Should we teach general skills in vocational education? Evidence from 19 developed countries[1]

Draft version: 30-3-2017
Paper for the International Conference on PIAAC and PIAAC-Longitudinal, April 5-6, Mannheim.
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Abstract

Whether upper secondary vocational education should primarily teach occupation-specific skills or should also aim at providing pupils with general skills is a hotly debated question. Recent research suggests that in many countries, vocational educated graduates from non-tertiary education experience higher quality school-to-work transitions than their academic educated peers, suggesting that occupation-specific skills are crucial in quickly finding a matching job. However, evidence also strongly suggests that early career education-to-job matching may come at a price. The relatively high returns to vocational education in the early career peter out during the career, and in the long run, academic educated workers appear to be better off. This regularity has been explained by assuming that the lack of general skills make vocational educated less flexible on the labour market, which would hamper their ability to find jobs outside of their field if they are unemployed.

Although this seems plausible, these assumptions have not yet been tested. One of the problems is that we lack information on specific skills and as such cannot directly assess the development of these skills over the life course, nor can we assess the effect of these skills on labour market outcomes. In this paper we develop an innovative model in which we assume a certain relation between the development of general and specific skills in vocational education. This development can either be seen as a trade-off (based on time-on-task theory: spending time on one type will come at the expense of time on another) or as complementary (based on theories on the development of expertise: the development of general and specific skills go hand in hand). The two models predict a totally different effect of general skills on labour market outcomes. In the 'trade-off regime' the effect of general skills on outcomes will be very low or zero at the start, and substantially increase over the life course. In the 'complementary regime' the effects of general skills over the life course for the vocational educated will be more or less flat.

We use data from the Programme for the International Assessment of Adult Competencies (PIAAC) to explore the relationship between general skills and labour market success of 20-55-year-old workers from 19 developed countries with advanced economies. Focusing on people who completed education at ISCED levels 3 or 4, we assess the differential role of general skills in predicting earnings for academic and vocational educated workers for different age groups. The results indicate that general skills affect earnings of vocational educated workers during all phases of their career, not just at later phases but also right from the start. As we assume that in the start of their career, vocational educated workers are mainly rewarded on the basis of the vocational skills and not their general skills, this implies that the

[1] This publication is part of the project "The Future of Craftmanship" and is made possible by a grant from the Programme Council for Policy-Oriented Education Research (ProBO) from the Netherlands Initiative for Educational Research (NRO) (grant 404-15-400). For more information on the project, see the website of ROA: http://roa.sbe.maastrichtuniversity.nl/" under research.
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development of general and vocational skills is largely intertwined. Only in so-called dual systems do we find evidence of a trade-off relation.

These findings have major implications for curriculum design of vocational education systems, which should not just aim at teaching occupation-specific skills that enable quick education-to-job matches, but also strive to inculcate general skills, because these form the basis on which these specific skills can effectively be developed at the start of their career and at the same time will help workers to remain employable and productive later in their careers.

1. Introduction

The question whether upper secondary vocational education should primarily teach occupation-specific skills or should also aim at providing pupils with general skills, is part of a larger debate on the future of education in the light of changes on the labour markets. Questions focus on the skills that students need to help them succeed in a globalised economy, where knowledge and innovation have become more important and where flexibility on the labour markets increasingly requires workers to assume responsibility for their sustainable employment (Autor, 2010; Levy, 2010; Allen and Van der Velden, 2013; Oesch, 2013; Arntz, Gregory and Zierahn, 2016). Education plays a central role in preparing future workers for these increasing demands in knowledge, innovation capacity, flexibility etc. (CEDEFOP, 2015; OECD, 2010).

This debate is especially relevant for vocational education. Research in the past few decades suggests that in many countries, vocational educated graduates from non-tertiary education experience higher quality school-to-work transitions than their academic educated peers (Shavit and Muller, 1998; Ryan, 2001, 2003; Van der Velden and Wolbers, 2003; Levels, Van der Velden and DiStasio, 2014). One of the explanations put forward is that vocational educated school-leavers are equipped with skills directly deployable at the labour market, thus making them relatively attractive for employers (Ryan, 2001, 2003; Hoffman, 2011). Another explanation is that vocational educated often have close contacts with prospective employers during their initial training, which leads to a smooth transition to the labour market (Ryan, 2001, 2003; Van der Velden and Wolbers, 2003).

However, occupational task demands change during careers, and occupation-specific skills that were acquired in education become obsolete. Better employment prospects associated with a vocational qualification seem to reverse later in life (Hanushek et al., 2016; Forster, Bol and Van de Werfhorst, 2016). The focus on occupation-specific skills and a lack of general skills could make vocational educated less flexible on the labour market, which would hamper their ability to find jobs outside of their field if they are unemployed.

A number of studies have pointed out that general skills (rather than specific skills) are most strongly linked to wages. After accounting for general cognitive ability, specific skills and abilities explain very little additional variance in performance (Ree, Earles and Teachout, 1994; Thorndike, 1986). Semeijn (2005) found that within types of university education, generic (and not occupation-specific) skills predict labour market success of graduates. And a job-level analysis by Rotundo and Sackett (2004) indicates that specific skills and abilities account for limited wage variance beyond general cognitive and technical skill factors.

This leaves us with an interesting puzzle. If general skills are so important, why would the vocational educated than have a better transition to the labour? Surely, they can only have a comparative advantage

on the labour market as a result of their specific skills and not on the basis of their general skills which are generally lower than for the academic educated. The whole idea of vocational education as a safety net is based on the assumption that vocational students will be equipped with skills that are different from those with an academic education, and not just lower (Lutz and Sengenberger, 1974; Shavit and Müller, 2000). This difference will give them some protection when competing with their academic educated peers on the labour market.

This brings us to the question of *how* the development of general and specific skills is related. There are basically two views: the complementary view and the trade-off view. In the complementary view, the acquisition of general skills and specific skills are largely intertwined and develop in a symbiotic process. First of all, basic levels of literacy and numeracy skills are often viewed as a prerequisite for acquiring more specific skills. Basic literacy and numeracy skills provide the foundation needed in order to develop vocational skills (Tuijnman, Kirsch and Wagner, 1997). Furthermore, studies indicate that developing higher order general skills such as problem solving also require context: information processing only becomes meaningful if it is embedded in a specific context (Schmidt, 1997). According to *theories on the development of expertise*, context-specific knowledge and skills play a crucial role in solving difficult tasks (Weinert, 2001; Boshuizen, Bromme and Gruber, 2004). Some even argue that *all* general skills are domain-specific (Perkins and Salomon, 1989; Tricot and Sweller, 2013). The context-dependent nature of problems in everyday life implies that students need to engage in leaning activities that include both practical, specific knowledge and authentic, contextualized problem-solving learning experiences (Middleton, 2002). In this view, general skills are seen as *complements* of vocational skills. From an education perspective, connecting general skills to domain-specific subjects and skills provides a powerful learning environment (Van der Velden, 2011, Van Merriënboer, 2013).

