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ORIGINAL ARTICLE

Non-cognitive skills and individual earnings: new evidence from PIAAC

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Abstract We use the Programme for the International Assessment of Adult Competencies (PIAAC) data to construct several measures of non-cognitive skills and to analyze the relationship between non-cognitive skills and earnings. We construct measures for non-cognitive skills based on previous research in the field, such as self-reports and non-response in the background questionnaire. We also take advantage of the computer based nature of the assessment to explore the effects of other constructs such as skipped questions in the test, average time per question, average time per correct answer and the number of keyboard and mouse movements before answering a question. We find that, even after controlling for PIAAC scores, previously proposed proxies of non-cognitive skills (self-reports and survey non-response) are significantly associated with individual earnings. We also use these measures of non-cognitive skills to propose a correction of the PIAAC scores as a measure of cognitive skills in the earnings equation. By doing so, we observe that the relationship between earnings and PIAAC scores might be partially mediated by non-cognitive skills. However, our results also show that PIAAC test scores remain highly significant and as the main determinant of earnings after the correction.

Keywords Non-cognitive skills · Earnings · PIAAC data

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1 Introduction

Despite the important role that human capital occupies in economic thinking, its non-observable nature has historically limited its measurement. Since the original works by Becker (1962) and Mincer (1970, 1974), years of schooling has remained as the predominant measure of human capital. It was with the improvement in testing techniques and after the works by Hanushek, Woessmann and their coauthors (see Hanushek and Woessmann 2008, 2011, among others) that the use of international standardized achievement tests started to be seen as a more adequate measure of human capital. As argued by Hanushek and Woessmann (2008) achievement tests provide a better measure of human capital than years of schooling because (1) they better capture skills acquired out of the classroom and (2) because there is substantial cross-country variation in skills acquired at each level of education. Nowadays, there is a growing attention towards the distinction between two different types of skills that are embedded in human capital, namely cognitive and non-cognitive skills. A better understanding of the importance of human capital requires the construction of measures that distinguish between these two types of skills.

We understand by cognitive skills individuals' knowledge on basic competences, such as numeracy and literacy. Non-cognitive skills (also known as soft skills or socio-emotional skills) are individual patterns of behaviors, attitudes and personality that are not directly related to individuals' knowledge. Recent research has found that this distinction is important when studying the relationship between human capital and economic outputs both at an individual (Duckworth et al. 2011; Kautz et al. 2014; Heckman and Rubinstein 2001; Heckman et al. 2006, 2010) as well as at an aggregate level (Brunello and Schlotter 2011). At the same time, as noted by Cunha et al. (2010), the type of interventions required to foster cognitive and non-cognitive skills are notably different which intensifies the necessity of a better understanding of the role of each type of skills for policy recommendations.[1]

The main challenge for the study of non-cognitive skills is often the availability of proper measures. This is not the case for cognitive skills. The evaluation of cognitive skills notably improved during the last decades of the twentieth century, thanks to the advance in testing techniques. This fostered the emergence of standardized achievement tests allowing for international comparisons of cognitive skills. In contrast, non-cognitive skills and personality traits are less present in internationally comparable datasets. First, because the measurement of non-cognitive skills has been traditionally based on self-reports which raises several methodological concerns due to misreports, difficulties in interpersonal comparisons or the socially desirable response bias (see King et al. 2004; Paulhus 1984; Soest et al. 2011). Second, because attention to these types of skills is relatively new and started to grow at the beginning of the twenty-first century with the works by Heckman and his coauthors. However, recent research has provided alternative measures of non-cognitive skills. First, Borghans et al. (2011),

[1] See García (2016) for an overview of the evidence on policy interventions to foster non-cognitive skills.

Duckworth et al. (2011) and Segal (2012) show that scores on low-stake achievement tests are not only driven by high cognitive skills but also by high non-cognitive skills. This observation provides an opportunity to have more detailed measures of human capital that specifically distinguish between cognitive and non-cognitive skills. Second, there is an increasing research towards the possibility of using testing and survey behavior as a measure of non-cognitive skills. Hedengren and Stratmann (2012) and Hitt et al. (2016) proposed and validated survey non-response as a measure of non-cognitive skills, while Cheng et al. (2016) found that conscientiousness and openness to experience, two of the personality traits of the big five taxonomy, predict patterns of survey non-response.[2] Zamarro et al. (2016a, b, 2017) further develop and review non-response as a measure of non-cognitive skills.

The above findings raise several questions regarding the measurement of human capital. The first one is, how should one interpret scores of achievement tests? According to the conclusions of Borghans et al. (2011), Duckworth et al. (2011) and Segal (2012), scores on low-stakes achievement tests should not be interpreted as a measure of cognitive skills but as a broader notion of human capital that also includes non-cognitive skills. The second question concerns the possibility of obtaining separate measures for each type of skill. For instance, Borghans and Schils (2012) proposed a methodology to separate PISA scores into a cognitive and non-cognitive component. Third, and based on the findings of Hedengren and Stratmann (2012), Hitt et al. (2016), Cheng et al. (2016) and Zamarro et al. (2016a, b, 2017) one may ask about the possibility of using some already available and internationally comparable assessments to create and study non-cognitive skills.

In the present paper we use the PIAAC database to construct several measures of non-cognitive skills and include them in the Mincerian equation. We construct different types of measures for non-cognitive skills. On the one hand, we use the answers in three items of the PIAAC background questionnaire to obtain self-reported measures of non-cognitive skills. On the other hand, we follow Hedengren and Stratmann (2012) and Hitt et al. (2016) to construct measures based on survey non-response in the background questionnaire. Finally, we use some other measures based on the testing behavior rather than on the background questionnaire. In particular, we take advantage of the computer based nature of the PIAAC test, to construct measures that might be related to non-cognitive skills, such as time spent on each item in the test, skipped questions or the number of actions done with the mouse before answering an item. To the best of our knowledge, only skipped test items has been used before as a proxy for non-cognitive skills by Hernández and Hershaff (2014).

We use the proposed measures to analyze the association between non-cognitive skills and earnings in a Mincerian equation. Our results show that measures of non-cognitive skills proposed in previous literature (self-reports and non-response in a questionnaire) are significantly associated to earnings in all our specifications (with the exception of self-reports on cultural engagement). When looking at test-based measures, we find that skipped test items and not-attempted items are negatively and

[2] The association between non-response patterns and non-cognitive skills was already suggested by Groves et al. (2011) and Boe et al. (2002). Using PISA data, Balart (2017) shows that parental non-response in a questionnaire is negatively associated with their children's tests scores.

significantly associated to earnings in all specifications. However, these two measures are the ones that exhibit higher correlation with test scores so they might be capturing cognitive skills. Average time per correct answer is also statistically correlated to earnings. Additionally, we perform various robustness checks to test the validity of our measures of non-cognitive skills.

We also pay attention to the relationship between cognitive skills and earnings and attempt to provide an estimate for the effects of cognitive skills in the Mincerian equation after correcting for the effect of non-cognitive skills. In a recent article, Hanushek et al. (2015) use data from the PIAAC database to study the relationship between human capital and individual earnings. They show that PIAAC scores have explanatory power on earnings above and beyond years of schooling (the traditional measure of human capital). However, as emphasized in the psychology field (Wechsler 1940) and in the economics literature (Duckworth et al. 2011; Segal 2012) performance on achievement tests depends not only on cognitive but also on non-cognitive skills.[3] Therefore, it is not clear until what extent the association between PIAAC scores and earnings found by Hanushek et al. (2015) is driven by cognitive or non-cognitive factors. In other words, interpreting the results of Hanushek et al. (2015) in terms of cognitive skills may be problematic. We propose a correction of the PIAAC test scores using our proxies for non-cognitive skills. To do so, first we regress PIAAC test scores on non-cognitive skills and, in a second stage, we use the residuals of the previous regression as a corrected measure of cognitive skills. This correction is based on the finding by Cunha and Heckman (2008) and Cunha et al. (2010) that non-cognitive skills foster the development of cognitive skills, while the opposite is not true. Thus, the proposed measure only takes into account variation in cognitive skills that is orthogonal to our measures of non-cognitive skills. Despite reducing the size of the estimates of cognitive skills, cognitive skills remain highly significant and the main determinant of individual earnings after this (over) correction of PIAAC test scores.

As cautioned by Hanushek et al. (2015) an important drawback of studies based on cross-sectional international data such as PIAAC relies on the impossibility of obtaining causal results. Ideally, one would like to have an exogenous source of random variation in skills. However, this possibility is extremely limited in the context of international samples as here. Consequently, the present paper is mainly intended to enrich the study of the relationship between PIAAC test scores and earnings started by Hanushek et al. (2015) by providing measures of human capital that address the distinction between cognitive and non-cognitive skills.

The structure of the paper is the following. In Sect. 2 we describe the measures of non-cognitive skills that we use in our paper. Section 3 explains the empirical strategy. Section 4 describes the data. Section 5 presents the results on the association between non-cognitive skills and earnings. Section 6 shows the results after computing corrected measures for non-cognitive skills. Section 7 provides a heterogeneous analysis of the results by education, age and gender. Section 8 shows a number of robustness checks. Finally, Sect. 9 concludes.

[3] See Almlund et al. (2011) for an extensive review on this evidence.

2 Non-cognitive skills

A crucial aspect of our study relies on constructing reliable measures of personality and non-cognitive skills. We use evidence from previous research to do that. Previous literature has considered self-reported and non self-reported measures based on non-response in a questionnaire as a proxy for non-cognitive skills. We also take advantage from the computer based nature of the PIAAC test to construct non self-reported measures based on testing behavior.

2.1 Self-reported measures of non-cognitive skills

Self-reported variables have been used extensively as the main source of information on non-cognitive skills. PIAAC study is mainly designed to obtain standardized measures of cognitive skills of adult population and, unfortunately, it provides poor information on non-cognitive skills.[4] However, in the background questionnaire we found three items that can be related to individuals' personality and beliefs: cultural engagement, political efficacy and social trust. Participants have to give each statement a score ranking from 1 to 5. We use the following items:

Cultural engagement In the last 12 months, how often, if at all, did you do voluntary work, including unpaid work for a charity, political party, trade union or other non-profit organization? (The choice of answers is the following: "Never", "Less than once a month", "Less than once a week but at least once a month", "At least once a week but not every day", "Every day").

Cultural engagement is related to the frequency of doing voluntary work for non-profit organizations. This indicator of volunteering from PIAAC shows lower results for subpopulations with lower literacy skills (Grotlüschen 2017). Therefore, we would expect a positive relationship between this variable and individual earnings.

Social trust There are only a few people you can trust completely (the choice of answers is the following: "Strongly agree", "Agree", "Neither agree nor disagree", "Disagree", "Strongly disagree").

Social trust has been often identified as a personality trait (see Allport 1961 or Uslaner 1999, 2000, among others). According to Uslaner (1999), social trust is related to other traits such as optimism and the control capacity. So, we expect to observe a positive relationship between this variable and the level of earnings.

Political efficacy People like me don't have any say about what the government does (the choice of answers is the following: "Strongly agree", "Agree", "Neither agree nor disagree", "Disagree", "Strongly disagree").

[4] In the initial design, PIAAC was expected to include two specific questions addressing individuals' personality, in particular grit, self-discipline and locus of control. Unfortunately, these questions were dropped from the main study (OECD 2013).

Almond and Verba (1965), Campbell (1980) or Campbell et al. (1954) suggested that personality traits like self-esteem or personal effectiveness lies behind political efficacy. Therefore, we would expect a positive relationship between political efficacy and earnings.

Self-reports have often been subject to criticism, due to misreports, subjectivity or the socially desirable response bias studied by Paulhus (1984). Without a common metric, individual responses are not likely to be interpersonally comparable (see King et al. 2004; Soest et al. 2011). In the case of PIAAC, there is the additional problem that the above questions might provide incomplete information on individuals' non-cognitive skills.

In Sect. 8.3 and the "Online Appendix", we provide some additional measures of non-cognitive skills based on the proposal of Cabrales et al. (2014).

2.2 Non self-reported measures of non-cognitive skills

To overcome the lack of self-reported measures of non-cognitive skills, we use the PIAAC database and previous literature to construct non self-reported measures of non-cognitive skills.

Measures based on the background questionnaire

Recent research by Hedengren and Stratmann (2012), Hitt et al. (2016), Cheng et al. (2016) and Zamarro et al. (2016a, b, 2017) proposes the use of survey effort, measured by non-response rates in a questionnaire, to capture non-cognitive skills.

