] For five countries in our sample (Austria, Canada, Germany, Sweden and the United States), the public use files only provide a respondent's decile rank in the earnings distribution. In these cases, we multiplied the decile ranks by ten to include them in the analysis. We also added a dummy variable indicating the five countries in the country-level regressions, so the relationships in the top row in Figure A B.1 are not pure bivariate relationships, but rather controlled for the influence of the "detail of rank measure" dummy.

explanation may be that for the ISEI gap we could include all respondents (also those who were non-employed at the time of interview, by taking the ISEI of their last job), while for the earnings we only consider those who were employed at the time of interview. Given the PIAAC survey years 2011/12, earnings might therefore be much more sensitive to the economic repercussions of the 2007 financial crisis than the ISEI.

## Returns to skills by level of formal qualifications

In our last step, we investigate whether labour market returns to general skills vary by formal qualifications at the individual level - that is, whether returns to education differ by formal qualification. Table 2 presents results from multilevel mixed-effects regressions with random intercepts to account for the clustering of individuals within countries. As before, we drop adults with tertiary education from the analysis and include controls for sex, potential work experience, foreign-birth/foreign-language status and parental education.

The focal variables are an indicator for having intermediate qualifications (in contrast to a low level of qualification) and the level of numeracy skills, which we z-standardised (mean of zero, standard deviation of one) for easier interpretation. Unlike in the preceding analysis, we do not include both skill domains simultaneously. This is because the high correlation between literacy and numeracy skills renders the associated coefficient estimates very imprecise when both are included in a regression. We present results for numeracy skills because previous research using PIAAC indicates that they are somewhat stronger predictors of labour market outcomes (Hanushek et al., 2015). We include potential work experience using linear splines, with knots at 10, 20 and 30 years. The splines are a flexible, yet easy to interpret way of capturing nonlinearities in returns to experience. They model the ISEI-experience relationship as a piecewise linear function. The associated coefficient estimates can be interpreted as the predicted increase in the ISEI score associated with an additional year of experience in the given interval. For example, the coefficient estimate on the term for 0-10 years of experience means that, other things being equal, an additional year of potential experience is associated with a .447 point increase in the ISEI scale between 0 and 10 years of experience. Between years 10 and 20 of experience, the predicted gain per additional year of experience is .134 ISEI points (and thus smaller, but still positive).

Model 1 enters the indicator for having intermediate qualifications and numeracy skills additively. According to the results, the occupational status of adults with intermediate qualifications exceeds that of less-educated adults by 5.3 ISEI points, net of differences in numeracy skills and controls. Numeracy skills likewise exhibit a strong association with labour market attainment. A standard deviation increase in numeracy skills is associated with an increase of the ISEI score by 3.3 points under ceteris paribus conditions.

Model 1 constrains the effect of numeracy skills to be equal across educational groups. Model 2 relaxes this assumption by introducing a multiplicative interaction term between having intermediate qualifications and numeracy skills. The estimates imply that a standard deviation increase in numeracy skills is associated with an increase in occupational status by approximately 2.5 ISEI points among the less educated. Among the intermediate educated, the association is substantially stronger, at approximately 3.6 points per standard deviation increase in numeracy skills. The difference of 1.1 ISEI points per standard deviation increase is highly statistically significant.

The association between numeracy skills and occupational status is thus considerably stronger among adults with intermediate formal qualifications than among the less educated. This is consistent with the idea that the "screening out" of less-educated adults and labour market segmentation limit the extent to which less-educated adults with comparatively high levels of skills can convert these into better labour market outcomes (e.g. Solga, 2002). Thus, members of less-educated group might find it particularly difficult to survive the initial (screening) phase of the hiring process to reach a stage where they can demonstrate their actual skills (e.g. a standardised assessment or job interview). Table A B.1 shows similar findings for the earnings rank measure. In particular, the interaction term between having intermediate qualifications in Model 2 is positive (b=.51), although it does not quite reach statistical significance (two-sided p-value =.102).