But the joint acquisition of general and specific skills is not evident. Although research on the integration of teaching literacy skills with subject-specific skills shows that language learning can enrich the learning of other (specific) subjects (Bonset and Ebbers, 2007), a number of conditions must be met: a focus on language skills that is relevant to the specific subject, the use of (authentic) teaching materials that integrate literacy with subject-specific tasks, and support of subject-teachers plus a clear role for literacy teachers. Similar results are found in adult education; embedding literacy and numeracy into vocational training improves the likelihood of retention, but only if the content is connected to real-life vocational contexts (Alkema and Rean, 2014). If this is not the case, a stronger focus on general skills in vocational education, may come at the expense of the development of vocational skills. Since learning a skill depends on the amount of time a student spends engaged in the learning process (Slavin, 2003), *time on task* is an important perquisite of mastering a skill. In this view, time spent on the acquisition of generic skills competes with the acquisition of specific skills, leading to a *trade-off*. This trade-off is often recognized in education (Turkenburg, 2014). And in an empirical study, Meng et al. (2017) find indeed a negative relation between the time spent on generic skills in vocational education and the development of specific skills.

So dependent on how general and specific skills are developed in education, we would expect a difference in the correlation between the two at the moment when vocational educated will enter the labour market. In the ‘complementary regime’ the level of general and specific skills are highly correlated, while in the ‘trade-off regime’ the correlation is much lower or even negative when there is only trade-off (once we control for levels of education within these vocational tracks). How does this help us to assess the effect of vocational and general skills on labour outcomes of vocational educated across the life course? Crucial here is that we will assume that in the beginning of their career vocational educated will only be awarded on the basis of their specific skills and not their level of general skill. This is not a crude assumption as all previous research showed that vocational educated have a better entry into the labour

market, and this can only be caused by their relative advantage in specific skills (which academic educated typically lack) and not on the basis of their general skills (which are lower compared to their academic educated peers). During their career however, general skills will become more important in determining labour market success, as technology and organisational changes will render the specific skills obsolete.

We can now use this information to observe the effect of general skills on wages over the life course for the vocational educated. If the effect of general skills on wages is more or less flat over the entire life course, this is an indication of the dominance of the 'complementary regime'. Note that this does not mean that this effect is always 'caused' by the general skills. In the beginning general skills will have a strong effect, just because they are highly correlated with specific skills. Later in the career, general skills will directly affect the wages as they become increasingly more important in directly affecting productivity. This situation is quite different from the situation in the 'trade-off regime'. Here we expect the effect of general skills on wages for the vocational educated to be zero or very low in the beginning of their career, while substantially increasing over the life course.

In this paper we use data from the Programme for the International Assessment of Adult Competencies (PIAAC) to explore the relationship between general skills and labour market success of 20-55-year-old workers from 19 developed countries with advanced economies. Focusing on people who completed education at ISCED levels 3 or 4, we assess the differential role of general skills in predicting earnings for academic and vocational educated workers for different age groups. The results indicate that general skills affect earnings of vocational educated workers during all phases of their career, not just at later phases, but also right from the start. This is a strong indication that the development of general and vocational skills is largely intertwined and that the 'complementary regime' is dominant. However this does not hold for all countries. In countries with a dominance of apprenticeships in vocational education (the so-called dual systems), we do find evidence of a 'trade-off regime', suggesting that here the development of general and specific skills do not go hand in hand.

The remainder of this paper is organised as follows. In Section 2 we will elaborate the theoretical model and formulate the hypotheses. Section 3 describes the data. In Section 4 we present the results and Section 5 concludes.

2. Model specification and hypotheses

In upper secondary education of most countries, students have a choice to follow a vocational track or an academic track. Both entry into as well as the successful completion of the academic track is positively related to general academic skills such as literacy and numeracy. Therefore we assume that degree holders from an academic track at ISCED levels 3 and 4 have higher general academic skills than degree holders from a vocational track at that level.
The specified model is:

$$AS_{ic} = \alpha_c + \beta(X_{ic}) + \gamma\,(V_{ic}) + \upsilon_{ic} + \omega_c \qquad (1)$$

In which AS_{ic} is the level of general academic skills of an individual i upon leaving upper secondary education in country c, α_c is a country-specific constant, X_{ic} is a vector of characteristics of individual i, including a variable indicating the level of upper secondary education expressed in years of schooling, V_{ic} is a dummy indicating whether an individual followed a vocational track in upper secondary education and

υ_{ic} and ω_c are random error terms at the individual and country level respectively. In this specification parameter γ is negative.

H1: School-leavers from academic tracks in upper secondary education have higher skill proficiency levels in key information-processing skills than school-leavers from vocational tracks.

As indicated above, when entering the vocational track, students have lower general academic skills than their peers in the academic track. During the upper secondary educational program, this gap will widen as the students in the academic track will solely focus on the further development of their general skills, while the students in the vocational track will focus more on the development of their vocational skills. A problematic issue is that we do not measure these vocational skills directly: measurements of the level and proficiency of workers' skills in studies such as PIAAC focus on general skills because they provide reliable predictors for a wide range of social and economic outcomes. However we can indirectly estimate the relevance of these vocational skills by assuming a certain relation between the development of these skills and the development of general academic skills. This relation between the development of vocational skills and general academic skills can be thought of as either complementary or as a trade-off.

In the 'complementary regime', we assume that the development of vocational and general skills is largely intertwined. Vocational skills build on a basis of general academic skills and are therefore a function of those skills and vice versa becoming an expert in a certain vocational domain also stimulates the development of general academic skills (Tuijnman, Kirsch and Wagner, 1997; Weinert, 2001; Van der Velden, 2011, Van Merrienboer, 2013). The level of achieved vocational skills is therefore directly related to the level of general academic skills. In the 'trade-off regime' however, we assume that the development of vocational skills is largely unrelated or even negatively related to the initial level or subsequent development of general skills. Following the 'time-on-task' argument (Slavin, 2003), investing time in developing specific skills will be at the expense of developing general skills. Even if students with higher initial general skills will have an initial advantage in learning specific skills, in the vocational program theyr not further develop their general skills. So at the end of their vocational program, the correlation between the two types of skills can be considered as very low, zero or even negative.[3]

Students who follow a vocational track acquire such vocational skills by practising in a working environment under the supervision of 'masters' (Sennett, 2008). Becoming an expert in a vocational domain is largely dependent on learning by doing and requires long working experience in a specific occupation. We assume that these acquired vocational skills are not transferable to another domain.
In the model:

$$\text{If } V_{ic} = 1: \quad VS_{ic} = \alpha_c + \beta\,(X_{ic}) + \gamma\,(AS_{ic}) + \upsilon_{ic} + \omega_c \qquad (2a)$$

$$\text{If } V_{ic} = 0: \quad VS_{ic} = 0 \qquad (2b)$$

In which VS_{ic} is the level of vocational skills of an individual i upon leaving upper secondary education in country c. Note that the acquisition of vocational skills only takes place in the vocational track: degree holders from an academic track have no such skills acquired. Following the above argumentation, parameter c will be positive in the case of the 'complementary regime' and turn zero in the 'trade-off regime'.