This approach suggests the use of non-response as a valuable proxy of socio-emotional skills because of several reasons. First, the time-consuming nature of filling out a questionnaire provides a task-based measure which, differently from self-reports, is interpersonally comparable. Second, the non-challenging nature of the tasks disregards cognitive skills as determinants of non-response. Third, this information is readily available in many international data sets that do not report individual information on non-cognitive skills. As Hedengren and Stratmann (2012) indicate: "surveys contain a valuable but neglected source of data: what respondents do not say.(...). When a respondent forgets to fill answers to some questions on the survey form, or refuses to provide an answer to the interviewer, we gain important information about the respondent". Hedengren and Stratmann (2012) validate survey non-response as a measure of personality by showing that it is correlated with other traditional measures of conscientiousness and that it has predictive power on individuals' earnings and longevity. Hitt et al. (2016) show that the correlation between survey non-response and earnings is not due to simultaneity bias by using longitudinal data from NLSY 79. Zamarro et al. (2016a, 2017) further develop and validate measures of carelessness in survey response as a proxy for non-cognitive skills.

Hedengren and Stratmann (2012) found that survey non-response is both correlated with cognitive and non-cognitive skills and, consequently, it may be interpreted as a measure of the two types of skills. Indeed, as recognized by Borghans et al. (2008), separating cognitive ability from non-cognitive skills is not only empirically, but also

conceptually complicated. However, in the line of Hitt et al. (2016), we consider survey nonresponse to be a measure of non-cognitive skills rather than cognitive ability (despite being correlated with the two). Our first argument to support this interpretation is that filling out a questionnaire is a time consuming but not a mentally challenging task, which is conceptually related to personality and non-cognitive skills. Second, in our estimations, the correlation between survey non-response and PIAAC scores is relatively small (-0.09 and -0.01 for "don't know" and "refused" answers, respectively). Third, the correlation between survey non-response and IQ scores found by Hedengren and Stratmann (2012) may not be motivated by the possibility that non-response is measuring cognitive skills but by the opposite effect, i.e. test scores are measuring non-cognitive skills. Indeed, non-cognitive skills have been found to be important for performance on IQ tests due to the low stakes nature of the latter. As shown by Borghans et al. (2008); Duckworth et al. (2011); Gneezy and Rustichini (2000) and Segal (2012), scores of low performers on IQ tests can be improved by offering a reward. As mentioned above, some of this literature have explicitly proposed a decomposition of test scores into a cognitive and a non-cognitive component, see Borghans and Schils (2012).

We use average non-response rates in the background questionnaire that accompanies the PIAAC test as a measure of non-cognitive skills. PIAAC distinguishes between two different categories of survey non-response: "Don't know" and "Refused to answer". We compute the proportion of these two categories of answers in the questionnaire. Based on questions on individual finances, Riphahn and Serfling (2005) show that the observable characteristics of "don't know" answerers differ substantially from those of individuals providing either valid responses or refusals. This indicates that the two types of non-response might be motivated by different reasons. In a similar line, Shoemaker et al. (2002) claim that the two types of non-response should be treated differently. In particular, they show that more sensitive questions get more refusals. In contrast, the two types of non-responses appear more often for questions that require more cognitive effort to be answered. However, this association is stronger for "don't know" answers.[5]

Test-based measures

A second approach to obtain task based measures of non-cognitive skills is based on testing behavior. Achievement tests such as PISA or PIAAC assessments are intended to provide standardized measures of individuals' cognitive skills. However, as pointed out by Borghans et al. (2011), Duckworth et al. (2011) or Segal (2012), high scores in achievement tests result not only from high individual cognitive abilities but also from high non-cognitive skills such as motivation or perseverance. The low stakes nature of achievement tests puts forward non-cognitive skills, such as motivation or persistence, as an important element for performing well. This is well illustrated by Almlund et al. (2011): "A smart child unable to sit still during an exam or uninterested in exerting much effort can produce spuriously low scores on an IQ test".

[5] In a robustness check, we sum the two categories in one variable.

Based on this idea several authors proposed the use of non self-reported measures of non-cognitive skills. One of the more promising identifications follows from Borghans and Schils (2012), who propose to use the performance drop experienced by test takers as a measure of non-cognitive skills. However, the PIAAC test has a multistage adaptive design in which an algorithm drives the participant to different exercises depending on their score on previous test items. This makes not feasible the use of the performance decline as a measure of non-cognitive skills. Moreover, as recognized by Borghans and Schils (2012), their strategy is too imprecise at the student level.

Hernández and Hershaff (2014) propose using test taking behavior as a measure for non-cognitive skills. According to them, in a test with no penalty for wrong answers and no time constraints (as PIAAC) skipping questions is not related with strategic reasons or knowledge but with a low interest to perform well in the test. In other words, when guessing has no penalty, not doing so denotes low motivation towards the test. Hernández and Hershaff (2014) show that a higher incidence of skipping questions is predictive of poorer future educational outcomes even after controlling for students' test scores. Therefore we expect the incidence of unanswered items to be negatively associated with individual earnings.

PIAAC distinguishes between two different types of non-responded items in the test: skipped items and not attempted items. Skipped items are those that the test taker does not answer after having them on the screen for more than 5 s. Not attempted items are blank questions for which the test taker spends less than 5 s on them, which means that he does not even try to solve the question.[6] The latter includes unreached questions in those cases where respondents decided not to finish the test (even though there is no time limit). We follow the PIAAC distinction and we construct the variables "Skipped" and "Not Attempted" as the average rate of test-items in each of these two categories for every test taker in numeracy and literacy questions.

Other test-based measures

The computer-based part of the PIAAC assessment contains information that is not generally available in paper based achievement tests. This includes time spent in responding each test item or the number of actions done before item completion (e.g., clicking and typing responses). Even though these variables have not been used before in the literature, they might be useful to gain additional information on the personality of the test taker.

One can reasonably argue that in a test with no time limitation as PIAAC, time per question might be related with non-cognitive skills. We might think in two possible hypotheses. On one hand, a more motivated test taker may be willing to spend more time per question. In that case time per question should indicate higher non-cognitive skills. On the other hand, time per question could indicate some other non-cognitive skills such as ability to stay focused or grit/thrift, in which case more time per question would indicate a lower level of non-cognitive skills.

[6] Skipped items were graded as wrong in the computation of PIAAC scores, while not attempted were graded as missing. Test takers were not aware about this distinction (OECD 2013).

We might also be especially interested in time needed for correct answers, which may indicate a more efficient use of cognitive skills. Therefore we construct two measures, average time per test-item and average time per correct test-item in numeracy and literacy tests.

The number of actions executed before completion of a test item may also be informative about (lack of) self-confidence or hesitation/resolution ability of the test-taker. We expect a higher number of actions to denote a lower level of non-cognitive skills. As in the previous case, we will distinguish between the number of actions per test-item and the number of actions needed per correct test-item in numeracy and literacy tests.

Unfortunately, the absence of specific measures of personality in the PIAAC database prevents us from reaching more precise conclusions about which traits may be captured by these additional measures provided in the computer based assessment.

As we show below, several of our test based measures (especially skipped items and non-attempted items) exhibit high correlation with PIAAC test scores. We believe that this implies that some of the results when using these variables might be quite mechanical rather than driven by non-cognitive skills. However, we show that they have explanatory power on earnings even after controlling for PIAAC test scores.

3 Empirical strategy

Our departing point is the work by Hanushek et al. (2015). In a recent paper these authors introduce PIAAC scores as a measure of human capital in a standard Mincerian equation. In particular they estimate:

$$\ln(y_i) = \alpha + \beta_1 C_i + \theta_1 S_i + \mu_1 E_i + \mu_2 Ei^2 + \mu_3 G_i + \varepsilon_i \quad (1)$$

where y_i is the hourly wage of individual i. S_i denotes years of schooling, E_i denotes years of labor market experience, G_i is a female indicator, and ε_i is a stochastic error term. C_i is individual's i score in the PIAAC test. The log-linear model has been a recurrent specification for the earnings equation. Heckman and Polachek (1974), specifically addressed the question of the functional form of the earnings equation finding support for the log-linear specification. Welland (1978) confirms their results when including cognitive ability in the right hand side of the equation.

Hanushek et al. (2015) show that PIAAC scores are positively associated with individual earnings. They interpret this finding as evidence on the importance of cognitive skills for individual earnings. However, there is a growing literature that highlights that scores in low stakes tests such as PIAAC are largely influenced by non-cognitive skills such as motivation. A natural question arising from these results is how the association between internationally standardized test scores and individual earnings (Hanushek et al. 2015) can be attributed to the cognitive or the non-cognitive components of human capital.

To answer this question we extend the model estimated by Hanushek et al. (2015) to include different measures of non-cognitive skills. Therefore, we estimate:

$$\ln(y_i) = \alpha + \beta_1 C_i + \beta_2 \, NC_i + \theta_1 S_i + \mu_1 \, E_i + \mu_2 \, Ei^2 + \mu_3 \, G_i + \varepsilon_i \tag{2}$$

where NC_i denotes non-cognitive skills, measured by the variables described above. NC_i may be a variable or a vector of variables depending on whether we include one or many of the measures for non-cognitive skills in the regression.

Secondly, we propose an alternative path to study how non-cognitive skills may affect the previous estimates of the relationship between earnings and cognitive skills found by Hanushek et al. (2015). According to Borghans et al. (2011), Duckworth et al. (2011) and Segal (2012) non-cognitive skills can affect PIAAC scores directly through testing behavior. However, there is a second channel through which non-cognitive skills can affect PIAAC test scores which is the formation of cognitive skills. According to Cunha and Heckman (2008) and Cunha et al. (2010), non-cognitive skills play an important role in the development of cognitive skills while the same is not true in the other way around. This second channel is more subtle and more difficult to detect as it is directly embedded in the cognitive skills accumulated by test takers. However, we might be interested in trying to have an idea on the importance of this "formation" role of non-cognitive skills. To do so we implement the following two-stage estimation of Eq. (1). In an initial step we regress:

$$C_i = \lambda \; NC_i + v_i \tag{3}$$

And then we use the residuals of this estimation $\hat{v}_i$ as a corrected measure of cognitive skills in Eq. (1), that is:

$$\ln(y_i) = \alpha + \beta_1' \hat{v}_i + \theta_1 \, S_i + \mu_1 \, E_i + \mu_2 \, Ei^2 + \mu_3 \, G_i + \varepsilon_i \tag{4}$$

The objective of this correction is to use in the Mincerian equation estimated by Hanushek et al. (2015) only the variation in cognitive skills that is orthogonal to non-cognitive skills. Grönqvist et al. (2017) implement a similar correction, but reversing the dependent and explanatory variables.[7] Interpretation of these results should be made with caution especially when using test based measures of non-cognitive skills. There are obvious concerns arising from using this type of correction. First, note that if the proposed measures of non-cognitive skills are also capturing cognitive skills, as it is very likely for test based measures, we will be overcorrecting the measures of cognitive skills.

As we show in our results, cognitive skills maintain its prominent role in the relationship with earnings. Thus, despite the potential overcorrection that we might be implementing, our results reinforce the importance of cognitive skills in the earnings equation. This (partially) mitigates the concern raised by the literature on non-cognitive skills towards the possibility that the role of cognitive skills have been overestimated.

[7] In their study, they analyze the intergenerational transmission of non-cognitive skills. In the absence of measures of parental non-cognitive skills, they use schooling information (more precisely, grades on non-theoretical subjects as well as survey information on educational aspirations and social interactions) to construct such a measure. As this measure is very likely to be also capturing parents' cognitive ability, they regress it on the measure of parental test scores to net out any cognitive ability captured by this schooling information.

4 Data

In its first round, PIAAC provides internationally comparable data about skills of adult population (16–65 years) in 24 countries. These countries are Australia, Austria, Belgium (albeit just Flanders), Canada, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Slovak Republic, Spain, Sweden, the Russian Federation, the United Kingdom (specifically England and Northern Ireland), and the United States. In our study, we exclude countries for which continuous data on earnings is not available: Austria, Canada, Germany, Sweden and the United States. Russian Federation is excluded because data is still at a preliminary stage and subject to modification (OECD 2013). Australia and Cyprus are not included because data is not publicly available. Therefore, we are left with 16 countries in our estimations.

PIAAC is intended to measure cognitive skills in three different domains: numeracy, literacy and problem solving. In the present paper we follow Hanushek et al. (2015) and consider the numeracy domain as a measure for cognitive skills.[8] Problem solving domain was optional and Cyprus, France, Italy and Spain did not take that option. Moreover, problem solving involves longer questions and less test items, which may affect some of our measures such as time per question or the number of skipped items.