To explore cross-national differences in the interaction between formal qualifications and numeracy skills, we ran Model 2 in Table 2 separately for each country using simple OLS (ordinary least squares) estimation. Figure 6 plots the country-specific coefficient estimates for the main effect of numeracy skills (orange circles), that is, the estimated effect of numeracy skills for less-educated adults (the reference group), and for the interaction term between having intermediate qualifications and numeracy skills (blue squares), that is the difference between equally skilled less- and intermediate-educated workers. Vertical lines depict two-sided 95% confidence intervals.

Consistent with the results for the pooled country sample, we find that the interaction between having intermediate qualifications and numeracy skills is positively signed in most countries—meaning that less-educated workers receive lower returns to skills than intermediate-educated workers. Estimates are quite uncertain due to moderate sample sizes, but they do attain statistical significance at the 5% level (i.e. the 95% confidence intervals do not include zero) for six countries (Norway, Poland, Italy, the Slovak Republic, Germany and Sweden). By contrast there are only four countries where the estimated interaction effect is negative, and in all of these cases the point estimates are close to zero and far from being statistically significant.

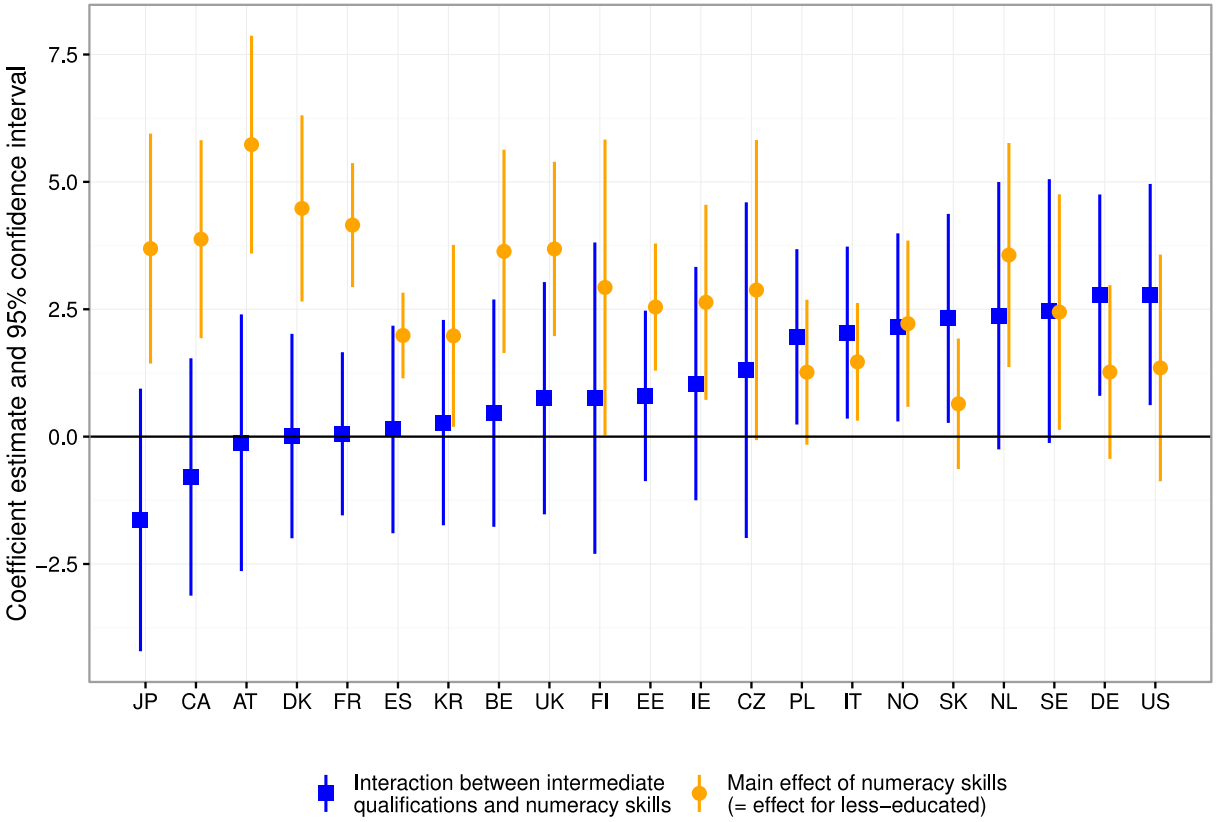
An obvious further step would be to explore whether the strength of the interaction between formal qualifications and numeracy skills is related to the skills transparency of the education system at the country level. If statistical discrimination against less-educated adults is the reason why returns to skills are smaller in this group, we would this pattern to be most pronounced in countries with high levels of skill transparency (where screening on the basis of formal qualifications should be more important). Unfortunately, the uncertainty of the country-specific estimates in Figure 6 is too high for generating clear evidence on this issue (results available upon request).