3. We control for years of schooling within upper secondary education, thus eliminating any effects resulting from the fact that within vocational education, students with higher general skills will enter the longer and more difficult tracks which are associated with higher rewards on the labour market. By controlling for this we can assume that the correlation between general and specific skills within such tracks is indeed zero in the 'trade-off regime'.

Now what happens if these degree holders enter the labour market? We assume that degree holders from the academic track will only be rewarded on the basis of their general skills, while degree holders from the vocational tracks will only be rewarded on the basis of their vocational skills, at least in the beginning of their career.

If V_{ic} =0: $$W_{ic} = \alpha_c + \beta 1\ (AS_{ic}) + \gamma\ (X_{ic}) + u_{ic} + \omega_c \quad (3a)$$

If V_{ic} =1 in a 'complementary regime':

$$W_{ic} = \alpha_c + \beta\ (VS_{ic}) + \gamma\ (X_{ic}) + u_{ic} + \omega_c$$
$$= \alpha_c + \beta 2\ (AS_{ic}) + \gamma\ (X_{ic}) + u_{ic} + \omega_c \quad (3b)$$

If V_{ic} =1 in a 'trade-off regime':

$$W_{ic} = \alpha_c + \beta\ (VS_{ic}) + \gamma\ (X_{ic}) + u_{ic} + \omega_c$$
$$= \alpha_c + \beta 3\ (AS_{ic}) + \gamma\ (X_{ic}) + u_{ic} + \omega_c \quad (3c)$$

In which W_{ic} is the natural logarithm of the hourly wages of individual i in country c. Parameters β1 and β2 are positive, while parameter β3 is zero. Moreover, because the vocational educated have some comparative advantage of having acquired vocational skills, and the relation between vocational skills and academic skills is not perfect, we expect the premium on general academic skills in the 'complementary regime' to be lower than in the case of the academic educated.
In the model:

$$\beta 1 > \beta 2 > \beta 3 \text{ and } \beta 3 = 0 \quad (4)$$

Now there are two complications that prevent a direct and straightforward estimation of this model. One complication is that skills and general skills in particular cannot be directly observed by employers. When entering the labour market, degree holders are therefore primarily rewarded on the basis of observable characteristics such as level of education, grades etc. (Spence, 1973; Weiss, 1995; Altonji and Pierret, 2001). After a while however, employers will 'discover' the true skills of their workers and base their rewards on those skills. This reveals itself in a lower skills premium for young age workers and a higher skills premium for so-called prime age workers (workers in the age of 30-44) (Altonji and Pierret, 2001). This should hold far less for the degree holders from the vocational tracks as vocational skills can more readily be observed by employers (partly because they are directly involved in the acquisition of such skills, for example in the dual system).

The second complication is that the vocational educated are confronted with technological and organisational changes, which may render their vocational skills obsolete, and which forces them to take up new tasks in their own occupation or even a whole new occupation altogether. This is one of the reasons why researchers find a negative effect of being vocational educated later in the life course (Hanushek et al., 2015; Forster, Bol and Van de Werfhorst, 2016). If this is true, we should observe this in a increasing effect of general academic skills on wages over the life course for the vocational educated, especially in the case of the 'trade-off regime', where the development of vocational and general skills are seen as substitutes rather than complements. This should be less observable in the case of the 'complementary regime' of acquiring such vocational skills, as in that scenario, general skills are always important, be it indirectly through their effect on vocational skills or directly.
In the model:

If V_{ic} =0:

$$W_{ic} = \alpha_c + \beta 1\ (AS_{ic}) + \gamma\ (YA_{ic}) + \delta\ (OA_{ic}) + \varepsilon 1\ (AS_{ic}*YA_{ic}) + \zeta 1\ (AS_{ic}*OA_{ic}) + \eta\ (X_{ic}) + \upsilon_{ic} + \omega_c \quad (5a)$$

If V_{ic} =1 in the 'complementary regime':

$$W_{ic} = \alpha_c + \beta 2\ (AS_{ic}) + \gamma\ (YA_{ic}) + \delta\ (OA_{ic}) + \varepsilon 2\ (AS_{ic}*YA_{ic}) + \zeta 2\ (AS_{ic}*OA_{ic}) + \eta\ (X_{ic}) + \upsilon_{ic} + \omega_c \quad (5b)$$

If V_{ic} =1 in the 'trade-off regime':

$$W_{ic} = \alpha_c + \beta 3\ (AS_{ic}) + \gamma\ (YA_{ic}) + \delta\ (OA_{ic}) + \varepsilon 3\ (AS_{ic}*YA_{ic}) + \zeta 3\ (AS_{ic}*OA_{ic}) + \eta\ (X_{ic}) + \upsilon_{ic} + \omega_c \quad (5c)$$

In which YA_{ic} and OA_{ic} are two dummies indicating young age workers (20-29) and old age workers (45-55) respectively (the reference group is prime age workers, aged 30-44).
As before we expect:

$$\beta 1 > \beta 2 > \beta 3 \quad (6)$$

which are the returns to general academic skills for the reference group of prime age workers.

Following the usual age – earnings profile which peaks at around age 45 and then tappers off, we expect a negative sign for parameter γ and a non-negative sign for parameter δ. Because we expect that general skills will reveal themselves later in the labour market, we expect for the academic educated:

$$\varepsilon 1 < 0 \quad (7)$$

For the vocational educated in the 'trade-off regime', we expect a substantial increase in the effect of general academic skills:

$$\varepsilon 3 < 0;\ \beta 3 > 0 \text{ and } \zeta 3 > 0 \quad (8)$$

For the vocational educated in the 'complementary regime', we expect basically a steady effect of general academic skills:

$$\varepsilon 2 = \zeta 2 = 0 \quad (9)$$

Graphically the hypotheses related to equations 6-9 can be expressed in the following figure.

<< Figure 1 about here >>

In the first three columns, we display the expected effects of general academic skills for the academic educated for 'young age', 'prime age' and 'old age' workers respectively. We expect the following:

H2a: For prime age workers, the effect of general academic skills is higher for academic educated than for vocational educated.

H2b: For academic educated, the effect of general academic skills is highest for prime age workers and lowest for young age workers.