Skills are measured preferably with a computer-based multiple item adaptive test, which drives test takers through different test paths depending on their performance on previous test items. The advantage of the computer-based assessment is that it offers rich information on test performance, in particular time used in each test item or the number of actions before completing a test item (e.g., clicking and typing responses). Therefore, in order to use this additional information and to have comparable subsamples, we restrict our analyses to the computer-based assessment. PIAAC assessment also gathers information about respondents labor market status, education, earnings, experience, socio-demographic characteristics and attitudes towards learning by means of a background questionnaire filled in before doing the test. The assignment of test takers to the computer-based test is clearly non-random as it depends on having previous experience with computers as well as on successful performance on an ICT test (previous to the assessment). Thus, our results cannot be extended to the group that did the paper based assessment. According to the PIAAC technical report (OECD 2016), on average a 73.5% of the respondents took the computer based form of the assessment.

Moreover, the adaptive multistage design of the computer based assessment might have some implications in the computation of test based measures of non-cognitive skills. In particular, given that best performers are driven to more difficult questions, we might expect that time per question, time per correct answer and the number of non-attempted or skipped items to be higher for more difficult items.[9]

[8] Our results are robust to consider literacy or problem solving domains instead of numeracy. These results are available in the "Online Appendix" and briefly commented in Sect. 8.6.

[9] The consequences that the adaptive design may have on actions per test item and on actions per correct answer are unclear.

We follow Hanushek et al. (2015) to obtain the variables included in Eq. (1). Therefore, we use the logarithm of gross hourly wages as the dependent variable of the model.

In PIAAC, skills are a latent variable that is estimated using item-response-theory models (see OECD 2013 for details). PIAAC provides 10 plausible values, instead of only one individual score, for each respondent and each skill domain. Using the average of the 10 plausible values provides an unbiased estimate of individual skills in each domain.

Years of schooling is measured as the number of years of education equivalent to the highest level of education obtained. Experience is measured as actual work experience, indicating the number of years the person has been working at least 6 months in full-time or part-time work.[10] As mentioned in Hanushek et al. (2015), whose analysis is by country, there is considerable variation across countries in average years of schooling and actual work experience in the sample of full-time prime-age workers.

Given the stratified and clustered nature of the PIAAC sample, we use PIAAC weights in all our regressions to ensure that national samples are representative of each country population. Furthermore, because of the complex sample design in PIAAC, the standard errors are computed using the replication method. For PIAAC research, the so called *jacknife* replicate procedure was chosen (for more detail see Efron 1982 or Levy and Lemeshow 1999).[11]

We use country fixed effects in all our pooled regressions to account for country idiosyncratic characteristics.

With the aim of obtaining a homogenous sample with strong labor-force commitment we also follow Hanushek et al. (2015) in limiting the sample to prime age non self-employed full-time workers. These are defined as workers between 35 and 54 years of age and working at least 30 h/week. As Hanushek et al. (2015) point out, by doing this we avoid the influence of some factors such as family demands or health limitations. However, we might be obtaining lower estimates for skills as long as higher skills also lead to higher employability. Finally, to avoid the influence of outliers we also trim the top and bottom 1% of the wage distribution of each country to prevent the influence of outliers.[12,13]

Table 1 provides descriptive statistics of the variables that we use in our estimations. PIAAC scores are measured on a 500-point scale. To simplify the interpretation, PIAAC scores as well as all our measures for non-cognitive skills are standardized to

[10] Actual work experience could be endogenous to the skills variable and one could argue that experience is actually one of the channels by which skills could affect earnings. Therefore, as in Hanushek et al. (2015), we perform our main estimations by using potential work experience calculated as age minus years of schooling minus six. In Sect. 8.2 we discuss again this issue. Results do not change significantly and they are available upon request.

[11] The correct estimation of standard errors with PIAAC data is done with the Stata command, *repest* (see Stata help for more details).

[12] Hanushek et al. (2015) suggest that the first source for outliers seems to be errors in data entry or coding.

[13] We also restricted the sample to only native-language speakers (about 95% of our sample), as non-cognitive test based measure such as average time per test item or proportion of skipped items could be affected by the language of assessment. Results hardly change and are available upon request.

Table 1 Descriptive statistics

Variable	Mean	SE	Min.	Max.
Gross hourly wage in PPP US$	18.06	9.65	1.91	105.35
PIAAC score in numeracy	287.01	44.86	104.83	454.13
Years schooling	13.50	2.83	3.00	22.00
Experience (years)	20.97	7.55	0.00	50.00
Female (share)	0.39	0.49	0.00	1.00
Non-cognitive skills test based measures				
Time per test item (s)	73,572.70	81,047.57	5456.76	6,372,903.00
Time per correct test item (s)	67,048.45	28,130.70	6743.38	619,218.44
Skipped	0.05	0.10	0.00	1.00
Not attempted	0.02	0.07	0.00	1.00
No. of actions per test item	2.69	1.35	0.00	55.10
No. of actions per correct test item	2.57	1.46	1.00	51.00
Non-cognitive skills measures from background questionnaire				
Don't know	0.0018	0.0051	0.0000	0.0800
Refused to answer	0.0004	0.0021	0.0000	0.0408
Self-reported non-cognitive skills				
Cultural engagement	1.58	0.98	1.00	5.00
Political efficacy	2.68	1.24	1.00	5.00
Social trust	2.30	1.11	1.00	5.00
Observations	14,591			

Observations per country: Belgium (899), Czech Republic (657), Denmark (1.392), Estonia (1032), Finland (1095), France (1280), Ireland (662), Italy (708), Japan (831), Korea (867), Netherlands (800), Norway (1152), Poland (334), Russian Federation (352), Slovak Republic (645), Spain (893), United Kingdom (1344)

have a zero mean and a standard deviation equal to one with respect to the pool of countries that we use in our estimations.

5 Results: non-cognitive skills in a Mincerian equation

We focus our estimations on the pooled sample containing all individuals of all countries with available information on earnings.

5.1 Non self-reported measures of non-cognitive skills using the PIAAC database

Our non self-reported measures of non-cognitive skills are test-based measures as well as non-response in the background questionnaire.

In Table 2, we show the correlations between PIAAC scores and the different proxies for non-cognitive skills. As expected, skipped and not-attempted questions present a

Table 2 Correlation matrix between PIAAC score in numeracy and non-cognitive skills measures

	PIAAC score in numeracy	Time per test item	Time per correct test item	Skipped	Not attempted	No. of actions per test item	No. of actions per correct test item	Don't know	Refused to answer	Cultural engage-ment	Political efficacy	Social trust
PIAAC score in Numeracy	1											
Time per test item	0.06	1										
Time per correct test item	0.21	0.32	1									
Skipped	− 0.52	− 0.04	− 0.11	1								
Not attempted	− 0.25	0.11	− 0.08	0.40	1							
No. of actions per test item	0.12	0.11	0.32	− 0.27	− 0.22	1						
No. of actions per correct test item	0.05	0.09	0.30	− 0.07	− 0.03	0.78	1					
Don't know	− 0.09	0.01	0.03	0.07	0.04	− 0.02	0.00	1				
Refused to answer	− 0.01	− 0.01	− 0.01	0.02	0.05	− 0.02	− 0.01	0.01	1			
Cultural engagement	0.10	− 0.01	0.00	− 0.07	− 0.03	− 0.01	− 0.02	− 0.02	− 0.03	1		
Political efficacy	0.18	0.01	0.02	− 0.14	− 0.06	0.04	0.02	− 0.05	0.01	0.07	1	
Social trust	0.15	− 0.01	0.01	− 0.12	− 0.04	0.02	0.00	− 0.04	− 0.01	0.10	0.30	1

Time per test item: average time spent in numeracy and literacy tests, time per correct test item: average time spent in responding correct answers in numeracy and literacy tests, skipped: proportion of skipped/no response questions in the in the numeracy and literacy tests (more than 5"), not attempted: proportion of not reached/not attempted questions in the in the numeracy and literacy tests, No. of actions per test item: average number of actions in the numeracy and literacy tests, No. of actions per correct test item: average number of actions in the numeracy and literacy tests, don't know answer: proportion of "Don't Know" answers in the background questionnaire, refused answer: proportion of "refused" answers in the background questionnaire

negative notable correlation with PIAAC proficiency, as they are directly based on test items. Time per correct test item also shows an important positive correlation with PIAAC scores. As we can see the remaining measures show a low correlation with PIAAC scores.

In Table 3 we present the results of estimating Eqs. (1) and (2). In the first three columns we can see the estimates for Eq. (1): first with only years of schooling as a measure of human capital, second with only PIAAC scores, i.e., the score in numeracy and third with years of schooling and PIAAC scores together. Even though our pooled sample includes fewer countries than the one in Hanushek et al. (2015), our estimates do not present significant differences from theirs. One standard deviation increase in PIAAC numeracy scores is associated with 18.7% higher earnings and 10% after controlling for years of schooling.[14] By comparing columns (1) and (3) we observe that the coefficient of years of schooling decreases by a 16.4% after including numeracy test scores. Hanushek and Woessmann (2008) attribute the reduction experienced in the coefficient of years of schooling together with the larger value of the adjusted R^2 in column (2), to the better measure of human capital provided by test scores in comparison to years of schooling. An alternative interpretation of this finding is in terms of returns to schooling and ability bias. If we interpret θ_1 as returns to schooling, the observed reduction might be associated to the ability bias, see Card (1999) among others.[15]

In the subsequent columns we include our constructs for non-cognitive skills. In columns (4), (6) and (8) proxies for non-cognitive skills are included in separate regressions while in columns (5), (7) and (9) we include all of them as explanatory variables in the same regression.

We estimate first the effects of non-cognitive skills without controlling for the measures of human capital, i.e., years of schooling and PIAAC scores. We add controls for PIAAC score in numeracy test in columns (6) and (7) as well as years of schooling in columns (8) and (9).

Our estimates are consistent with previous studies that proposed survey non-response as a measure of non-cognitive skills. As in Hedengren and Stratmann (2012) and Hitt et al. (2016) the ratio of "don't know" answers in the questionnaire is negatively associated with individual earnings. When not controlling for PIAAC scores and level of education, we find that one standard deviation in questionnaire non-response, is associated with 8.54% lower earnings. We complement the findings of Hedengren and Stratmann (2012) and Hitt et al. (2016) by showing that this result is robust to controlling for PIAAC test scores. When controlling for PIAAC scores and level of education, one standard deviation in questionnaire non-response, is associated with a 3.58% reduction in earnings. We also see that the different types of non-response, i.e., "don't know" and "refused to answer", have opposite effects (also when included in separate regressions), even though the proportion of "refused to answer" is not

[14] The (small) differences arising with respect to the estimates in Hanushek et al. (2015) are completely due to the fact that we only have available data for a smaller set of participating countries.

[15] In contrast, the coefficient of years of schooling does not change when we control for measures of non-cognitive skills but not for cognitive skills. By doing this exercise, the value of θ_1 is very similar to the one estimated in column (1) of Table 3 (its value varies from 0.724 to 0.768).