**Table 2. Random-intercept models of occupational status**

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | b | s.e. | b | s.e. |
| **Highest degree** | | | | |
| Low (ISCED 0-2) | Ref. | Ref. | Ref. | Ref. |
| Intermediate (ISCED 3-4) | 5.313*** | (0.190) | 5.675*** | (0.200) |
| | | | | |
| **Numeracy skills (standardised)** | 3.320*** | (0.086) | 2.549*** | (0.151) |
| | | | | |
| **Intermediate degree X numeracy skills** | --- | --- | 1.088*** | (0.173) |
| | | | | |
| **Sex** | | | | |
| Male | -2.402*** | (0.145) | -2.430*** | (0.145) |
| Female | Ref. | Ref. | Ref. | Ref. |
| | | | | |
| **Potential experience in years (linear splines)** | | | | |
| 0-10 | 0.447*** | (0.037) | 0.446*** | (0.037) |
| 10-20 | 0.134*** | (0.030) | 0.131*** | (0.030) |
| 20-30 | 0.074* | (0.029) | 0.081** | (0.029) |
| 30+ | -0.043 | (0.047) | -0.061 | (0.047) |
| | | | | |
| **Foreign-birth/foreign-language status** | | | | |
| Native-born, test language is first language | Ref. | Ref. | Ref. | Ref. |
| Native-born, test language is not first language | 1.943*** | (0.418) | 1.926*** | (0.419) |
| Foreign-born, test language is first language | -0.728 | (0.418) | -0.761 | (0.418) |
| Foreign-born, test language is not first language | -2.139*** | (0.338) | -2.239*** | (0.339) |
| | | | | |
| **Parental education** | | | | |
| Both parents below upper secondary | Ref. | Ref. | Ref. | Ref. |
| At least one parent with upper secondary education | 2.213*** | (0.179) | 2.226*** | (0.179) |
| At least one parent with tertiary education | 4.127*** | (0.243) | 4.107*** | (0.243) |
| | | | | |
| **Self-employment status** | | | | |
| Self-employed | 2.214*** | (0.220) | 2.236*** | (0.220) |
| Wage and salary | Ref. | Ref. | Ref. | Ref. |
| | | | | |
| **Intercept** | 26.182*** | (0.662) | 25.795*** | (0.666) |
| Standard deviations of random effects | | | | |
| Intercept | 2.58 | | 2.59 | |
| Residual | 15.29 | | 15.28 | |
| *N* | 48 029 | | 48 029 | |

*Note*: Multilevel mixed-effects estimates with country-specific random intercepts. Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$ (two-tailed tests). b = estimated regression slope. s.e. = standard error.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

**Figure 6. Country variation in returns to numeracy skills by educational attainment**




*Note*: See Table 1 for country codes. Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. Fully adjusted ISEI gaps estimated using country-specific linear regressions with an indicator for having low formal qualifications (ISCED Levels 0-2), numeracy skills and interaction with formal qualification, and as controls sex, potential work experience, foreign-birth/foreign-language status, parental education and self-employment. Vertical lines depict 95% confidence intervals. ISEI = International Socio-Economic Index of Occupational Status.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

## Conclusions

Our analyses have produced several findings. Focusing on less- and intermediate-educated adults, we have demonstrated that higher formal qualifications are associated with higher cognitive skills, but that both educational groups also exhibit considerable internal heterogeneity. We have further shown that the relationship between formal qualifications and skills differs across countries, both in terms of the skills differential between less- and intermediate-educated adults and in terms of their internal homogeneity. This variation is systematically related to secondary education systems: greater external differentiation (i.e. stronger tracking) is associated with larger skills differentials between less- and intermediate-educated adults and greater internal homogeneity of these groups, whereas vocational orientation of upper secondary education is negatively related to skills differentials (and shows no clear relationship with the internal homogeneity). These findings suggest that the signalling value or "skills

transparency" of educational credentials varies systematically across countries (Andersen and van de Werfhorst, 2010).