In the next three columns we display the expected effects of general academic skills for the vocational educated in a 'complementary regime'. We expect the effect to be significant but lower than in the case of the academic educated (see *H2a*). Furthermore we expect the effect to be more or less the same across all age groups. Note that this does not imply that these general skills directly affect wages. As indicated

before we assume that vocational educated young age workers are primarily rewarded on the basis of their specific skills, but as these are largely correlated with general skills in the 'complementary regime' we will observe a strong effect here (and maybe even stronger than for the academic educated, as the reward is here based on the relation with specific skills which are observable to employers). In later phases of the career the effect of general skills will be more direct and substitute the effect of specific skills. The result is that the overall-effect will not substantively change over the life course. The final three columns display our expectations for the vocational educated in the 'trade-off regime'. We expect the effect of general skills to be close to zero for 'young age' workers and then to increase over the life cycle as specific skills will be rendered obsolete and workers will become more and more dependent on their general skills to compete on the labour market.

H3a: For vocational educated, the effect of general academic skills is not significantly different across the different age cohorts ('complementary regime').

H3b: For vocational educated, the effect of general academic skills is very low or zero for young age workers and increases substantially over the age cohorts ('trade-off regime').

In the analyses we will test equations 6-9 to assess whether the development of vocational skills follows primarily a 'complementary regime' or a 'trade-off regime'. However we should be aware that it is highly unlikely that in all vocational programs the underlying pedagogy and instructional principles are the same. Between countries we would expect that in school-based vocational systems the development of vocational skills is probably more complementary in nature than in apprenticeship-based vocational systems. In that case effects of general skills on outcomes over the life cycle for the vocational educated in a country with a school-based vocational system would more look like the middle three columns in Figure 1, while the effects for similar educated in an apprenticeship-based vocational system would more look like the last three columns in Figure 1.

H4a: For vocational educated in countries with a general system or school-based vocational system, the effect of general academic skills is not significantly different across the different age cohorts ('complementary regime').

H4b: For vocational educated in countries with an apprenticeship-based vocational system the effect of general academic skills is very low or zero for young age workers and increases substantially over the age cohorts ('trade-off regime').

3. Data

We make use of the PIAAC data set (OECD, 2013a; OECD, 2013b), which assesses the proficiency of the adult population in key information-processing skills in OECD countries. The survey is designed to be cross-culturally and cross-nationally valid. The original dataset comprises 24 countries and some 166,000 respondents. The national samples are representative samples of non-institutionalized persons aged 16-65. Most countries have around 5.000 respondents in the sample, with the exception of Canada which has more than 27,000 respondents. From this dataset we excluded Australia, because of data protection rules, and the Russian Federation because we are not fully sure about the data quality. Cyprus was omitted because of measurement issues, and Belgium and Italy because no respondents in ISCED 3 and 4 that were classified as academic educated. From the Canadian sample we took a random sample of some 20% to avoid an overrepresentation of the Canadian sample in the total data set.

PIAAC assesses the proficiency of respondents in three key information-processing areas: numeracy, literacy and problem solving in technology-rich environments. In this paper we only focus on numeracy and check comparability of the results for literacy. The reason to leave out problem solving is that around one third of the respondents did not take the test, because they lacked computer skills or because they choose to only use paper-and-pencil tests (which was not available for the problem solving domain). Moreover, some countries (France, Cyprus, Spain and Italy) decided not to have this test. Adaptive testing and item response techniques were used to calculate 10 plausible values for each of these two domains. Together, these plausible values on numeracy and literacy provide an unbiased estimate of the 'real' score if the respondent would have taken all the numeracy and literacy related items (OECD, 2013b). The numeracy scale has a range from 0 to 500 with an OECD international average of 273 and the literacy scale has a similar range with an OECD average of 270.

For all analyses we only selected respondents whose highest achieved level of education is ISCED 3 or 4, as we would like to concentrate on the vocational and academic educated in upper secondary education. We leave out the 16-19-year-olds as they will not have finished a full upper secondary education yet. Moreover the wages for this group may be subject to institutional youth wage setting regimes. We also decided to leave out the people aged 56 or older, as countries differ largely in the age at which workers are allowed to retire. Furthermore we selected male, fulltime working employees who are not currently employed as an apprentice or still in education. This selection is done to avoid different wage setting regimes for part-timers and women. Also the relation between skills and earnings for self-employed or skills for those who are currently working as an apprentice or as a student are quite different from that for employees. Fulltime is defined as working 32 hours or more per week. We only selected respondents for whom we have valid information on skills proficiency and hourly wages. Wages were trimmed per country leaving out the 1st and 99th percentile of the respondents in each country.

The resulting dataset includes 19 countries and 9,482 individuals. Table A1 in the Appendix provides an overview of the number of respondents (for the main analysis on male fulltime working employees) in each country, distinguished by educational system characteristics (school-based vocational system, dual system or general system).

The dependent variable is the log hourly wage, excluding bonuses and PPP converted to US dollars. Before calculating the hourly wages, the number of hours was top-coded at 60 hours per week. The main predictors are the numeracy proficiency scores (mean-centred per country), a dummy indicating whether someone followed a vocational track or not and two age dummies: 'young age workers' (20-29) and 'old age workers' (45-55).[4] As control variables we add years of schooling as the qualifications at ISCED level 3 and 4 may vary in length. To test our hypotheses we add interaction terms between the two age dummies and numeracy. Table A2 in the Appendix presents the descriptive statistics for these variables.

4. Results

First we analysed equation 1, to estimate the average level of academic educated versus vocational educated at ISCED 3 and 4 level, controlled for age, age squared and number of years of schooling.

<<Figure 2 about here>>

4. As a robustness check (results available on request) we also run all the analyses with age and age square.

Figure 2 presents the results, showing that the academic educated on average score 11 points higher on the numeracy proficiency scale. Given that the standard deviation of numeracy is about 50 points in the entire population, this amounts to some 22% of a standard deviation. This confirms our expectation that the vocational educated score lower on general academic skills than the academic educated, either due to negative selection on these skills into vocational education, and/or through subsequent lower development of these skills. This confirms *Hypothesis 1*.

<<Table 1 about here>>

In Table 1 we present the outcomes of our main analysis of the effect of numeracy skills on log hourly wages. Robustness analyses are presented in the appendix.[5] The first column in Table 1 (model 1) shows the familiar steep age-earnings profile with a negative wage effect of being in the young age group (minus 20%) and a small positive effect of being in the old age group (plus 3%). Each year of schooling increases the wages with some 6% which is the usual effect found in this type of research (Groot and Maassen-Van den Brink, 2000). But there is also an average negative effect of coming from a vocational track which amounts to some 5%.

In model 2 we add the numeracy proficiency level. As indicated before, numeracy-scores are based on IRT modelling which produce 10 so-called plausible values (PV's). We experimented with various ways of modelling with the variance introduced by the plausible values. For example, we used STATA software piaacreg, which is designed to model regressions with piaac plausible values. However, this did not allow multilevel modelling and as a result did not provide a satisfying way of modelling cross-national variation. We now used the average score of the ten plausible values of numeracy (and literacy) as dependent variables, to obtain correct point estimates. This procedure disregards variance generated by the plausible values, and underestimates standard errors. To get the most conservative estimation of the significance of our effects, we ran additional analyses on the ten plausible values as dependent variables separately and used the highest estimated standard errors of the separate analyses to construct conservative confidence intervals around our estimates. This provides the most conservative test of hypotheses and allows us to determine whether our results are sensitive to the way we model numeracy skills.