Table 3 Non-cognitive skills in the Mincerian equation (non-self reports)

	(1)	(2)	(3)	(4) Separated	(5) Joint	(6) Separated	(7) Joint	(8) Separated	(9) Joint
PIAAC score in numeracy		0.187***	0.103***			0.177***–0.195***	0.184***	0.0982***–0.110***	0.106***
		(0.007)	(0.008)			(0.007)	(0.008)	(0.008)	(0.009)
Years of schooling	0.0767***		0.0641***					0.0637***–0.0642***	0.0630***
	(0.002)		(0.002)					(0.002)	(0.002)
Non-cognitive skills test based measures									
Time per test item				−0.00285	−0.00277**	−0.00782	−0.00264	−0.00472	−0.000433
				(0.002)	(0.001)	(0.005)	(0.002)	(0.004)	(0.002)
Time per correct test item				−0.00797	−0.0115*	−0.0403***	−0.0379***	−0.0331***	−0.0321***
				(0.007)	(0.007)	(0.007)	(0.008)	(0.006)	(0.007)
Skipped				−0.0897***	−0.109***	−0.0175**	−0.0309***	−0.00904	−0.0158**
				(0.006)	(0.008)	(0.007)	(0.008)	(0.007)	(0.008)
Not attempted				−0.0211***	0.0168**	0.0222***	0.0289***	0.0149*	0.0189*
				(0.007)	(0.008)	(0.007)	(0.009)	(0.008)	(0.011)
No. of actions/test item				0.00612	−0.0306***	−0.0101**	−0.00968	−0.00841*	−0.00403
				(0.006)	(0.009)	(0.005)	(0.008)	(0.005)	(0.008)
No. of actions/correct test item				−0.000352	0.0211***	−0.00530	0.0103	−0.00585	0.00423
				(0.005)	(0.008)	(0.004)	(0.007)	(0.004)	(0.007)
Non-cognitive skills measures from Background questionnaire									
Don't know answer				−0.0854***	−0.0770***	−0.0569***	−0.0541***	−0.0358**	−0.0337**
				(0.015)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)

Table 3 continued

	(1)	(2)	(3)	(4) Separated	(5) Joint	(6) Separated	(7) Joint	(8) Separated	(9) Joint
Refused to answer				0.0544	0.0570*	0.0613*	0.0514	0.0190	0.0126
				(0.034)	(0.034)	(0.033)	(0.033)	(0.029)	(0.029)
Adj. R2		0.361	0.456	0.272–0.301	0.306	0.359–0.361	0.368	0.455–458	0.459
No. of observations		14,591	14,523	14,450–14,523	14,518	14,450–14,523	14,518	14,450–14,523	14,450

Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

significantly correlated with earnings. The existence of differences in the "refused" and "don't know" categories of non-response has been emphasized by Riphahn and Serfling (2005) and Shoemaker et al. (2002). If we collapse the two measures in a single variable of non-response, the results are similar to the ones obtained for "don't know" answers.[16] Thus, consistently with Hedengren and Stratmann (2012) and Hitt et al. (2016) when using a unique category, survey non-response is negatively correlated with earnings. Moreover, our results suggests that this relationship is exclusively driven by a specific type of non-response: "don't know" answers.

Some of the test based measures are significantly associated with individual earnings in most of the specifications. Time per correct answer and skipped test items are significantly and negatively associated with individual earnings, respectively. The size of these coefficients implies that one standard deviation decrease in the average time spent per correct answer or in the incidence of skipping test items is associated with 3.21 and 1.58% higher earnings, respectively, after controlling for PIAAC score in numeracy and number of years of schooling [column (9) of Table 3]. The size of these estimates is relatively lower than that of PIAAC scores.; however we need to have in mind that these may be interpreted as lower bounds since PIAAC scores are likely to be also influenced by non-cognitive skills.[17]

Skipped test items are negatively associated with individual earnings in all specifications, confirming the findings by Hernández and Hershaff (2014) [except when controlling for PIAAC scores and years of education in column (8), when the result is not statistically significant]. Conditional on having the same level of cognitive test scores, individuals that do not answer questions in a non-penalized test have lower earnings.

Average time per correct test item has a negative and statistically significant coefficient in the specifications of Table 3 [except in column (4) where we do not control for cognitive skills and it is included separately in the regression]. Having in mind that this variable is also relevant after controlling for PIAAC scores, this means that, conditional on having the same proficiency in PIAAC numeracy test, needing less time to provide the correct answer for a question is positively associated with earnings. This finding suggests the idea that human capital does not only involve having numeracy skills but also being able to use them in an efficient way.

Unstable results arise for not attempted test items. Not attempted items are significantly negatively associated with individual earnings when we do not control for cognitive test scores, while they are positively associated with individual earnings when we control for cognitive test scores. We suspect that this result is mainly driven by reversed causality. People with a higher opportunity cost (higher earnings) might be less willing to spend time in the test. An alternative explanation for the change in the coefficient of non-attempted items might arise from the multi-adaptive design of the computer based assessment discussed above. Better performers might be driven to more difficult questions, which in turn might be more likely to be left non-attempted.

[16] Results are available upon request.

[17] This might be especially relevant in the case of rate of skipped questions, which exhibits substantial correlation with PIAAC scores but it does not decrease the size of PIAAC coefficients when jointly added in the regression.

Despite low performers exhibit a higher overall level of non-attempted items (the correlation is −0.25, see Table 2), the effect of the adaptive design on increasing the number of non-attempted questions may be captured only when controlling for test performance. This explains why the coefficient of non-attempted items is only negative when not including further controls and positive in all other cases.

When using the additional test based measures we find that average time per question is not significantly correlated with individual earnings (except when included jointly with other non-self-reported measures and not controlling for PIAAC test scores [column (5)].

"Number of actions" has a negative effect in some of the specifications, while the coefficients of "number of actions per correct test items" are more unstable across our specifications. The potential collinearity between "number of actions per correct answer" and "number of actions" (from Table 2, the correlation coefficient between these two variables is the highest: 0.78) may cause that the coefficient of the former changes its sign when both of them are included in a joint regression.

5.2 Self-reported measures of non-cognitive skills using the PIAAC database

Table 4 reports the results of estimating Eq. (2) using as measures for non-cognitive skills the self-reported variables. As in Table 3, columns (1), (3) and (5) show the estimations by introducing separately these three measures, while in columns (2), (4) and (6) we include all of them in the estimations jointly with the non self-reported measures from the previous sub-section. In columns (1) and (2) we do not control for the traditional measures of cognitive skills, in columns (3) and (4) we control for PIAAC scores in numeracy and in columns (5) and (6) we add years of schooling.

Political efficacy and social trust have statistically significant coefficients in all the specifications, when they are included both separately and jointly. Both of them are positively related to earnings, as expected. A one standard deviation increase in political efficacy or in social trust is associated with 1.62 and 2.31% higher earnings, when we control for both the PIAAC score in numeracy and the number of years of schooling. The magnitude of these effects is similar to the impact of time per correct test item or of skipped test items.

The frequency of cultural engagement is positively related to earnings in all columns, but it is statistically significant only in columns (1) and (2), when we do not control neither for PIAAC scores nor for years of schooling.

When we include both self-reported and non-self-reported measures of non-cognitive skills in the estimations, we find robust significant results for the same variables as in Table 3: "don't know" answers, skipped test items and non-attempted items, as well as time per correct answer in columns (4) and (6).

6 Results: corrected measures of cognitive skills

As we have previously commented, there is a growing attention towards the importance of non-cognitive skills in the production of tests' scores. On the one hand, the low stakes nature of the PIAAC test may imply that personality plays a prominent role

Table 4 Non-cognitive skills in the Mincerian equation (self reports)

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
PIAAC score in numeracy			0.180***–0.186***	0.174***	0.101***–0.103***	0.103***
			(0.008)	(0.009)	(0.008)	(0.009)
Years of schooling					0.0625***–0.0641***	0.0611***
					(0.002)	(0.002)
Self-reported non-cognitive skill measures						
Cultural engagement	0.0244***	0.00984*	0.00893	0.00298	0.000511	−0.00241
	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)
Political efficacy	0.0612***	0.0406***	0.0410***	0.0292***	0.0217***	0.0162***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)
Social trust	0.0676***	0.0485***	0.0505***	0.0414***	0.0271***	0.0231***
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)	(0.006)
Non self-reported non-cognitive skill measures						
Time per test item		−0.00216*		−0.00215		−0.000313
		(0.001)		(0.002)		(0.002)
Time per correct test item		−0.0102		−0.0354***		−0.0308***
		(0.007)		(0.008)		(0.006)
Skipped		−0.0997***		−0.0279***		−0.0150*
		(0.008)		(0.008)		(0.008)

Table 4 continued

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
Not attempted		0.0161*		0.0277***		0.0189*
		(0.008)		(0.009)		(0.011)
No. of actions/test item		−0.0283***		−0.00922		−0.00399
		(0.008)		(0.008)		(0.008)
No. of actions/correct test item		0.0194***		0.00965		0.00385
		(0.007)		(0.007)		(0.006)
Don't know answer		−0.0785***		−0.0569***		−0.0363**
		(0.015)		(0.015)		(0.015)
Refused to answer		0.0584		0.0527		0.0185
		(0.036)		(0.035)		(0.031)
Adj. R2	0.272–0.287	0.325	0.361–0.360	0.380	0.456–459	0.463
Observations	14,549–14,588	14,471	14,549–14,588	14,471	14,482–14,520	14,404

Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

in obtaining high scores in the test. On the other hand, non-cognitive skills play an important role in the formation of cognitive skills while the same is not true in the other way around (Cunha and Heckman 2008; Cunha et al. 2010). If that is the case, the estimates of Hanushek et al. (2015) may be better interpreted as the effect of a broader notion of human capital rather than the specific effect of cognitive skills on earnings. In other words, the relationship between PIAAC scores and earnings might be mediated by non-cognitive skills. We might be interested in studying how this may affect the highly studied association between earnings and cognitive skills.

Table 5 presents the results obtained after implementing the correction proposed in Eqs. (3) and (4). Notice that, by doing so we are only using the part of cognitive skills that is orthogonal to our proxies for non-cognitive skills.

Similarly, in Table 6 we use self-reported measures to apply the same correction.

We can see that in all cases, the estimated coefficients for the corrected measures of PIAAC scores are smaller than the uncorrected ones. In most of the cases the variation is higher than 12%. The highest reduction takes places when using skipped questions to correct for the effect of non-cognitive skills (−35.63%, controlling for years of education). This is not surprising as skipping incidence is the proxy for non-cognitive skills that presents the highest correlation with PIAAC scores.

Due to the high correlation of some of the items we might be overcorrecting PIAAC test scores, which might downward bias the estimate of β_1. However, test scores are still highly significant after the correction. This finding supports the prominent role of cognitive skills in the earning equation and reinforces the results of Hanushek et al. (2015). This (partially) mitigates the concern raised by the literature on non-cognitive skills towards the possibility that the role of cognitive skills has been overestimated.

7 Subgroup analysis

7.1 Differences by education level

In this sub-section we estimate the impact of non-cognitive skills separately for different education levels. We distinguish three levels of education: low education (lower secondary, primary or less education), medium education (upper-secondary, post-secondary and other non-tertiary education) and higher education (tertiary education). Results of estimations of specifications (1) and (2) are shown in Table 7.

We observe that, in general, there are no significant changes in the sign and the statistical significance of our variables of interest in all the three groups. However, there are some differences among the different measures of non-cognitive skills and according to the different educational levels.

Skipped test items and "don't know" answers have a negative and statistically significant effect on earnings regardless of the level of education.

In the case of skipped questions and when we do not control for cognitive skills, our results show that the higher the educational attainment of the individual, the stronger the impact of non-cognitive skills. The estimates almost double, when we compare a low-educated person with a high-educated person: 5.63 versus 9%. However, when we control for cognitive skills measured by the PIAAC score and years of schooling, we

Table 5 Corrected measures for cognitive skills (non self-reports)

	Time per test item	Time per correct test item	Skipped	Not attempted	No. of actions/test item	No. of actions/correct test item	Don't know answer	Refused to answer	All Non-cognitive skills test items
Corrected PIAAC score	0.161***	0.164***	0.128***	0.162***	0.161***	0.161***	0.185***	0.187***	0.132***
	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)
Years of schooling									
Adj. R2	0.361	0.363	0.328	0.361	0.36	0.36	0.359	0.361	0.332
No. of obs.	14,568	14,518	14,591	14,591	14,590	14,518	14,591	14,591	14,518
Corrected PIAAC score	0.0888***	0.0921***	0.0663***	0.0897***	0.0890***	0.0884***	0.102***	0.103***	0.0709***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.006)
Years of schooling	0.0640***	0.0636***	0.0691***	0.0641***	0.0641***	0.0641***	0.0643***	0.0641***	0.0685***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Adj. R2	0.456	0.457	0.447	0.456	0.456	0.455	0.455	0.456	0.448
Observations	14,500	14,450	14,523	14,523	14,522	14,450	14,523	14,523	14,450

Estimations of log gross hourly wage on corrected PIAAC score in Numeracy. Each column shows only the coefficient of corrected PIAAC score when correcting for each of the non-cognitive skills measures that we use in the paper. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6 Corrected measures for cognitive skills (self-reports)

	Cultural engagement	Political efficacy	Social trust	All self-reported non-cognitive skills	All self-reported and non-self-reported non-cognitive skills	Cultural engagement	Political efficacy	Social trust	All self-reported non-cognitive skills	All self-reported and non-self-reported non-cognitive skills
Corrected PIAAC score	0.181***	0.169***	0.171***	0.159***	0.121***	0.0998***	0.0910***	0.0919***	0.0848***	0.0641***
	(0.007)	(0.007)	(0.008)	(0.007)	(0.006)	(0.008)	(0.007)	(0.008)	(0.007)	(0.006)
Years of schooling						0.0648***	0.0663***	0.0662***	0.0676***	0.0700***
						(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Adj. R2	0.356	0.347	0.348	0.340	0.323	0.455	0.452	0.452	0.451	0.446
No. of obs.	14,588	14,549	14,582	14,542	14,471	14,520	14,482	14,514	14,475	14,404