Our second analysis has focused on differences in occupational attainment between less- and intermediate-educated adults. We have documented substantial variation in the labour market disadvantage across the 21 countries in our sample. Accounting for differences in literacy and numeracy skills partly explains the occupational attainment gap in all countries and also reduces cross-national variation in its size, but country differences remain even after accounting for cognitive skills and other key observables. Further cross-country analyses reveal that the remaining variability is related to the signalling value (or "skill transparency") of educational degrees. The disadvantage of less-educated adults grows as the gap in occupational attainment (measured as ISEI) between less- and intermediate-educated adults increases and as these groups more homogeneous with respect to cognitive skills. Consistent with previous research, we also find the labour market disadvantage to be larger in countries with a stronger vocational orientation (e.g. Bol and van de Werfhorst, 2011; Müller and Shavit, 1998). Finally we have shown that returns to numeracy skills are smaller for less-educated adults than intermediate-educated adults.

While further research is certainly needed (see below), our findings do suggest some general recommendations for social and labour market policy. Formal qualifications appear to play an important role for labour market attainment, and efforts to improve the labour market position of less-educated adults need to take this into account. Especially in countries where skills transparency is high, it may not be enough to improve the skills of less-educated adults. It may also be crucial that skill improvements are certified according to clear and transparent standards and that less-educated adults perhaps even attain higher educational degrees. The finding that labour market returns to skills are lower for adults with low formal qualifications suggests that less-educated workers with relatively high levels of skills have the most to gain from attaining higher formal qualifications. The labour market prospects of skilled adults with low formal qualifications might also be improved by measures that reduce the weight of formal qualifications in selection procedures. In particular, they should benefit when selection procedures incorporates standardised assessments or other instruments that allow them to demonstrate their abilities during the early stages of the hiring process.

Our study inevitably has some limitations that call for further research. First, while the quality of the skills measures provided by PIAAC is a major step forward, it remains limited to general cognitive skills. Thus, we can only speculate to what extent our findings are driven by unobserved differences in other types of skills, most-importantly occupation-specific and non-cognitive skills. A second limitation is the exclusion of so-called literacy-related non-respondents, who did not complete the survey for reasons such as language problems or mental disabilities and for whom only information on age and sex is available (see Annex A and OECD, 2013). This exclusion is particularly worrisome because less-educated adults (whom most literacy-related non-respondents presumably belong to) are central to our analysis (see Heisig and Solga, 2015). In future rounds of PIAAC, it may be worth collecting some additional information on this group (e.g. educational attainment) to facilitate the assessment of potential biases resulting from their exclusion (Van de Kerckhove, Mohadjer and Krenzke, 2013). A third limitation is that, because of small sample sizes, we could not conduct gender-specific analyses, although processes of labour market attainment and the selectivity of labour market participation are known to differ between men and women.

Our findings suggest several interesting questions for future research that go beyond addressing these potential limitations. An issue of central importance to the signalling story is how employers perceive formal qualifications and if they have accurate understandings of the distribution of skills across and within different educational groups. Large-scale assessments such as PIAAC provide useful benchmarks for assessing the accuracy of employer perceptions about the distribution of skills (Bills, 1988, 1992). Another interesting question is if effects of group-level skills composition on labour market outcomes can also be found for other easily observable characteristics such as gender or race/ethnicity.