We note that the positive wage effect for the old age group increases a bit from 3% to 5%, indicating that the workers in the old age group in general have lower skill proficiency levels. The wage penalty for vocational educated also reduces from 5% to 3% once we control for numeracy, indicating that this wage penalty is partly due to the lower general academic skills of this group. The effect of the proficiency level of numeracy on wages is huge: a one standard deviation increase in skills is associated with some 10% (=0,204*50) increase in wages.

In model 3, we add the interaction terms between vocational track and numeracy. The results show that the effect of numeracy skills on wages is higher for academic educated (0,233) than for vocational educated (0,233 – 0,044 = 0,189). In other words, one standard deviation increase in numeracy skills is associated with some 12% increase in wages for academic educated and some 10% increase for vocational educated. This confirms *Hypothesis 2a*. However, the difference in the effect-size is barely significant and we tentatively conclude that general academic skills are almost as important in determining success on the labour market for vocational educated as it is for academic educated.

5. We perform the following robustness checks: similar analyses on literacy (Table A3), and fulltime working female workers (Table A4).

In models 4 and 5, we look at the skills effect across different age groups separately for academic and vocational educated. The results are also shown in Figure 3.

<<Figure 3 about here>>

The first three columns in Figure 3 illustrate the effects of numeracy skills for academic educated workers across the different age groups. One standard deviation increase in skills is associated with 13.6% wage premium for prime age workers. Controlled for years of schooling, the effects of numeracy skills on wages is 3.3 percentage points lower for young age workers than for prime age workers, while the effect for old age workers is also 3.1 percentage points lower. However, both differences are not significant. Although the pattern is in line with *Hypothesis 2b,* the differences are not significant and we therefore refute *Hypothesis 2b*: effects of numeracy skills do not differ significantly by age groups for the academic educated.

The second set of columns visualizes the results for the vocational educated. The most important conclusion is that the wage effect for the young age workers is significantly different from zero. A one standard deviation increase in skills is associated with 6.5% increase in wages for young age workers while a similar increase for prime age workers leads to a 9.7% wage premium. For old age workers a similar increase in skills is associated with a wage premium of 11%. The difference between the young age and the prime age workers is significant, but only at p= 0.01 level. The difference between the old age and prime age workers is not significant.

How do we interpret this in terms of the expectations in Figure 1 and *Hypotheses 3a* and *3b*? Clearly, the findings for the academic educated are not perfectly in line with *Hypothesis 3a*, as the skills effect for the young age and old age workers are not significantly different from the skills effect for the prime age workers. However we do find the expected inverse U-shape.

In the case of the vocational educated, the results are not perfectly in line with the *Hypotheses 3a and 3b* either. Contrary to *Hypothesis 3a,* we find a significant difference between the young age and the prime age workers, but contrary to *Hypothesis 3b* we find no significant difference between old age and prime age workers. Moreover, in line with *Hypothesis 3a* the skills effect for young age workers is significantly different form zero. We conclude that the results are more in favour of the 'complementary regime' (*Hypothesis 3a*) than with the 'trade-off regime' (*Hypothesis 3b*). This is based on the fact that the skills effect for the young age workers is closer to that of the prime age workers than to zero, and that the effect for the old age workers is not significantly different from that for the prime age workers.

Although, the development of vocational skills seems to follow the 'complementary regime' rather than the 'trade-off regime', we also see some indications that the effect of general academic skills increases over the life course, at least between the young age and the prime age, suggesting that there is some trade-off as well. Part of this may arise from the fact that the results are based on all countries. As suggested in *Hypothesis 4a* and *4b*, the specific characteristic of the vocational education in a country may well affect how academic skills affect outcomes.

As a robustness check, we also ran the same analyses with literacy (Table A3 in the Appendix) and for fulltime working women (Table A4 in the Appendix). The results are substantially the same.

In Table 2, we show the results for Models 4 and 5 separately for general education systems (system with a low share of vocational education), school-based vocational education systems (systems where vocational education mainly takes place in schools), and apprenticeship-based vocational education

(systems where vocational education mainly takes place during workplace training). The results are also displayed in Figures 4a-c.

<<Table 2 about here>>

<<Figures 4a-4c about here>>

For the school-based vocational systems, the results point clearly to more or less similar effects of general academic skills on wages across different age groups for the vocational educated. The skills effects for the young and the old age group are not significantly different from the skills effect for the prime age workers. The same is true for the academic educated. This is a confirmation of *Hypothesis 4a*.

For the general education systems (these are systems characterized by only a small proportion of young people choosing a vocational track), we see that the skills effect for the younger workers is lower, but not significantly, than the skills effect for the prime age workers. The skills effect for the old age workers from the vocational tracks in this type of countries is also lower, but again not significantly, from that of the prime age workers. We observe the same pattern for the academic educated in these countries. Vocational tracks in such countries are much smaller and typically involve a negative selection of students. As can be seen from Table A1 in the Appendix, in the general systems 45% of the workers from ISCED 3 and 4 have followed the vocational track, while in the school-based vocational systems this is 71% and in the apprenticeship-based systems even 84%. Nevertheless, we do not observe a large difference in the way general skills affect outcomes. These effects are more or less the same for the academic and the vocational educated in these countries.

If we look at Figure 4c, we can clearly see that the effect of general skills on wages of vocational educated increases over the life cycle in the apprenticeship-based systems. Although the effects of skills on wages for prime age workers is lower than in the general system, the effect for old age workers is clearly the highest and even surpasses the effect for the academic educated. We see this is as a partial confirmation of *Hypothesis 4b*, even though the effect for young workers is still significantly different from zero.

5. Conclusions and discussion

The world is changing rapidly and key-information processing skills are becoming more and more important in determining success in the world of work as well as in life in general (OECD, 2013a). Still there is a debate to what extent these skills should be a prime focus in vocational education. The vocational educated have a ‘protected’ position on the labour market because they have acquired specific skills that their academic educated peers lack. Without these specific skills, they would lose this comparative advantage and be worse off. This confirmed in earlier research: young people with a vocational degree have little trouble entering the labour market, despite the fact that they have lower academic skills than their competitors (Ryan, 2001; 2003; Van der Velden and Wolbers, 2003; Levels et al., 2014). The problem is that this initial advantage peters out over the life course and can even reverse at older age (Hanushek et al. 2016; Forster et al. 2016). This is because their specific skills are rendered obsolete and they increasingly need general skills to stay employable. The conclusions from earlier research seem to indicate that general skills are important for vocational educated, but mainly to help adjust to changes in the job requirements and work tasks later in life (Hanushek et al. 2016).