Estimations of log gross hourly wage on corrected PIAAC score in Numeracy. Each column shows only the coefficient of corrected PIAAC score when correcting for each of the non-cognitive skills measures that we use in the paper. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 Non-cognitive skills in the Mincerian equation by level of education (non self-reports)

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Separated	(8)	(9)	(10) Joint	(11)	(12)
	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.
PIAAC score in numeracy	0.0768***	0.0976***	0.1508***	0.0728***	0.0915***	0.1191***						
	(0.022)	(0.011)	(0.013)	(0.023)	(0.011)	(0.013)						
Years of schooling				0.0137	0.0492***	0.0824***						
				(0.012)	(0.010)	(0.006)						
Non-cognitive test based measures												
Time per test item							−0.0002	0.0015	−0.0348***	0.0740	0.0010	−0.0111
							(0.011)	(0.001)	(0.011)	(0.092)	(0.001)	(0.008)
Time per correct test item							−0.0053	−0.0060	−0.0239***	−0.0281	−0.0106	−0.0234**
							(0.018)	(0.010)	(0.009)	(0.042)	(0.011)	(0.010)
Skipped							−0.0370***	−0.0512***	−0.0762***	−0.0563***	−0.0589***	−0.0899***
							(0.013)	(0.007)	(0.011)	(0.015)	(0.009)	(0.015)
Not attempted							0.0104	−0.0145*	−0.0184*	0.0340	0.0071	0.0057
							(0.019)	(0.009)	(0.010)	(0.028)	(0.009)	(0.013)
No. of actions/test item							0.0064	0.0051	−0.0020	−0.0267	−0.0138	−0.0173
							(0.014)	(0.007)	(0.007)	(0.019)	(0.014)	(0.014)

Table 7 continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Separated	(8)	(9)	(10) Joint	(11)	(12)
	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.
No. of actions/correct test item							0.0029 (0.015)	− 0.0009 (0.008)	− 0.0044 (0.004)	0.0161 (0.019)	0.0083 (0.013)	0.0128 (0.011)
Non-cognitive measures from Background questionnaire												
Don't know answer							− 0.0548	− 0.0453**	− 0.0527**	− 0.0639*	− 0.0379*	− 0.0471**
							(0.041)	(0.021)	(0.022)	(0.038)	(0.022)	(0.022)
Refused to answer							− 0.0648	− 0.0056	0.0549	− 0.0465	− 0.0112	0.0640
							(0.074)	(0.048)	(0.050)	(0.077)	(0.047)	(0.052)
Adj. R2	0.3587	0.4377	0.3135	0.3686	0.4428	0.3627	0.3289 to 0.3528	0.4138 to 0.4253	0.2606 to 0.2737	0.3581	0.4264	0.2762
Observations	1355	5414	6784	1295	5414	6779	1.334 to 1.355	5.388–5.414	6.767–6.784	1334	5388	6767

Table 7 continued

	(13) Separated	(14)	(15)	(16) Joint	(17)	(18)	(19) Separated	(20)	(21)	(22) Joint	(23)	(24)
	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.
PIAAC score in numeracy	0.0587***–0.0871***	0.0847***–0.1028***	0.1446***–0.1578***	0.0589**	0.0909***	0.1527***	0.0554***–0.0824***	0.0793***–0.0964***	0.1144***–0.1255***	0.0553**	0.0856***	0.1220***
	(0.022)	(0.011)	(0.014)	(0.026)	(0.013)	(0.014)	(0.023)	(0.011)	(0.013)	(0.027)	(0.013)	(0.014)
Years of schooling							0.0136–0.0158	0.0484***–0.0497***	0.0811***–0.0824***	0.0160*	0.0472***	0.0809***
							(0.012)	(0.010)	(0.007)	(0.009)	(0.010)	(0.007)
Non-cognitive skills test based measures												
Time per test item	−0.0044	0.0000	−0.0543***	0.0780	0.0003	−0.0066	−0.0022	0.0005	−0.0470***	0.1000	0.0009	−0.0029
	(0.017)	(0.002)	(0.017)	(0.092)	(0.001)	(0.009)	(0.014)	(0.002)	(0.016)	(0.094)	(0.001)	(0.009)
Time per correct test item	−0.0219	−0.0262**	−0.0423***	−0.0409	−0.0254**	−0.0411***	−0.0209	−0.0256**	−0.0379***	−0.0469	−0.0249**	−0.0386***
	(0.019)	(0.010)	(0.011)	(0.043)	(0.011)	(0.013)	(0.017)	(0.010)	(0.010)	(0.042)	(0.011)	(0.012)
Skipped	−0.0210	−0.0195**	−0.0157	−0.0385**	−0.0250**	−0.0243	−0.0208	−0.0186**	−0.0119	−0.0388**	−0.0229**	−0.0186
	(0.014)	(0.008)	(0.013)	(0.016)	(0.010)	(0.015)	(0.014)	(0.008)	(0.012)	(0.016)	(0.010)	(0.014)
Not attempted	0.0257	0.0068	0.0121	0.0373	0.0138	0.0157	0.0246	0.0064	0.0107	0.0363	0.0125	0.0138
	(0.020)	(0.008)	(0.010)	(0.028)	(0.009)	(0.012)	(0.020)	(0.008)	(0.010)	(0.028)	(0.009)	(0.012)

Table 7 continued

	(13) Separated	(14)	(15)	(16) Joint	(17)	(18)	(19) Separated	(20)	(21)	(22) Joint	(23)	(24)
	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.	Low educ.	Medium educ.	High educ.
No. of actions/test item	−0.0088 (0.012)	−0.0040 (0.008)	−0.0078 (0.006)	−0.0231 (0.019)	−0.0040 (0.013)	−0.0038 (0.013)	−0.0132 (0.012)	−0.0039 (0.008)	−0.0053 (0.006)	−0.0255 (0.019)	−0.0023 (0.013)	−0.0030 (0.013)
No. of actions/correct test item	−0.0048 (0.013)	−0.0057 (0.008)	−0.0041 (0.004)	0.0128 (0.019)	0.0037 (0.013)	0.0074 (0.010)	−0.0113 (0.013)	−0.0065 (0.008)	−0.0019 (0.004)	0.0064 (0.019)	0.0014 (0.013)	0.0082 (0.010)
Non-cognitive skills measures from Background questionnaire												
Don't know answer	−0.0460 (0.041)	−0.0377* (0.021)	−0.0412** (0.021)	−0.0545 (0.038)	−0.0358* (0.021)	−0.0350* (0.021)	−0.0417 (0.043)	−0.0337* (0.020)	−0.0434** (0.019)	−0.0503 (0.040)	−0.0321 (0.020)	−0.0374* (0.020)
Refused to answer	−0.0230 (0.070)	−0.0055 (0.047)	0.0722 (0.050)	−0.0226 (0.073)	−0.0190 (0.046)	0.0717 (0.050)	−0.0173 (0.073)	−0.0062 (0.046)	0.0619 (0.048)	−0.0141 (0.075)	−0.0197 (0.045)	0.0621 (0.048)
Adj. R2	0.3502–0.3634	0.4375–0.4392	0.3123–0.3181	0.3665	0.4411	0.3197	0.3605–0.3729	0.4427–0.4442	0.3612–0.3659	0.3761	0.4457	0.3672
Observations	1334–1355	5388–5414	6767–6784	1334	5388	6767	1274–1295	5388–5414	6774–6779	1274	5388	6762

Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

find very similar effects of non-cognitive skills on earnings among the three subgroups, but statistically significant only for the groups of low-educated and medium-educated individuals. The incidence of skipped questions in these two groups is also higher: 10 and 6% respectively, while in the group of high-educated workers is less than 3%. This reinforces the general result that we emphasized in Sect. 5: conditional on having the same level of cognitive test scores and the same number of years of schooling, individuals that do not answer questions in a non-penalized test have lower earnings, regardless the level of education they achieved.

The rate of "don't know" answers in the background questionnaire seems to have a smaller effect on earnings as the level of education increases. However, when we take into account the PIAAC proficiency level and the years of schooling, we find that this measure of non-cognitive skills affects only earnings of the high-educated workers.

In Table 3, we saw that time per correct answer had a negative and significant effect on earnings across all the specifications. Here we observe that when cognitive skills are not taken into account, this measure of non-cognitive skills has a statistically significant impact only in the group of high-educated workers. When PIAAC scores and years of schooling are controlled for, the effect is significant also for the medium-educated workers and, moreover, it increases slightly with the level of education: from 2.5% for medium-educated to 3.86% for high-educated.

Finally, for the rest of our non self-reported measures of non-cognitive skills we do not observe any significant pattern by level of education.

7.2 Differences by age group

In this heterogeneity analysis, we extend the sample to full-time 25–64 years employees and divide them in three groups: entry-age employees (25–34 years), prime-age employees (35–54 years) and exit-age employees (55–64 years).

When we look at the non-cognitive skills test based measures, we observe that "Time per correct test item" and the proportion of skipped questions in the test are significantly and negatively correlated with earning only in the case of prime-age and exit-age workers, when controlling for PIAAC scores and for the rest of non-cognitive skills measures as well (columns 16, 17 and 18 in Table 8). The magnitude of the impact is slightly bigger for older workers (55–64). However, when the level of education is accounted for, the coefficient is statistically significant only for the sample of prime-age workers.

The proportion of not attempted items in the test has a positive and statistically significant coefficient for all the age groups. An interesting result arises when we look at the number of actions per test item, whose coefficient is negative and statistically significant for the group of exit-age workers only, when controlling for both cognitive skills and years of schooling. Decreasing by one standard deviation the number of actions per test item, increases earnings between 4.4 and 4.8%, which is an economically important impact if we compare it to the increase in earnings of about 5.5% due to one more year of schooling in this group age.

In the case of non-cognitive skills measures based on the background questionnaire, it is worth noting that for the group of entry-age workers, the proportion of "Don't

Table 8 Non-cognitive skills in the Mincerian equation by groups of age (non-self reports)

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Separated	(8)	(9)	(10) Joint	(11)	(12)
	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age
PIAAC score in numeracy	0.1536***	0.1873***	0.1978***	0.0934***	0.1032***	0.1324***						
	(0.008)	(0.007)	(0.019)	(0.008)	(0.008)	(0.021)						
Years of schooling				0.0486***	0.0641***	0.0556***						
				(0.003)	(0.002)	(0.005)						
Non-cognitive test based measures												
Time per test item							−0.0025	−0.0029	0.0213	−0.0205	−0.0028**	0.0244
							(0.022)	(0.002)	(0.069)	(0.071)	(0.001)	(0.053)
Time per correct test item							−0.0046	−0.0079	−0.0196	−0.0033	−0.0115*	−0.0311
							(0.010)	(0.007)	(0.015)	(0.031)	(0.007)	(0.023)
Skipped							−0.0769***	−0.0900***	−0.0843***	−0.0855***	−0.1093***	−0.1183***
							(0.007)	(0.006)	(0.012)	(0.009)	(0.008)	(0.013)
Not attempted							−0.0220***	−0.0208***	−0.0016	0.0121	0.0168**	0.0263***
							(0.006)	(0.007)	(0.009)	(0.010)	(0.008)	(0.010)
No. of actions/test item							0.0161*	0.0072	−0.0262	−0.0183	−0.0306***	−0.0732***
							(0.009)	(0.006)	(0.017)	(0.016)	(0.009)	(0.017)

