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The Impact of Literacy, Numeracy and Computer Skills on Earnings and Employment Outcomes

Marguerita Lane,

Gavan Conlon

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THE IMPACT OF LITERACY, NUMERACY AND COMPUTER SKILLS ON EARNINGS AND EMPLOYMENT OUTCOMES

OECD Education Working Papers No. 129

By Marguerita Lane and Gavan Conlon, London Economics.

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

Marguerita Lane, London Economics (mlane@londoneconomics.co.uk)
Gavan Conlon, London Economics (gconlon@londoneconomics.co.uk)
Gara Rojas González, Directorate for Education and Skills, OECD (Gara.RojasGonzalez@oecd.org)

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ABSTRACT

Using the 2012 PIAAC data, our analysis confirms that there are significantly higher earnings and employment returns to *both* increasing levels of formally recognised education, and to increasing levels of numeracy, literacy and Information and communication technologies (ICT) skills proficiencies controlling for the level of education.

Unsurprisingly, the labour market returns to changes in formally recognised levels of education in general exceed the labour market returns associated with increasing levels of skills proficiency. In the case of literacy and numeracy proficiencies, improved literacy and numeracy skills narrow the labour market outcomes gap between individuals with different levels of formally recognised education, but do not close it completely. The analysis demonstrates more substantial returns to ICT skills. Furthermore, possession of higher levels of ICT skills and lower levels of formally recognised qualification are often associated with higher returns compared to individuals with higher levels of formally recognised education but lower ICT proficiency levels. In other words, ICT skills proficiencies often entirely compensate for lower formally recognised qualifications in the labour market.

RÉSUMÉ

Sur la base des données de 2012 du PIAAC, notre analyse confirme que *tant* l'élévation du niveau d'éducation formellement reconnue *que* celle du niveau de compétences en numératie, en littératie et en TIC après contrôle du niveau d'éducation entraînent des bénéfices significativement supérieurs.

Sans surprise, les bénéfices sur le marché du travail associés à une élévation du niveau d'éducation formellement reconnue sont en général supérieurs à ceux découlant de l'amélioration du niveau de compétences. Dans le cas des niveaux de compétences en littératie et en numératie, leur élévation réduit l'écart de résultats sur le marché du travail entre les individus ayant des niveaux différents d'éducation formellement reconnue, sans pour autant le combler totalement. L'analyse met au jour des bénéfices plus importants pour les compétences en TIC. En outre, un niveau plus élevé de compétences en TIC associé à un niveau inférieur d'éducation formellement reconnue entraînent souvent des bénéfices plus importants par comparaison avec un niveau plus élevé d'éducation formellement reconnue associé toutefois à un niveau inférieur de compétences en TIC. En d'autres termes, sur le marché du travail, les compétences en TIC compensent souvent totalement un niveau inférieur d'éducation formellement reconnue.

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EXECUTIVE SUMMARY

Introduction

This paper examines which incremental increases in numeracy skills, literacy skills and skills and readiness in using ICT for problem solving have the biggest impact on employment participation and related labour market outcomes, and how these compare to incremental increases in educational attainment.

Data under consideration

The source of the data is the 2012 Survey of Adult Skills, a product of the OECD Programme for the International Assessment of Adult Competencies (PIAAC). The full dataset contains information on roughly 166 000 adults aged 16 to 65. Sample size varies by country, ranging from 4 469 (Sweden) to 27 285 (Canada) but is close to 6 000 for most countries. For this analysis, the sample under consideration was all non-students aged between 16 and 65. When the impact on earnings was assessed, the self-employed were also excluded since their earnings may be unreliable and may not accurately reflect returns to education and skills.

Model description

The impacts of skills on labour market outcomes were estimated the following types of model:

- Earnings model: Ordinary Least Squares (OLS) regression model which estimates the percentage point impact of improvements in skills and education on (log hourly) earnings by country, in the form:

$$\log(earnings)_c = \alpha_c + \beta_c X_c + \gamma_c Y_c$$

  where c represents the country, X represents the set of included skill x education interaction terms with associated coefficients in vector β; Y represents the control variables with associated coefficients in vectors γ, and α represents baseline log earnings.

- Employment model: Logistic regression model which estimates the impact (in terms of odds ratios) of improvements in skills and education on the probability of employment by country, in the form:

$$\text{logit}(\pi)_c = \delta_c + \theta_c X_c + \rho_c \bar{Y}_c$$

  where π represents the probability of employment (upon which a logit or log-odds function is applied); c represents the country; X represents the set of included skill x education interaction terms with associated coefficients in vector θ; $\bar{Y}_c$ represents the control variables with associated coefficients in vectors ρ; and δ represents the baseline log-odds of employment.

Throughout, a range of standard personal and socioeconomic characteristics were also included as independent variables.

Skills classification

Proficiency levels for numeracy and literacy were defined using the following approach:

- proficiency at or below Level 1 (score of 0 to less than 226 points)
- proficiency at Level 2 (score of 226 to less than 276 points)
- proficiency at Level 3 (score of 276 to less than 326 points)
- proficiency at Level 4 or 5 (score of 376 points or higher).