This does not automatically imply that more attention should be paid to teaching general skills in vocational education, as there might be a price to be paid. The acquisition of more general skills in vocational education may come at the expense of acquiring specific skills, which are the skills that protect these workers in the beginning of their career. This is the situation that we have described in this paper as the 'trade-off regime': time spent on general skills cannot be spent on specific skills. This would imply that providing more general skills in vocational education is good for vocational educated workers at prime age or old age, but bad for young workers making the transition to the labour market. And vice versa, focusing solely on specific skills is good for entering the labour market, but may become a disadvantage later in the career. What looks like a choice between Scylla and Charybdis, may actually be less complicated if the acquisition of general and specific skills is more developed in a symbiotic way. In what we have called the 'complementary regime' the development of general and specific skills is largely intertwined. Basic general skills provide the foundation for developing specific skills and vice versa, the higher order general skills are developed as a function of the development of specific expertise.

What we do not know is how important general skills are for vocational educated in the different phases of their career and how this compares to the effect of the same skills for the academic educated. Moreover, we lack information on how general and specific skills are developed in vocational education. Is there a 'trade-off regime' or a 'complementary regime'? And does this differ between countries that have organised their vocational education in a different way?

In this paper we have addressed these questions using data from the PIAAC survey to explore the relationship between general skills and labour market success of 20-55-year-old workers from 19 developed countries with advanced economies. Focusing on people who completed education at ISCED levels 3 or 4, we have assessed the differential role of general skills in predicting earnings for academic and vocational educated workers for different age groups.

The results indicate that general skills affect earnings of vocational educated workers during all phases of their career, not just at later phases but right from the start. This is already an important conclusion, as the theoretical assumption has always been that these general skills should not be that important for young vocational educated workers as these will be recruited primarily on the basis of their specific skills. This is not true: general skills are important for all workers and at all phases of their career, and not just for academic educated or for vocational educated workers at prime or old age.

This does not imply that these general skills directly affect the wages of young vocational educated workers. In the paper we have argued that this can be seen as evidence that the dominant mode of acquisition of general and specific skills in vocational education is the 'complementary regime'. As a result, general skills are important in every phase of the career of vocational educated (just like for the academic educated). In the beginning this is related to the high correlation with acquisition of specific skills (which are the ones that get rewarded) and later in the career the effect of general skills is more direct, and substituting the effect of specific skills that have become obsolete. However, we also found evidence that this 'complementary regime' does not work in all countries. In countries where the vocational system is primarily apprenticeship-based (the so-called dual systems) we find clear evidence of a trade-off relation. Here the effect general skills increase substantially over the life course and for older workers even surpass the effect compared to their academic educated peers.

These findings have major implications for curriculum design of vocational education systems, which should not just aim at teaching occupation-specific skills that enable quick education-to-job matches, but also strive to inculcate general skills, because these form the basis on which these specific skills can

effectively be developed at the start of their career and at the same time will help workers to remain employable and productive later in their careers. A successful integration is not automatically guaranteed as we have seen from the example of the dual systems. Apparently it is difficult to develop a sufficient level of general skills outside a school setting. But even in a school setting, a successful integration of the development of the two types of skills can be further fostered by the use of (authentic) teaching materials that integrate the learning of general skills with subject-specific tasks.

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Figure 1 Hypothetical effects of skills on wages over the life course for academic and vocational educated

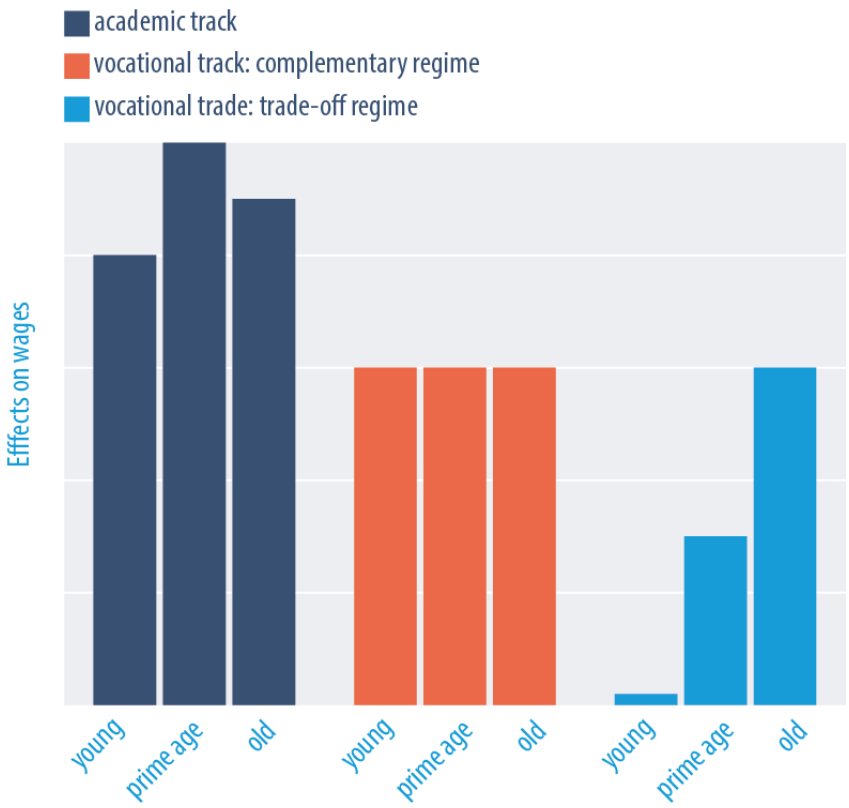


Figure 2 Difference in numeracy proficiency score between academic and vocational educated workers at ISCED levels 3 and 4

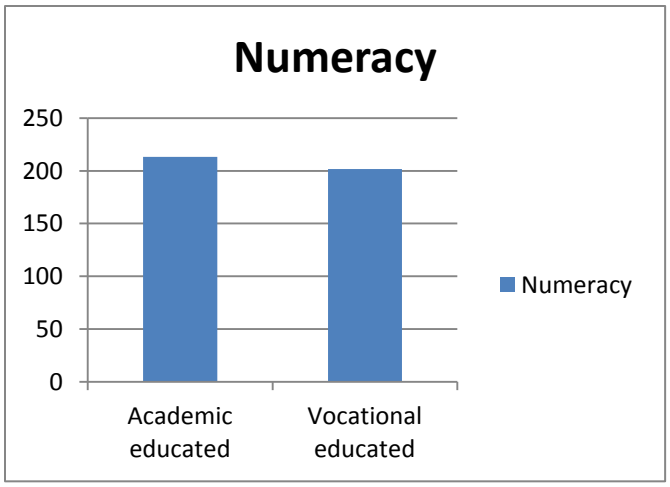


Figure 3 Effect of numeracy skills across different age groups, separately for academic and vocational educated