Table 8 continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Separated	(8)	(9)	(10) Joint	(11)	(12)
	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age
No. of actions/correct test item							0.0021	0.0003	−0.0148	0.0177	0.0211***	0.0396**
							(0.008)	(0.005)	(0.013)	(0.014)	(0.008)	(0.017)
Non-cognitive measures from Background questionnaire												
Don't know answer							−0.0625***	−0.0873***	−0.0673*	−0.0373***	−0.0770***	−0.0271
							(0.014)	(0.015)	(0.038)	(0.013)	(0.015)	(0.033)
Refused to answer							−0.0443	0.0548	−0.0806	−0.0316	0.0570*	−0.0326
							(0.066)	(0.034)	(0.086)	(0.055)	(0.034)	(0.074)
Adj. R2	0.3594	0.3605	0.3175	0.4209	0.4558	0.3844	0.278 to 0.3021	0.2697 to 0.2997	0.2297 to 0.2578	0.3006	0.3055	0.2797
Observations	8169	14,591	3437	8158	14,523	3408	8135–8169	14,518–14,591	3407–3437	8135	14,518	3407
PIAAC score in numeracy	0.1524***–0.1604***	0.1770***–0.1952***	0.1930***–0.2134***	0.1599***	0.1838***	0.1980***	0.0932***–0.0993***	0.1024***–0.1098***	0.1296***–0.1455***	0.1009***	0.1058***	0.1355***
	(0.008)	(0.008)	(0.020)	(0.010)	(0.008)	(0.024)	(0.008)	(0.008)	(0.020)–(0.027)	(0.010)	(0.009)	(0.026)
Years of schooling							0.0481***–0.0488***	0.0637***–0.0642***	0.0546***–0.0562***	0.0485***	0.0630***	0.0545***
							(0.003)	(0.002)	(0.006)	(0.003)	(0.002)	(0.005)

Table 8 continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Separated	(8)	(9)	(10) Joint	(11)	(12)
	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age
Non-cognitive skills test based measures												
Time per test item	−0.0749***	−0.0078	0.0137	−0.0315	−0.0026	0.0212	−0.0604***	−0.0047	0.0146	−0.0418	−0.0004	0.0202
	(0.022)	(0.005)	(0.096)	(0.069)	(0.002)	(0.053)	(0.020)	(0.004)	(0.079)	(0.062)	(0.002)	(0.044)
Time per correct test item	−0.0380***	−0.0403***	−0.0453***	−0.0251	−0.0379***	−0.0490**	−0.0279***	−0.0331***	−0.0314**	−0.0101	−0.0321***	−0.0318
	(0.009)	(0.007)	(0.016)	(0.030)	(0.008)	(0.024)	(0.008)	(0.006)	(0.015)	(0.027)	(0.007)	(0.021)
Skipped	−0.0049	−0.0175**	−0.0071	−0.0120	−0.0309***	−0.0384**	0.0002	−0.0090	0.0066	−0.0084	−0.0158**	−0.0224
	(0.008)	(0.007)	(0.017)	(0.010)	(0.008)	(0.017)	(0.008)	(0.007)	(0.017)	(0.010)	(0.008)	(0.017)
Not attempted	0.0152**	0.0222***	0.0339***	0.0245***	0.0289***	0.0402***	0.0131**	0.0149*	0.0279**	0.0216**	0.0189*	0.0274**
	(0.006)	(0.007)	(0.011)	(0.009)	(0.009)	(0.011)	(0.007)	(0.008)	(0.011)	(0.009)	(0.011)	(0.013)
No. of actions/test item	−0.0069	−0.0101**	−0.0401***	−0.0009	−0.0097	−0.0406**	−0.0080	−0.0084*	−0.0444***	−0.0085	−0.0040	−0.0485***
	(0.008)	(0.005)	(0.013)	(0.016)	(0.008)	(0.017)	(0.008)	(0.005)	(0.013)	(0.014)	(0.008)	(0.017)
No. of actions/correct test item	−0.0043	−0.0053	−0.0262**	0.0060	0.0103	0.0163	−0.0023	−0.0058	−0.0259**	0.0111	0.0042	0.0172
	(0.007)	(0.004)	(0.013)	(0.013)	(0.007)	(0.016)	(0.007)	(0.004)	(0.012)	(0.012)	(0.007)	(0.016)

Table 8 continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7) Separated	(8)	(9)	(10) Joint	(11)	(12)
	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age	Entry-age	Prime-age	Exit-age
Non-cognitive skills measures from Background questionnaire												
Don't know answer	−0.0285**	−0.0569***	−0.0229	−0.0248*	−0.0541***	−0.0058	0.0055	−0.0358**	−0.0188	0.0090	−0.0337**	−0.0080
	(0.013)	(0.014)	(0.037)	(0.013)	(0.014)	(0.035)	(0.013)	(0.014)	(0.038)	(0.013)	(0.014)	(0.036)
Refused to answer	−0.0448	0.0613*	−0.0833	−0.0433	0.0514	−0.0476	-0.0689*	0.0190	−0.1172*	−0.0689*	0.0126	−0.0861
	(0.042)	(0.033)	(0.073)	(0.040)	(0.033)	(0.070)	(0.040)	(0.029)	(0.065)	(0.038)	(0.029)	(0.061)
Adj. R2	0.3566–0.3614	0.3595–0.3636	0.3168–0.3246	0.3621	0.3682	0.3378	0.4186–0.4216	0.4548–0.4575	0.3839–0.3931	0.4225	0.4589	0.4001
Observations	8135–8169	14,518–14,591	3407–3437	8135	14,518	3407	8124–8158	14,450–14,523	3379–3408	8124	14,450	3379

Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

know" answers has a negative and statistically significant coefficient, when PIAAC scores in Numeracy are controlled for. However, this effect disappears when we include years of schooling as well, and the correlation between this variable and earnings remains significant only for prime-age workers.

As argued by Hanushek et al. (2015), the earnings gradient for cognitive skills is lower in early career spans and higher later. In contrast, we find that the earnings gradient for some of our non-cognitive skills does not vary considerably across age groups, and the correlation between non-cognitive skills and earnings is strongest for prime-age workers.

7.3 Differences by gender

Some differences by gender arise as well. Time per correct test item is correlated with earnings for both males and females. The increase in male earnings due to spending on standard deviation less time per correct test item is 4%, which doubles the increase in female earnings (2%). In the last specification when we control for both PIAAC scores and years of schooling this non-cognitive skills measure is correlated only with female earnings. The same applies to the proportion of not attempted questions in the test, it is only correlated with female earnings, when cognitive skills and years of schooling is accounted for.

The increase in earnings due to skipping less questions is very similar for males and females when we control for PIAAC score in numeracy (between 2 and 3.5%, due to a decrease of one standard deviation in the proportion of skipped questions). This result could be explained by the finding of Hernández and Hershaff (2014) that females and males do not skip questions at significantly different rates. However, when years of schooling are included and all non-cognitive skills measures are added jointly, the variable Skipped is only significant for males.

When looking at the measures based on the background questionnaire, the ratio of "Don't know" answers in the questionnaire is only significant for males (see Table 9, columns 14 and 16) when we control for both the score in numeracy and years of schooling.

In general, male earnings show a stronger correlation with non-cognitive skills than female earnings-

8 Robustness checks

8.1 Principal component analysis

In this section we implement Principal Component Analysis to reduce the number of variables representing non-cognitive skills. Our first observation is that the proposed measures of non-cognitive skills exhibit a low level of unidimensionality. The Principal Component analysis reveals that each of the fifth first components accounts from a 19.29 to a 9.33% of the total variance, thus it is quite disperse (see Table 10). The low unidimensionality is confirmed by the Cronbach alpha which equals 0.27. A potential explanation for this finding is that, in contrast to cognitive skills, personality traits

Table 9 Non-cognitive skills in the Mincerian equation by gender (non-self reports)

	(1)	(2)	(3)	(4)	(5) Separated	(6)	(7) Joint	(8)
	Female	Male	Female	Male	Female	Male	Female	Male
PIAAC score in numeracy	0.1906***	0.1816***	0.1050***	0.1046***				
	(0.010)	(0.010)	(0.011)	(0.010)				
Years of schooling			0.0680***	0.0588***				
			(0.003)	(0.003)				
Non-cognitive skills test based measures								
Time per test item					0.0000	−0.0259*	−0.0036***	−0.0246
					(0.001)	(0.015)	(0.001)	(0.050)
Time per correct test item					0.0095	−0.0166*	0.0056	−0.0098
					(0.010)	(0.009)	(0.010)	(0.020)
Skipped					−0.0818***	−0.0978***	−0.1024***	−0.1167***
					(0.008)	(0.009)	(0.009)	(0.011)
Not attempted					−0.0135	−0.0237**	0.0254***	0.0121
					(0.008)	(0.010)	(0.009)	(0.013)
No. of actions/test item					0.0131*	0.0003	−0.0137	−0.0489***
					(0.007)	(0.009)	(0.011)	(0.015)
No. of actions/correct test item					0.0033	−0.0047	0.0103	0.0325**
					(0.005)	(0.009)	(0.009)	(0.014)

Table 9 continued

	(1)	(2)	(3)	(4)	(5) Separated	(6)	(7) Joint	(8)
	Female	Male	Female	Male	Female	Male	Female	Male
Non-cognitive skills measures from Background questionnaire								
Don't know answer					−0.0713***	−0.1017***	−0.0638***	−0.0894***
					(0.022)	(0.022)	(0.022)	(0.021)
Refused to answer					0.0884**	0.0490	0.0993**	0.0405
					(0.042)	(0.044)	(0.045)	(0.044)
Adj. R2	0.3952	0.2852	0.5005	0.3736	0.3031–0.335	0.1874–0.2214	0.3424	0.2279
Observations	6736	7855	6708	7815	6699–6736	7819–7855	6699	7819
PIAAC score in numeracy	0.1893***–0.1981***	0.1709***–0.1906***	0.1841***	0.1776***	0.1022***–0.1096***	0.1030***–0.1127***	0.1082***	0.1052***
	(0.011)	(0.010)	(0.011)	(0.012)	(0.011)	(0.010)–(0.012)	(0.012)	(0.012)
Years of schooling					0.0676***–0.0681***	0.0583***–0.0589***	0.0670***	0.0578***
					(0.003)	(0.003)	(0.003)	(0.003)
Non-cognitive skills test based measures								
Time per test item	−0.0012	−0.0589	−0.0033**	−0.0277	−0.0003	−0.0430	−0.0008	0.0017
	(0.002)	(0.036)	(0.002)	(0.057)	(0.001)	(0.034)	(0.001)	(0.060)
Time per correct test item	−0.0249***	−0.0475***	−0.0238**	−0.0323	−0.0201***	−0.0399***	−0.0221***	−0.0368
	(0.009)	(0.011)	(0.009)	(0.026)	(0.007)	(0.009)	(0.008)	(0.025)
Skipped	−0.0171**	−0.0200*	−0.0302***	−0.0355***	−0.0043	−0.0133	−0.0077	−0.0244**

Table 9 continued

	(1)	(2)	(3)	(4)	(5) Separated	(6)	(7) Joint	(8)
	Female	Male	Female	Male	Female	Male	Female	Male
	(0.007)	(0.011)	(0.009)	(0.012)	(0.007)	(0.010)	(0.008)	(0.012)
Not attempted	0.0277***	0.0191*	0.0347***	0.0258*	0.0156**	0.0151	0.0179**	0.0200
	(0.008)	(0.010)	(0.008)	(0.013)	(0.007)	(0.011)	(0.008)	(0.016)
No. of actions/test item	−0.0004	−0.0215**	−0.0000	−0.0195	0.0012	−0.0205**	0.0081	−0.0191
	(0.006)	(0.009)	(0.011)	(0.015)	(0.005)	(0.008)	(0.010)	(0.014)
No. of actions/correct test item	0.0013	−0.0171**	0.0062	0.0117	0.0005	−0.0175**	−0.0007	0.0088
	(0.005)	(0.009)	(0.009)	(0.014)	(0.004)	(0.008)	(0.007)	(0.014)
Non-cognitive skills measures from Background questionnaire								
Don't know answer	−0.0512**	−0.0641***	−0.0483**	−0.0617***	−0.0210	−0.0502**	−0.0197	−0.0487**
	(0.020)	(0.022)	(0.021)	(0.021)	(0.020)	(0.021)	(0.020)	(0.020)
Refused to answer	0.0877*	0.0570	0.0808*	0.0418	0.0572*	0.0057	0.0531	−0.0052
	(0.045)	(0.042)	(0.045)	(0.042)	(0.034)	(0.039)	(0.034)	(0.040)
Adj. R2	0.3951–0.3975	0.2831–0.2892	0.4031	0.2942	0.5003–0.5012	0.3719–0.376	0.5023	0.3786
Observations	6699–6736	7819–7855	6699	7819	6671–6708	7779–7815	6671	7779

Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10 Principal components

Ppal componen\Var.	Eigenvalue	Var. proportion	Cumulative
1st Component	2.12168	0.1929	0.1929
2nd Component	1.4531	0.1321	0.325
3rd Component	1.25563	0.1141	0.4391
4th Component	1.13042	0.1028	0.5419
5th Component	1.02607	0.0933	0.6352
6th Component	0.959718	0.0872	0.7224
7th Component	0.930084	0.0846	0.807
8th Component	0.713482	0.0649	0.8718
9th Component	0.614928	0.0559	0.9277
10th Component	0.584808	0.0532	0.9809
11th Component	0.210092	0.0191	0

have been found to be multidimensional rather than unitary (Almlund et al. 2011). The most prominent taxonomy is the Big-Five (see McCrae and John 1992), which classifies personality traits in five independent categories (agreeableness, conscientiousness, extraversion, openness to experience and neuroticism). The fact that the proposed measures do not a capture a unidimensional variable may be explained by the multidimensionality in the variables of interest. Moreover, as previously argued, some of our test based measures might be capturing cognitive skills.