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# Annex A. Data, sample and methods

## Individual-level data and sample

Our individual-level data are from the first round of PIAAC, conducted in 2011/2012 (OECD, 2013). The main analysis uses 21 of the 24 countries that participated in the first round of the survey.[7]

Our primary goal is to explain the labour market disadvantage of less-educated workers (highest degree below the upper secondary level). We therefore exclude respondents with a tertiary degree (ISCED Levels 5 and 6) from the analysis, as they rarely compete for the same kinds of jobs as less-educated adults. Our sample includes men and women aged 16 to 54 who worked for pay either at the time of interview or within the last five years before the interview. The upper age threshold ensures that results are not affected by cross-country differences in late-career trajectories and the prevalence of early retirement. We exclude respondents who were enrolled in full-time education at the time of interview. We further drop individuals who did not obtain their highest educational degree in the country where they were surveyed. This guarantees a good match with the education system measures included in some of the analyses and allows us to circumvent the difficult question how employers perceive foreign degrees. We also exclude so-called literacy-related non-respondents from the analysis because there is too little information on these cases (only on sex and age) for including them in the analysis (OECD, 2013; Van de Kerckhove et al., 2013).

A total of 48 880 cases meet our sample restrictions. We drop 851 of these cases (1.7%) because of missing information on one of the variables included in the analysis. The only variables with non-negligible proportions of missing data are parental education and occupational status, which are unavailable for 3 537 (7.4%) and 610 (1.3%) cases, respectively. We use multiple imputation to fill in missing values on these two measures, obtaining imputations separately by country and gender.[8] We generate ten imputations, one for each of the so-called plausible values for the skills measures (see "Individual-level variables" section below). The final sample comprises 48 029 respondents, with country-specific sample sizes ranging from 1 277 cases in Japan to 7 366 cases in Canada.

[7] We exclude Cyprus (see note 1) because of a very high share of literacy-related non-respondents (OECD, 2013), the Russia Federation because of concerns about data quality, and Australia because it does not provide a public-use file.

[8] We do not impute the other variables because the low proportions of missing data on these measures do not justify the considerable computational effort for obtaining country- and gender-specific imputations.

## Individual-level variables

The unique feature of PIAAC is the availability of direct, high-quality measures of respondents' actual skills. All countries that participated in PIAAC administered test items to assess the reading and text comprehension skills (literacy) and practical mathematical skills (numeracy) of participants. To limit respondent burden, each participant received only a relatively small number of test items, rendering individual competence estimates quite uncertain. PIAAC therefore provides ten plausible values rather than a single competence score for each case. To appropriately handle the plausible values (as well as the multiply imputed values for parental education and occupational status), we run all analyses ten times. We then use the appropriate rules for multiplying imputed data to obtain final point estimates, standard errors, and p-values (Little and Rubin, 2002).[9]

Occupational status is measured as the score on the International Socio-Economic Index of Occupational Status (ISEI) (Ganzeboom, De Graaf, and Treiman, 1992). We assign scores based on one-digit 2008 International Standard Classification of Occupation (ISCO-08) codes. For respondents who worked at the time of interview ISCO-08 codes refer to the current job. For those who did not work at the time of interview (but stopped working no more than five years ago) codes refer to the respondent's last job. All analyses that have occupational status as the dependent variable are qualitatively similar when we restrict the sample individuals who were employed at the time of interview (results available upon request).The one-digit ISCO-08 groups workers into ten broad occupational categories. It would be preferable to assign occupational status using occupational categories at the two- or higher-digit level, but unfortunately four countries in our sample only provide one-digit codes in their PIAAC public use file. To ensure consistency we use the one-digit version of ISCO-08 for all countries in the main analysis. In supplementary analyses (available upon request), we explored the consequences of using two-digit occupational codes for the 17 countries where these are available. The results were very similar to those reported above.

We repeated parts of the analysis with the respondent's rank in the distribution of monthly earnings as the dependent variable. For all countries except four PIAAC provides the percentile rank. For respondents in Austria, Canada, Germany, Sweden, and the United States, only the decile rank is available. In these cases, we multiplied the latter by 10. The country-level regressions reported in Figure A B.1 include an indicator variable that takes the value one for these for countries and the value zero for all others.

Educational attainment is measured using the respondent's highest educational degree. PIAAC provides the highest degree in terms of the 1997 revision of the International Standard Classification of Education (ISCED) (OECD, 1999). We classify respondents as less-educated if their highest degree is at ISCED Levels 0–2 and as intermediate-educated if they have attained ISCED Levels 3-4. This corresponds to the highest degree being at the lower secondary level or below and at the upper secondary or non-tertiary post-secondary level, respectively.