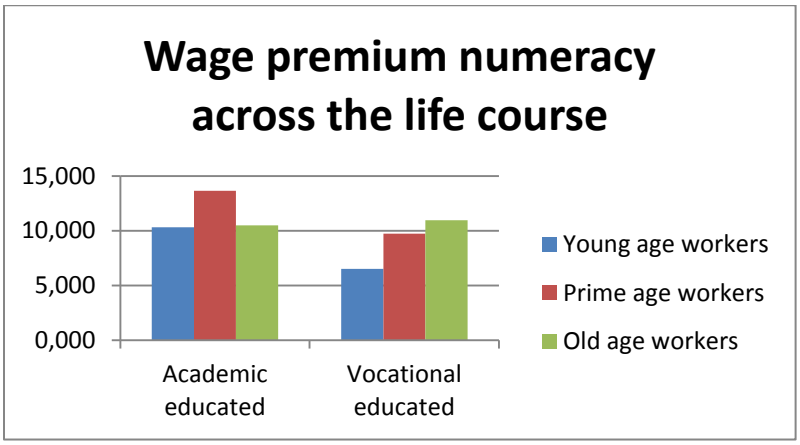
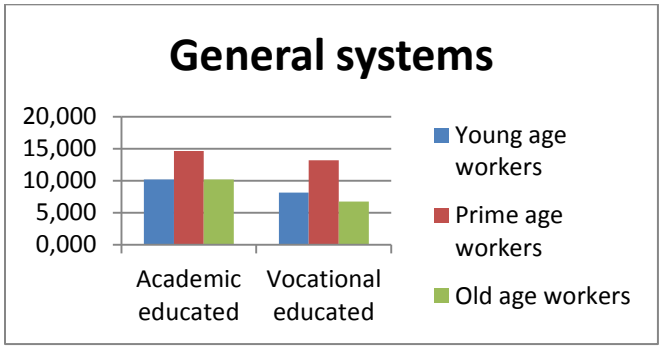
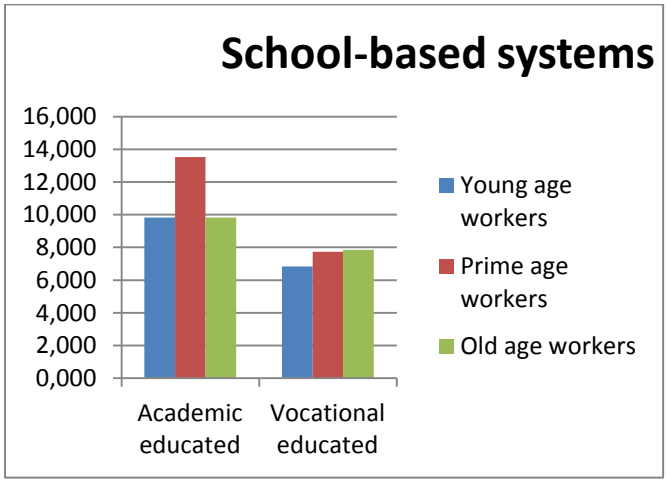


Figure 4 Effect of numeracy skills for different types of educational systems





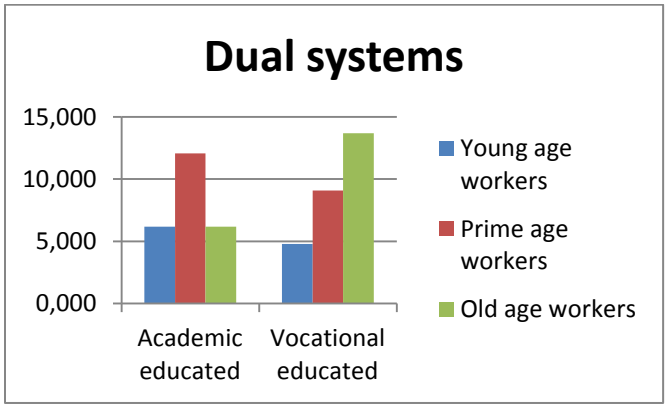


Table 1 Multilevel regression on log hourly income (no bonusses, ppp corrected)

	Model 1			Model 2			Model 3			Academic Model 4			VET Model 5		
Estimates of Fixed Effects															
Intercept	2,514	***	*0,080*	1,998	***	*0,083*	1,918	***	*0,090*	1,736	***	*0,117*	1,960	***	*0,095*
Young (20-29)	-0,199	***	*0.010*	-0,193	***	*0,010*	-0,192	***	*0,010*	-0,043		*0,113*	0,000		*0,075*
Old (45-55)	0,034	***	*0,009*	0,047	***	*0,009*	0,047	***	*0,009*	0,254	*	*0,106*	-0,033		*0,073*
Education level (years)	0,058	***	*0,006*	0,039	***	*0,006*	0,039	***	*0,006*	0,055	**	*0,017*	0,048	***	*0,007*
Vocational education	-0,054	***	*0,010*	-0,030	**	*0,010*	0,092		*0,055*						
Numeracy (/100, mean centered)				0,204	***	*0,010*	0,233	***	*0,016*	0,273	***	*0,026*	0,195	***	*0,017*
Vocational education*numeracy							-0,044	*	*0,019*						
Young*numeracy										-0,066		*0,040*	-0,064	*	*0,027*
Old*numeracy										-0,063		*0,038*	0,024		*0,026*
Random effects															
Individuals	0,139	***	*0,002*	0,133	***	*0,002*	0,133	***	*0,002*	0,148	***	*0,004*	0,125	***	*0,002*
Countries	0,115	**	*0,038*	0,112	**	*0,037*	0,112	**	*0,037*	0,108	**	*0,037*	0,118	**	*0,040*

Table 2 Numeracy effects on wages across the life course by type of educational system

	Vocational educated			Academic educated		
School-based systems						
Fixed components						
Intercept	2,051	*0,181*	***	1,889	*0,193*	***
Young (20-29)	-0,098	*0,105*		0,001	*0,167*	
Old (45-55)	0,046	*0,116*		0,401	*0,180*	*
Education level (years)	0,054	*0,009*	***	0,009	*0,021*	
Numeracy (/100, mean centered)	0,155	*0,029*	***	0,271	*0,037*	***
Young*numeracy	-0,018	*0,038*		-0,074	*0,057*	
Old*numeracy	0,002	*0,042*		-0,087	*0,061*	
Random components						
Individuals	0,095	*0,003*	***	0,094	*0,005*	***
Countries	0,156	*0,099*		0,127	*0,081*	
General systems						
Fixed components						
Intercept	1,874	*0,173*	***	1,580	*0,148*	***
Young (20-29)	0,048	*0,242*		-0,017	*0,171*	
Old (45-55)	0,346	*0,223*		0,244	*0,151*	
Education level (years)	0,032	*0,016*	*	0,104	*0,025*	***
Numeracy (/100, mean centered)	0,264	*0,049*	***	0,293	*0,039*	***
Young*numeracy	-0,101	*0,088*		-0,089	*0,063*	
Old*numeracy	-0,128	*0,082*		-0,064	*0,056*	
Random components						
Individuals	0,220	*0,009*	***	0,172	*0,006*	***
Countries	0,056	*0,033*		0,037	*0,022*	
Dual systems						
Fixed components						
Intercept	1,885	*0,199*	***	2,148	*0,418*	***
Young (20-29)	0,063	*0,110*		0,141	*0,328*	
Old (45-55)	-0,218	*0,096*	*	0,181	*0,356*	
Education level (years)	0,066	*0,012*	***	-0,058	*0,096*	
Numeracy (/100, mean centered)	0,181	*0,023*	***	0,241	*0,065*	***
Young*numeracy	-0,086	*0,039*	*	-0,118	*0,110*	
Old*numeracy	0,092	*0,034*	**	-0,055	*0,118*	
Random components						
Individuals	0,106	*0,003*	***	0,162	*0,010*	***
Countries	0,205	*0,130*		0,172	*0,116*	