Applying the Kaiser (1960) criterion to reduce the number of variables in the analysis, we retain the first five components.[18] In Table 11 we report the loadings of each original variable in the retained components (to make easier its interpretation we highlighted in bold values above 0.3). As we can see the first and the fourth components seem to be related with test-based measures, despite not offering a very clear pattern of a latent structure. The second component presents its higher correlations with self-reported measures of non-cognitive skills. The third component captures a mix of time per question and self-reported measures presenting its higher correlation with time per question. Finally, the fifth component is mainly capturing non-self-reported measures based on performance in the background questionnaire ("don't know" and refused items).

We replicate our main regressions after substituting the set of proposed variables for non-cognitive skills by the first five components that survived the Kaiser (1960) criterion, see Table 12. When not controlling for cognitive skills (column 1), all factors are significantly associated to earnings except the fourth component. When including numeracy scores as a measure for cognitive skills (column 2), the first component is no longer statistically significant, while the third component also loses its significance after adding years of schooling as a control (column 3). Thus, the second component (associated to self-reported measures on political efficacy and social trust) and the fifth

[18] The Kaiser (1960) criterion proposes to retain only factors with eigenvalues greater than 1. It is one of the most extended criteria in this type of analysis.

Table 11 Correlation between principal components and variables for non-cognitive skills

Variable\Ppal component	1st Component	2nd Component	3rd Component	4th Component	5th Component
Time per test item	0.2506	0.2318	0.4572	**0.4713**	0.0404
Time per correct test item	0.346	0.2458	**0.4074**	0.3271	0.0078
Skipped	− 0.3193	**0.4165**	0.2781	0.3038	0.1272
Not attempted	− 0.2747	0.3433	0.3758	**0.3918**	0.1566
No. of actions/ test item	**0.5839**	0.1261	0.2065	0.2695	0.032
No. of actions/ correct test item	**0.5146**	0.2736	0.0929	0.4321	0.09
Don't know answer	− 0.0306	0.1433	0.0402	0.118	**0.6355**
Refused to answer	− 0.0216	0.055	0.0301	0.1323	**0.7324**
Cultural engagement	0.0861	0.2588	**0.2866**	0.0588	0.0791
Political efficacy	0.1195	**0.4623**	0.3373	0.2594	0.0116
Social trust	0.1055	**0.4467**	0.3958	0.2521	0.0416

component (associated to "don't know" and refused items) are the ones that present a robust correlation with individual earnings. This is consistent with our previous results in which "don't know" answers and self-reports on social trust and political efficacy were the variables presenting a more robust correlation with earnings. Also note that, the first component which is the one more clearly related to test based measures, is the one that clearly drops its significance after including numeracy scores.

8.2 Additional controls

For our main estimations we followed the specification of the earnings equation proposed by Hanushek et al. (2015) which uniquely controls for years of schooling, gender, the second degree polynomial of experience and country fixed effects. There is a wide range of elements that potentially affect individual earnings and that are not contemplated among the previous regressors. Consequently, in this section we include additional controls available in the PIAAC database.[19] In particular, we include health status (in three categories: excellent-very good, good-fair or poor), type of occupation (in four categories: high skill occupations, medium-skill white collar occupations, medium-skills blue collar occupations and low skill occupations), economic sector

[19] Despite extending the number of controls, it is difficult to completely exclude the possibility of an omitted variables bias when analyzing cross sectional data as PIAAC. For instance, data on disabilities or ethnicity is not available in the PIAAC database.

Table 12 Non-cognitive skills in the Mincerian equation by level of education using principal components

	(1)	(2)	(3)
PIAAC score in numeracy		0.1798***	0.1045***
		(0.009)	(0.009)
Years of schooling			0.0618***
			(0.002)
1st Principal component	0.0310***	−0.0005	−0.0046
	(0.004)	(0.005)	(0.004)
2nd Principal component	−0.0871***	−0.0469***	−0.0267***
	(0.004)	(0.005)	(0.005)
3rd Principal component	0.0155***	0.0187***	0.0077
	(0.005)	(0.006)	(0.006)
4th Principal component	−0.0086	0.0225***	0.0136*
	(0.007)	(0.008)	(0.007)
5th Principal component	−0.0572***	−0.0500***	−0.0366**
	(0.016)	(0.016)	(0.015)
Adj. R2	0.31	0.37	0.46
Observations	14,471	14,471	14,404

Dependent variable: log gross hourly wages
Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

(private vs public-non for profit) and immigration status (first or second generation immigrant vs not immigrant).

Results are available in Tables 13 and 14. Our results are qualitatively similar to the ones in our main specifications in Tables 3 and 4. "Don't know" answers, "time per correct test item" and self-reports on social trust remain statistically significant under all specifications. In contrast, some of the variables that were presenting a less robust association with earnings, like "skipped test items", "non-attempted test items" and background questionnaire "refusals" now exhibit an even weaker association. Self-reports on "political efficacy" lose some significance after adding controls but still remain significant in most specifications. In summary, by including these additional controls we confirm our results for the variables that exhibited a more robust association with earnings in our main analysis.

The specification proposed by Hanushek et al. (2015) controls for a quadratic polynomial in actual work experience. Experience measured this way could be endogenous to skills and it could be one of the channels through which skills could affect individual earnings. In a robustness check, we replace this measure by potential experience, measured as age minus years of schooling minus six. Results do not change considerably with respect to our main specification.[20]

[20] They are available upon request.

Table 13 Non-cognitive skills in the Mincerian equation (non-self reports). Additional controls

	(1)	(2)	(3) Separated	(4) Joint	(5) Separated	(6) Joint	(7) Separated	(8) Joint
PIAAC score in numeracy	0.1211***	0.0845***			0.1157***–0.1272***	0.1235***	0.0809***–0.0904***	0.0888***
	(0.008)	(0.008)			(0.008)	(0.009)	(0.008)	(0.010)
Years of schooling		0.0417***					0.0416***–0.0418***	0.0413***
		(0.003)					(0.003)	(0.003)
Non-cognitive skills test based measures								
Time per test item	0.0007	0.0013	−0.0028	0.0011	−0.0023	0.0015	0.0007	0.0013
	(0.002)	(0.001)	(0.003)	(0.002)	(0.003)	(0.001)	(0.002)	(0.001)
Time per correct test item	−0.0070	−0.0117*	−0.0290***	−0.0304***	−0.0284***	−0.0294***	−0.0070	−0.0117*
	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Skipped	−0.0517***	−0.0593***	−0.0098	−0.0134*	−0.0066	−0.0086	−0.0517***	−0.0593***
	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.006)	(0.007)
Not attempted	−0.0109*	0.0076	0.0146**	0.0165**	0.0122*	0.0131	−0.0109*	0.0076
	(0.006)	(0.008)	(0.006)	(0.008)	(0.007)	(0.009)	(0.006)	(0.008)
No. of actions/test item	0.0063	−0.0119	−0.0037	−0.0002	−0.0051	0.0008	0.0063	−0.0119
	(0.005)	(0.008)	(0.005)	(0.008)	(0.004)	(0.008)	(0.005)	(0.008)
No. of actions/correct test item	0.0012	0.0108*	−0.0020	0.0048	−0.0041	0.0017	0.0012	0.0108*
	(0.004)	(0.006)	(0.004)	(0.006)	(0.003)	(0.006)	(0.004)	(0.006)

Table 13 continued

	(1)	(2)	(3) Separated	(4) Joint	(5) Separated	(6) Joint	(7) Separated	(8) Joint
Non-cognitive skill measures from Background questionnaire								
Don't know answer	−0.0477***	−0.0446***	−0.0338**	−0.0326**	−0.0262*	−0.0251*	−0.0477***	−0.0446***
	(0.016)	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)	(0.016)	(0.016)
Refused to answer	0.0293	0.0319	0.0370	0.0313	0.0214	0.0166	0.0293	0.0319
	(0.026)	(0.027)	(0.027)	(0.027)	(0.026)	(0.027)	(0.026)	(0.027)
Adj. R2	0.47	0.5	0.44–0.45	0.45	0.47	0.47	0.5	0.5
No. of observations	13,613	13,551	13,485–13,551	13,547	13,547–13,613	13,547	13,485–13,551	13,485

Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14 Non-cognitive skills in the Mincerian equation (self reports). Additional controls

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
PIAAC score in numeracy			0.1192***–	0.1216***	0.0837***–0.0849***	0.0881***
			(0.008)	(0.009)	(0.008)	(0.010)
Years of schooling					0.0811***–0.0849***	0.0408***
					(0.003)	(0.003)
Self-reported non-cognitive						
Cultural engagement	0.0016	− 0.0035	− 0.0052	− 0.0071	− 0.0063	− 0.0076
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Political efficacy	0.0216***	0.0141**	0.0139**	0.0088	0.0095*	0.0066
	(0.006)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
Social trust	0.0298***	0.0244***	0.0244***	0.0223***	0.0158***	0.0145**
	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
Non self-reported non-cognitive skills						
Time per test item		0.0014		0.0012		0.0015
		(0.001)		(0.002)		(0.001)
Time per correct test item		− 0.0111*		− 0.0297***		− 0.0288***
		(0.006)		(0.007)		(0.006)
Skipped		− 0.0574***		− 0.0129		− 0.0086
		(0.007)		(0.008)		(0.008)
Not attempted		0.0072		0.0161**		0.0131
		(0.008)		(0.008)		(0.009)
No. of actions/test item		− 0.0117		− 0.0003		0.0007
		(0.008)		(0.008)		(0.008)

Table 14 continued

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
No. of actions/correct test item		0.0103		0.0045		0.0015
		(0.006)		(0.006)		(0.006)
Don't know answer		−0.0490***		−0.0365**		−0.0283*
		(0.017)		(0.016)		(0.016)
Refused to answer		0.0378		0.0366		0.0233
		(0.029)		(0.029)		(0.028)
Adj. R2	0.44	0.45	0.47	0.47	0.5	0.5
Observations	13,576–13,610	3505	13,576–13,610	13,505	13,542–13,515	13,444

Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

8.3 Additional measures of non-cognitive skills

An alternative measure of non-cognitive skills is constructed using a set of self-reported variables on learning strategies, as in Cabrales et al. (2014). This could be considered as a measure of the degree of motivation. We create a dummy variable which takes the value 1 if the person responds that she feels identified "To some extent" or "To a high extent" to at least one of the following questions: Relate new ideas into real life, Like learning new strategies, Attribute something new, Get to the bottom of difficult things, Figure out how different ideas fit together and Looking for additional info. Then, we standardize this dummy with respect to the mean and standard deviation of the pool of countries (as for the rest of the variables).[21] Results are available in the "Online Appendix". The proxy for motivation is strongly and positively correlated with earnings in all specifications. Moreover, its sign and statistical significance do not change when we include it jointly with the other self-reported and non self-reported measures of non-cognitive skills. Overall, results for the rest of the measures hardly change with respect to those reported in Table 4.

8.4 Extended sample including all workers aged 25–64

In order to work with a homogenous sample, as in Hanushek et al. (2015), we restricted our sample to prime age workers (35–54 years). To show the relevance of this sample restriction, in Tables 15 and 16 we estimate using the extended sample of employees: 25–64 years, which includes entry-age (25–34 years), prime-age (34–54 years) and exit-age workers (55–64 years).

The main conclusions that we draw from Tables 3 and 4 maintain when we extend the sample. Time per correct test item and Skipped questions show the same stable coefficients across all the specifications and, moreover, the magnitude of the coefficients is very similar to that estimated for the prime-age sample (almost 3 and 1.6% increase in earnings). The number of actions per test item is now strongly significant in the last specification where we control for both the PIAAC score and the number of years of schooling and include jointly all the non-cognitive skills measures (before it was significant only when the non-cognitive skills measures were included separately). The ratio of "Don't know" answers in the questionnaire is still negatively correlated with individual earnings, even though it is not statistically significant in the last specification when we include all the measures of non-cognitive skills jointly. One important difference with respect to the restricted sample, is that now the ratio of "Refused to answer" questions in the questionnaire is also negatively correlated and statistically significant when we control for both years of schooling and cognitive.