Some of our analyses include the following control variables (or a subset thereof): Sex (dummy variable); potential work experience (linear splines with knots at 10, 20 and 30); foreign-birth/foreign-language status (four categories: born in survey country and test

[9] In fact, this would have been necessary even in the absence of multiple plausible values because we used multiple imputation to replace missing values on individual-level variables (see above).

language is first language; born in survey country and test language is not first language; born in foreign country and test language is first language; born in foreign country and test language is not first language); parental educational attainment (three categories: no parent has completed upper secondary education; at least one parent has completed upper secondary education; at least one parent has completed tertiary education); respondent was self-employed in last/current job (dummy variable).

## Country-level predictors

To construct the (fully adjusted) skills gap measure, we run country-specific regressions with literacy and numeracy skills as the dependent variables and with the sample restrictions matching those of the main analysis. The regressions control for sex, age (five-year groups), potential work experience, foreign-birth/foreign-language status, and parental education. We adjust the skills gap for these characteristics because they are readily observable and because we want to isolate the additional information conveyed by an individual's educational degree. The literacy/numeracy gap for a given country simply is the coefficient estimate on having intermediate rather than low formal qualifications in the country-specific regression. Our final measure is the unweighted average of the literacy and numeracy gaps for each country.

To measure the internal homogeneity of the two educational groups, we first compute the residuals from the country-specific regressions used in constructing the skills gap measures. For each educational group and for both literacy and numeracy, we then calculate the standard deviation of the residuals as a straightforward measure of within-group heterogeneity. The resulting four standard deviations (literacy, less educated; numeracy, less educated; literacy intermediate educated; numeracy, intermediate educated) turn out to be strongly positively correlated (Heisig, forthcoming). To reduce the dimensionality, we run a principal factor analysis of the four standard deviations.[10] The first factor loads positively on all four standard deviations and has an eigenvalue of 2.44 (averaged across the ten plausible values). The internal consistency of is high, with the value of Cronbach's alpha (standardised) being equal to .83 (again, averaging across the ten plausible values). We reverse-code the factor scores to arrive at a measure of within-group homogeneity (i.e. higher values indicate greater homogeneity). We refer to this measure as the index of internal homogeneity.

To examine whether emphasis on occupation-specific skills explains variation in the labour market disadvantage of less-educated adults, we use Bol and van de Werfhorst's (2013) vocational orientation index. This index is based on the proportion of students in upper secondary education who are enrolled in a vocational programme, as provided in two sources: OECD (2006, Table C2.5) and UNESCO's online database (http://data.uis.unesco.org/). Values refer to 2004 (OECD) and 2006 (UNESCO) or the closest year available. Bol and van de Werfhorst constructed this index by running a principal factor analysis. They report an eigenvalue of 1.87 (Bol and van de Werfhorst, 2013:295) for the underlying factor. Using the raw data, we calculate Cronbach's alpha as .96.