Appendix

Table A1: Number of respondents per country cluster

	academic	vet	Total
Dual systems			
Austria	43	731	774
Czech Republic	34	658	692
Denmark	83	413	496
Germany	8	650	658
Netherlands	65	330	395
Slovak Republic	354	358	712
General systems			
Canada	214	176	390
Estonia	246	379	625
Ireland	167	152	319
Japan	259	154	413
Korea	225	228	453
United Kingdom	173	102	275
United States	240	77	317
School-based systems			
Finland	64	450	514
France	144	141	285
Norway	127	392	519
Poland	182	824	1006
Spain	172	25	197
Sweden	164	278	442
	2964	6518	9482

Table A2 Descriptive statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Young age workers (20-29)	9482	0,000	1,000	0,276	0,447
Prime age workers (30-44)	9482	0,000	1,000	0,422	0,494
Old age workers (45-550	9482	0,000	1,000	0,302	0,459
Education in years	9482	0,000	9,000	9,405	1,118
Vocationally trained	9482	0,000	1,000	0,687	0,464
Numeracy (/100)	9482	0,738	4,160	2,761	0,415
Literacy (/100)	9482	0,695	3,908	2,743	0,381

Table A3 Results for literacy

Estimates of Fixed Effects	**Model 1**		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
Intercept	2,164 ***	*0,094*	1,776 ***	*0,095*	1,679 ***	*0,104*	1,386 ***	*0,190*	1,670 ***	*0,113*
Young (20-29)	-0,199 ***	*0.010*	-0,199 ***	*0,010*	-0,199 ***	*0,010*	0,098	*0,126*	0,082	*0,082*
Old (45-55)	0,034 ***	*0,009*	0,051 ***	*0,009*	0,051 ***	*0,009*	0,352 **	*0,120*	-0,041	*0,078*
Education level (years)	0,056 ***	*0,006*	0,043 ***	*0,006*	0,043 ***	*0,006*	0,052 **	*0,017*	0,052 ***	*0,007*
Vocational education	-0,054 ***	*0,010*	-0,031 **	*0,010*	0,111	*0,061*				
Literacy			0,188 ***	*0,011*	0,221 ***	*0,018*	0,289 ***	*0,028*	0,182 ***	*0,019*
Vocational education*literacy					-0,051 *	*0,021*				
Young*literacy							-0,119 **	*0,044*	-0,096 **	*0,029*
Old*literacy							-0,096 * $	*0,043*	0,029	*0,029*
Random effects										
Individuals	0,139 ***	*0,139*	0,134 ***	*0,002*	0,134 ***	*0,002*	0,150 ***	*0,004*	0,126 ***	*0,002*
Countries	0,115 **	*0,115*	0,113 **	*0,038*	0,114 **	*0,038*	0,108 **	*0,037*	0,121 **	*0,041*

*p<0.01 ** p<0.001 ***p<0.0001; $: Sensitive to measurement of skills

Table A4 Results for fulltime working women

	Model 1			Model 2			Model 3			Model 4			Model 5		
Numeracy															
Estimates of Fixed Effects															
Intercept	1,344	***	*0,114*	1,296	***	*0,120*	1,286	***	*0,120*	1,441	***	*0,207*	1,199	***	*0,129*
Young (20-29)	-0,138	***	*0,011*	-0,137	***	*0,011*	0,020		*0,084*	0,019		*0,140*	0,003		*0,104*
Old (45-55)	0,035	***	*0,010*	0,035	***	*0,010*	0,140	*	*0,070*	0,235	*	*0,113*	0,058		*0,089*
Education level (years)	0,061	***	*0,006*	0,061	***	*0,006*	0,054	***	*0,006*	0,036		*0,018*	0,071	***	*0,007*
Vocational education	-0,057	***	*0,011*	0,024		*0,065*									
Numeracy (/100)	0,215	***	*0,012*	0,233	***	*0,019*	0,249	***	*0,018*	0,267	***	*0,029*	0,214	***	*0,023*
Vocational education*numeracy				-0,030		*0,024*									
Young*numeracy							-0,058		*0,031*	-0,064		*0,051*	-0,049		*0,039*
Old*numeracy							-0,039		*0,026*	-0,078		*0,042*	-0,007		*0,033*
Random effects															
Individuals	0,117	***	*0,002*	0,117	***	*0,002*	0,117	***	*0,002*	0,129	***	*0,004*	0,108	***	*0,002*
Countries	0,174	***	*0,058*	0,174	***	*0,058*	0,174	***	*0,058*	0,175	***	*0,059*	0,176	***	*0,059*
Reading literacy															
Estimates of Fixed Effects															
Intercept	1,348	***	*0,115*	1,280	***	*0,123*	1,292	***	*0,121*	1,444	***	*0,209*	1,216	***	*0,132*
Young (20-29)	-0,142	***	*0,012*	-0,142	***	*0,012*	0,027		*0,094*	0,012		*0,162*	0,004		*0,115*
Old (45-55)	0,042	***	*0,010*	0,041	***	*0,010*	0,134		*0,078*	0,261	*	*0,129*	0,033		*0,098*
Education level (years)	0,063	***	*0,006*	0,063	***	*0,006*	0,056	***	*0,006*	0,034		*0,018*	0,074	***	*0,007*
Vocational education	-0,063	***	*0,011*	0,045		*0,072*									
Literacy (/100)	0,201	***	*0,013*	0,225	***	*0,020*	0,234	***	*0,020*	0,267	***	*0,032*	0,189	***	*0,025*
Vocational education*literacy				-0,039		*0,026*									
Young*literacy							-0,060		*0,034*	-0,062		*0,057*	-0,049		*0,041*
Old*literacy							-0,034		*0,028*	-0,083		*0,046*	0,005		*0,036*
Random effects															
Individuals	0,118	***	*0,002*	0,118	***	*0,002*	0,119	***	*0,002*	0,130	***	*0,004*	0,109	***	*0,003*
Countries	0,171	***	*0,057*	0,171	***	*0,057*	0,172	***	*0,057*	0,172	***	*0,058*	0,173	***	*0,058*