Finally, coefficients of self-reported measures of non-cognitive skills in the extended sample are very similar to the ones from Table 4, though they are slightly smaller in magnitude.

[21] We could also calculate the average of these variables and then standardize it with respect to the mean and standard deviation of the pool of countries. Results are the same and they are available upon request.

Table 15 Non-cognitive skills in the Mincerian equation (non-self reports)

	(1)	(2)	(3) Separated	(4) Joint	(5) Separated	(6) Joint	(7) Separated	(8) Joint
PIAAC score in numeracy	0.1821***	0.1033***			0.1742***–0.1893***	0.1813***	0.1001***–0.1089***	0.1066***
	(0.006)	(0.006)			(0.006)	(0.007)	(0.006)	(0.007)
Years of schooling		0.0591***					0.0587***–0.0592***	0.0583***
		(0.002)					(0.002)	(0.002)
Non-cognitive skills test based measures								
Time per test item			0.0058	0.0068	−0.0024	0.0058	−0.0002	0.0062
			(0.010)	(0.012)	(0.011)	(0.011)	(0.009)	(0.009)
Time per correct test item			−0.0054	−0.0124*	−0.0373***	−0.0376***	−0.0289***	−0.0291***
			(0.006)	(0.007)	(0.006)	(0.007)	(0.005)	(0.006)
Skipped			−0.0884***	−0.1072***	−0.0137**	−0.0279***	−0.0059	−0.0160***
			(0.005)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)
Not attempted			−0.0195***	0.0174***	0.0224***	0.0303***	0.0165***	0.0208***
			(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.007)
No. of actions/test item			0.0034	−0.0374***	−0.0147***	−0.0155**	−0.0147***	−0.0170**
			(0.005)	(0.008)	(0.004)	(0.007)	(0.004)	(0.008)
No. of actions/correct test item			−0.0029	0.0238***	−0.0088**	0.0110*	−0.0084**	0.0105
			(0.004)	(0.007)	(0.004)	(0.006)	(0.003)	(0.006)

Table 15 continued

	(1)	(2)	(3) Separated	(4) Joint	(5) Separated	(6) Joint	(7) Separated	(8) Joint
Non-cognitive skills measures from Background questionnaire								
Don't know answer			−0.0777***	−0.0587***	−0.0437***	−0.0389***	−0.0204*	−0.0170
			(0.012)	(0.012)	(0.012)	(0.011)	(0.012)	(0.012)
Refused to answer			0.0039	0.0125	0.0064	0.0033	−0.0318*	−0.0344**
			(0.022)	(0.021)	(0.019)	(0.019)	(0.018)	(0.017)
Adj. R2	0.3833	0.465	0.299–0.3263	0.3284	0.3819–0.3851	0.3891	0.4638–0.4659	0.4677
No. of observations	26,128	26,020	25,885–26,020	25,992	25,992–26,128	25,992	25,885–26,020	25,885

Sample extended to employees 25–64 years old. Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects
Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16 Non-cognitive skills in the Mincerian equation (self reports)

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
PIAAC score in numeracy			0.1756***–0.1810***	0.1717***	0.1016***–0.1033***	0.1038***
			(0.006)	(0.007)	(0.006)	(0.007)
Years of schooling					0.0577***–0.0591***	0.0565***
					(0.002)	(0.002)
Self-reported non-cognitive skills measures						
Cultural engagement	0.0260***	0.0118***	0.0106**	0.0048	−0.0000	−0.0028
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Political efficacy	0.0560***	0.0362***	0.0370***	0.0260***	0.0192***	0.0139***
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Social trust	0.0640***	0.0462***	0.0467***	0.0385***	0.0254***	0.0220***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Non self-reported non-cognitive skills measures						
Time per test item		0.0068		0.0059		0.0062
		(0.011)		(0.010)		(0.009)
Time per correct test item		−0.0120*		−0.0359***		−0.0283***
		(0.007)		(0.007)		(0.006)
Skipped		−0.0995***		−0.0264***		−0.0163***
		(0.005)		(0.006)		(0.006)
Not attempted		0.0182***		0.0302***		0.0213***
		(0.006)		(0.006)		(0.007)

Table 16 continued

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
No. of actions/test item		−0.0357***		−0.0154**		−0.0170**
		(0.008)		(0.007)		(0.008)
No. of actions/correct test item		0.0221***		0.0105*		0.0102
		(0.007)		(0.006)		(0.006)
Don't know answer		−0.0638***		−0.0448***		−0.0240**
		(0.012)		(0.012)		(0.012)
Refused to answer		0.0172		0.0075		−0.0295
		(0.022)		(0.020)		(0.019)
Adj. R2	0.2992–0.3121	0.3457	0.3836–0.3912	0.3991	0.4649–0.4675	0.4705
Observations	26,046–26,124	25,903	26,046–26,124	25,903	25,939–26,016	25,797

Sample extended to employees 25–64 years old. Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects
Standard errors in parentheses $*p < 0.10$, $**p < 0.05$, $***p < 0.01$

8.5 Sample size across countries

As indicated in Table 1, samples of participating countries have different size. Given the pooled nature of our study, countries with larger number of observations may be contributing more to the obtained results. To study this possibility we re-estimate Eq. (2) separately for each country and then we average the estimates across countries. The results are reported in Tables 17 and 18. Results are qualitatively unchanged with respect the pooled sample with the only exception that "don't know" answers lose significance when jointly controlling for numeracy and years of schooling.

8.6 Alternative measures of cognitive skills

Following Hanushek et al. (2015) we have considered PIAAC numeracy scores as our baseline measure for non-cognitive skills. Our results do not change if we substitute numeracy scores by scores in the other two domains: literacy and problem solving. This results are available in the "Online Appendix".

9 Conclusions

One of the main contributions of the PIAAC database and similar international assessments is the provision of accurate measures of cognitive skills. However, international assessments usually do not contain information on a set of skills that has been identified to be as relevant as cognitive skills for individual success, namely non-cognitive skills. In the present paper, we complement the PIAAC database by constructing several measures of non-cognitive skills. An important advantage of our approach is that it provides a cheap and readily available way of adding information on non-cognitive skills.

Consistent with the previous literature, several of our proxies for non-cognitive skills have explanatory power on individual earnings beyond the one captured by PIAAC test scores. Some evidence arises from questionnaire non-response. First, because this variable has been previously validated as a proxy for non-cognitive skills related to the personality trait of conscientiousness and openness to experience (Hedengren and Stratmann 2012; Hitt et al. 2016; Cheng et al. 2016). Second, because this variable exhibits a robust correlation with individual earnings even after including other measures of human capital such as years of schooling and PIAAC test scores. Consistently with the previous literature, individuals with a higher incidence of non-response have a lower level of individual earnings.

We also exploit the computer based nature of the PIAAC test to construct other variables that can be potentially related to individuals' personality. Among the proposed variables, the ones that seem to provide relevant information on individual skills are skipped test item and time per correct test item. Despite these results need to be interpreted with caution, due to the correlation between these two test based measures and PIAAC scores, the fact that skipped test item enters in a statistically significant way in the earnings equation even after controlling for PIAAC test scores, suggests that they may be better capturing some non-cognitive skills than PIAAC test scores.

Table 17 Non-cognitive skills in the Mincerian equation (non-self reports)

	(1)	(2)	(3) Separated	(4) Joint	(5) Separated	(6) Joint	(7) Separated	(8) Joint
PIAAC score in numeracy	0.177***	0.101***			0.1622***–0.1822***	0.1648***	0.0924***–0.1055***	0.0971***
	(0.005)	(0.005)			(0.005–0.006)	(0.006)	(0.005–0.006)	(0.006)
Years of schooling		0.0604***					0.0599***–0.0605***	0.0589***
		(0.002)					(0.002)	(0.002)
Non-cognitive skills test based measures								
Time per test item			0.0024	−0.0232	−0.0504***	−0.0007	−0.0438***	0.0060
			(0.011)	(0.027)	(0.011)	(0.027)	(0.010)	(0.024)
Time per correct test item			−0.0010	0.0055	−0.0311***	−0.0289**	−0.0274***	−0.0289**
			(0.005)	(0.012)	(0.005)	(0.012)	(0.004)	(0.011)
Skipped			−0.0982***	−0.111***	−0.0290***	−0.0385***	−0.0175***	−0.0217***
			(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)
Not attempted			−0.0306***	0.0148**	0.0100	0.0218***	0.0050	0.0122**
			(0.007)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
No. of actions/test item			0.0060	−0.238***	−0.0101***	−0.0076	−0.0093***	−0.0059
			(0.004)	(0.006)	(0.004)	(0.006)	(0.004)	(0.006)
No. of actions/correct test item			−0.0024	0.0113*	−0.0082**	0.0034	−0.0072**	0.0034
			(0.004)	(0.006)	(0.004)	(0.006)	(0.003)	(0.006)

Table 17 continued

	(1)	(2)	(3) Separated	(4) Joint	(5) Separated	(6) Joint	(7) Separated	(8) Joint
Non-cognitive skills measures from Background questionnaire								
Don't know answer			−0.0669***	−0.0486***	−0.0330**	−0.0260*	−0.0225	−0.0178
			(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.013)
Refused to answer			0.0833	0.090*	0.0975**	0.0775**	0.0756**	0.0540
			(0.055)	(0.051)	(0.041)	(0.039)	(0.038)	(0.035)

Separate estimations for each country (the table reports average results with same weight for each country). Dependent variable: log gross hourly wages. Separate estimations for each country using sample weights and 80 replicates for standard errors. Average results with same weight for each country. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects

Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 18 Non-cognitive skills in the Mincerian equation (self reports)

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
PIAAC score in numeracy			0.1683***–0.1758***	0.1545***	0.0976–0.1005***	0.0942***
			(0.005–0.006)	(0.006)	(0.005)	(0.006)
Years of schooling					0.0588***–0.0603***	0.0566***
					(0.002)	(0.002)
Self-reported non-cognitive skills measures						
Cultural engagement	0.0261***	0.0097**	0.0124***	0.0040	0.0009	-0.0037
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Political efficacy	0.0699***	0.0461***	0.0478***	0.0356***	0.0273***	0.0212***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Social trust	0.0645***	0.0408***	0.0453***	0.0329***	0.0250***	0.0180***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Non self-reported non-cognitive skills measures						
Time per test item		−0.0146		0.0040		0.0097
		(0.027)		(0.027)		(0.025)
Time per correct test item		0.0019		−0.0292**		−0.0294***
		(0.012)		(0.012)		(0.011)
Skipped		−0.0985***		−0.0334***		−0.0199***

Table 18 continued

	(1) Separated	(2) Joint	(3) Separated	(4) Joint	(5) Separated	(6) Joint
		(0.005)		(0.006)		(0.005)
Not attempted		0.0147**		0.0211***		0.0121*
		(0.006)		(0.006)		(0.006)
No. of actions/test item		−0.0207***		−0.0065		−0.0057
		(0.006)		(0.006)		(0.006)
No. of actions/correct test item		0.0093		0.0024		0.0026
		(0.006)		(0.006)		(0.005)
Don't know answer		−0.0487***		−0.0304**		−0.0216
		(0.014)		(0.014)		(0.014)
Refused to answer		0.1133***		0.0953***		0.0705**
		(0.029)		(0.029)		(0.033)

Separate estimations for each country (the table reports average results with same weight for each country). Dependent variable: log gross hourly wages. Estimations using sample weights and 80 replicates for standard errors. All estimations include a constant, experience, the square of experience, a dummy for female and country fixed effects Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

However, further research would be necessary to validate these test based measures as a proxy for non-cognitive skills.

We find similar results when using two questions of the background questionnaire that are related to individuals' personality to construct self-reported measures of non-cognitive skills: political efficacy and social trust. However, the same is not true for cultural engagement.

In addition, we use our constructs to provide corrected measures of PIAAC scores that try to net-out the effect of non-cognitive skills. By doing so, we observe that the relationship between earnings and PIAAC scores might be partially mediated by non-cognitive skills. However, our results also show that PIAAC test scores remain highly significant and as the main determinant of earnings after the correction. Given that our strategy might be seen as an over correction of PIAAC scores, this result highlights the prominent role of cognitive skills in the earnings equation and reinforces the results of Hanushek et al. (2015).

Finally, our study reveals the necessity of including items in the international assessments that facilitate information and measurement of non-cognitive skills that can complement the already existing information on cognitive skills.

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