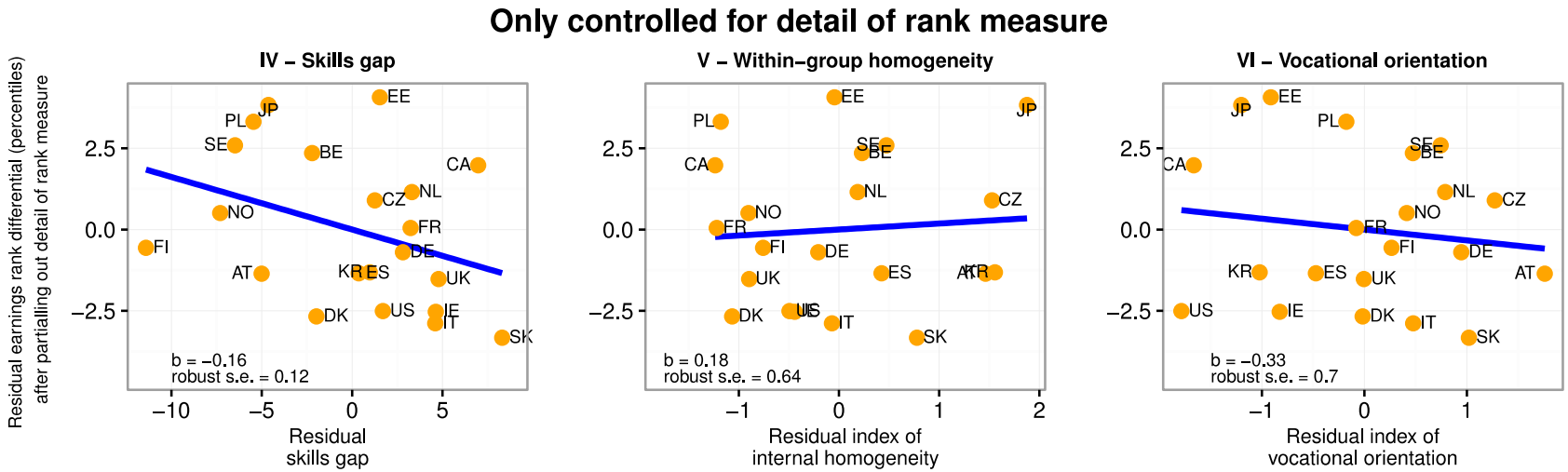
To measure the extent of tracking in secondary education, we use the external differentiation index by Bol and van de Werfhorst (2013). The index is based on a

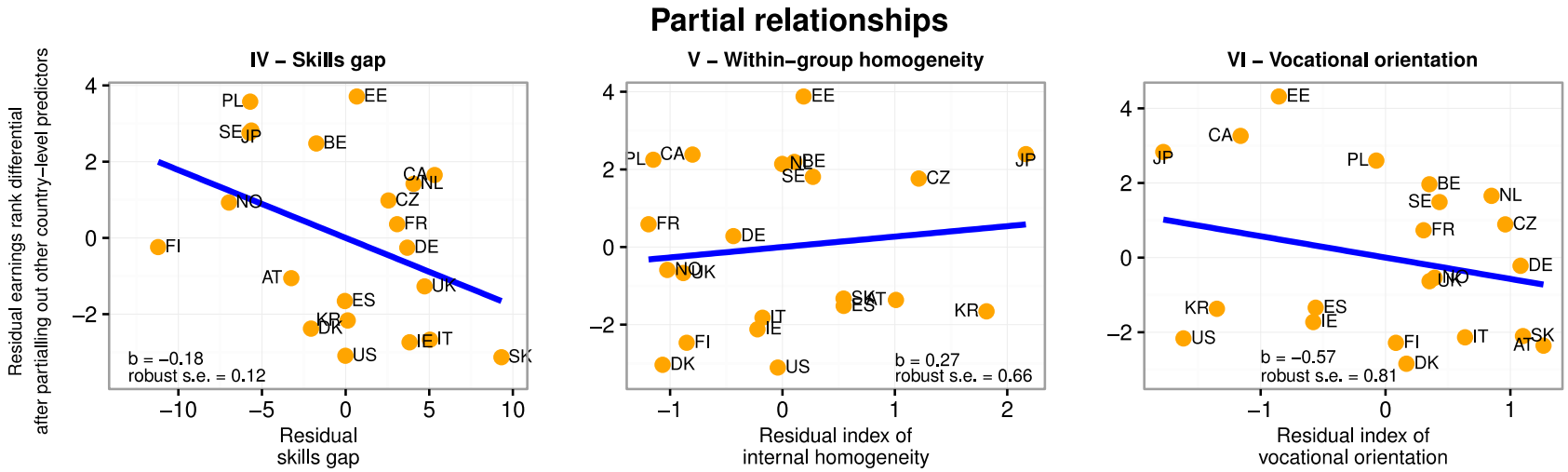
[10] Using the first component from a principal component analysis yields practically identical results (available upon request).

principal factor analysis of three measures: age of first selection into different tracks (reverse coded), number of tracks available at age 15, and length of tracked education as a proportion of the total duration of primary and secondary education. Values for these variables refer to 2003 (age of first selection and number of tracks at age 15) and 2002 (length of tracked curriculum) or the closest year available (for details, see Bol and van de Werfhorst, 2013). The factor underlying the index has an eigenvalue of 1.76 (Bol and van de Werfhorst, 2013:294). Based on the raw data provided in their data set, we calculate a standardised Cronbach's alpha of .87.

# Annex B. Additional results

**Figure A B.1. Aggregate skills distributions, vocational orientation, and earnings rank differential between less- and intermediate-educated adults**






*Note*: Dots represent fully adjusted ISEI gap between less- and intermediate-educated adults based on country-specific individual-level regressions. Lines are country-level relationships between the ISEI gap and the different predictors. Relationships in the top row are only adjusted for a dummy variable that indicates the detail of the earnings rank measure for a given country. As discussed in the text, we have data on percentile ranks for all countries except Austria, Canada, Germany, Sweden, and the United States. In the latter we used the decile rank, multiplied by ten. The bottom row shows partial relationships after further accounting for the other two country-level predictors. b = estimated regression slope; robust s.e. = robust (HC3) standard error for slope estimate.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.

**Table A B.1. Random-intercept models of earnings rank (percentile of monthly earnings)**

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | b | s.e. | b | s.e. |
| **Highest degree** | | | | |
| Low (ISCED 0-2) | Ref. | Ref. | Ref. | Ref. |
| Intermediate (ISCED 3-4) | 6.798*** | (0.332) | 6.945*** | (0.345) |
| | | | | |
| **Numeracy skills (standardised)** | 4.501*** | (0.156) | 4.125*** | (0.269) |
| | | | | |
| **Intermediate degree X numeracy skills** | --- | --- | 0.511 | (0.311) |
| | | | | |
| **Sex** | | | | |
| Male | 19.249*** | (0.247) | 19.237*** | (0.247) |
| Female | Ref. | Ref. | Ref. | Ref. |
| | | | | |
| **Potential experience in years (linear splines)** | | | | |
| 0-10 | 1.536*** | (0.063) | 1.535*** | (0.063) |
| 10-20 | 0.304*** | (0.051) | 0.303*** | (0.051) |
| 20-30 | 0.211*** | (0.048) | 0.214*** | (0.048) |
| 30+ | -0.059 | (0.078) | -0.068 | (0.078) |
| | | | | |
| **Foreign-birth/foreign-language status** | | | | |
| Native-born, test language is first language | Ref. | Ref. | Ref. | Ref. |
| Native-born, test language is not first language | 2.732*** | (0.739) | 2.729*** | (0.739) |
| Foreign-born, test language is first language | -3.683*** | (0.714) | -3.702*** | (0.714) |
| Foreign-born, test language is not first language | -4.146*** | (0.589) | -4.190*** | (0.590) |
| | | | | |
| **Parental education** | | | | |
| Both parents below upper secondary | Ref. | Ref. | Ref. | Ref. |
| At least one parent with upper secondary education | 2.067*** | (0.307) | 2.074*** | (0.307) |
| At least one parent with tertiary education | 1.420*** | (0.404) | 1.413*** | (0.404) |
| | | | | |
| **Self-employment status** | | | | |
| Self-employed | -9.339*** | (0.376) | -9.331*** | (0.375) |
| Wage and salary | Ref. | Ref. | Ref. | Ref. |
| | | | | |
| **Intercept** | 12.534*** | (0.750) | 12.369*** | (0.758) |
| **Random effects variances** | | | | |
| Intercept | 2.19 | | 2.20 | |
| Residual | 23 11 | | 23.10 | |
| *N* | 40 258 | | 40 258 | |

*Note*: Multilevel mixed-effects estimates with country-specific random intercepts. Sample restricted to 16-to-54-year olds who obtained their highest formal qualification in the country of assessment and who were not enrolled in full-time education at the time of interview. $^{*}$ $p < 0.05$, $^{**}$ $p < 0.01$, $^{***}$ $p < 0.001$ (two-tailed tests). b = estimated regression slope. s.e. = standard error.
*Source*: Authors' calculations based on OECD (2012), *Survey of Adult Skills (PIAAC) Database 2012*, www.oecd.org/skills/piaac/publicdataandanalysis/.