The indicator for skills and readiness in using information and communication technologies (ICT) for problem solving was based on the approach developed by Ms Annus and Ms Valk, from the Estonian Ministry of Education and Research, in 2014 for the LSO Network, as follows:

- group 0 (no use or no skills) & Group 1 (lack of readiness, opted out of computer-based assessment)
- group 2 (minimal ICT skills)
- group 3 (moderate ICT and problem-solving skills)
- group 4 (good ICT and problem-solving skills).

Education classification

The education variable consists of 3 categories:

- lower secondary or less (ISCED 0,1,2 and 3C short programmes)
- upper secondary/post-secondary (ISCED 3A, 3B, 3C long programmes, and 4)
- tertiary (ISCED 5A, 5B and 6).

For each of the three skill types and each of the plausible values for skills, the education variable (with three categories) was interacted with the skill variable (with four categories). For example, for the modelling relating to the impact of literacy proficiency on earnings or employment, there were 12 interaction terms of interest (4 literacy categories x 3 education levels). For the purpose of presenting the results, the interaction of the lowest skills category and the lowest education level is treated as the baseline reference group.

Main Findings

The labour market returns to changes in formally recognised levels of education in general exceed the labour market returns associated with increasing levels of skills proficiency (at given education levels). For instance:

- On average, the earnings return across the OECD to upper secondary education is approximately 10% while the returns to tertiary education stand at approximately 37% (compared to lower secondary education).
- The possession of incremental numeracy *or* literacy skills (i.e. moving from Level 0/1 to Levels 4/5) adds approximately 8-10% to hourly earnings *on average* for those in possession of upper-secondary level education or below. Furthermore, the returns to incremental literacy and numeracy skills increase with the highest level of formally recognised qualification. In particular,

the possession of improved numeracy or literacy skills adds approximately 15%-18% to hourly earnings on average for those in possession of tertiary education.

In the case of literacy and numeracy proficiencies, improved literacy and numeracy skills narrow the labour market outcomes gap between individuals with different levels of formally recognised education – but do not close it completely. In contrast, the analysis demonstrates an even greater return to skills and readiness in using ICT for problem solving– at all levels of formally recognised qualification. Furthermore, possession of higher levels of skills and readiness in using ICT for problem solving and lower levels of formally recognised qualification are often associated with higher returns compared to individuals with higher levels of formally recognised education but lower levels of skills and readiness in using ICT for problem solving. In other words, skills and readiness in using ICT for problem solving often entirely compensate for lower formally recognised qualifications in the labour market.

An interpretation of this finding is that there may be a significant blurring of the lines between the acquisition of skills and readiness in using ICT for problem solving and those skills that might be expected to be acquired during formal schooling. In particular, where an individual might be expected to be in possession of *representative* literacy and numeracy skills on completion of different levels of formal schooling (and different levels of schooling signal these skills), the acquisition of skills and readiness in using ICT for problem solving appear more *stand-alone* and may or may not be acquired in general schooling. As such, the high reward associated with skills and readiness in using ICT for problem solving is in part *independent* of the level of schooling achieved. Given the potential independence from formal schooling, this outcome might pose some challenges to policy makers in relation to the delivery of targeted interventions to raise skills and readiness in using ICT for problem solving.

1. INTRODUCTION

This paper examines which incremental increases in numeracy skills, literacy skills and skills and readiness in using ICT for problem solving have the biggest impact on employment participation and related labour market outcomes, and how these compare to incremental increases in educational attainment. The source of the data is the 2012 Survey of Adult Skills, a product of the OECD Programme for the International Assessment of Adult Competencies (PIAAC).

Section 2 of this paper sets out the methodological approach adopted including details of the data and the model specifications. Section 3 presents the empirical findings, with Section 3.1 focusing on the impact of education and literacy proficiency on earnings outcomes, while Sections 3.2 and 3.3 focus on the role of numeracy and skills and readiness in using ICT for problem solving on earnings, respectively. Section 3.4 presents the findings relating to the employment effects associated with literacy skills, numeracy skills and skills and readiness in using ICT for problem solving , while sections 3.8 and 3.9 provide some policy-oriented indications across OECD countries of those skills increments offering the largest earnings and employment boosts to individuals at different education levels. Section 4 provides some exploratory analysis on grouping of countries with similar returns to skills and education, while Section 5 concludes.

This paper was commissioned by the INES Network on Labour Market, Economic and Social Outcomes of Learning (LSO) to London Economics. INES is the OECD Indicators of Education Systems programme.

2. METHODOLOGY

1.1 Data

The analysis described in this paper is derived from the full PIAAC dataset, housed by the OECD although initial model specifications and variations were tested using the Public Use File (PUF). The full dataset contains information on roughly 166 000 adults aged 16 to 65. Sample size varies by country, ranging from 4 469 (Sweden) to 27 285 (Canada) but is close to 6 000 for most countries.

The sample under consideration is restricted to non-students, as including the reported earnings and employment status for students would likely obscure the impact of skills on labour market outcomes. There is no restriction based on age implying that the sample includes those aged between 16 and 65. When the impact of skills and education on earnings is undertaken, the self-employed are excluded since their earnings may be unreliable and may not accurately reflect returns to education and skills.

Education level in this paper corresponds to educational attainment, i.e. successful completion of a level of education. The classification of levels of education is based on the International Standard Classification of Education (ISCED-97) and is defined as: below upper secondary corresponds to Levels 0, 1, 2 and 3C short programmes; upper secondary or post-secondary non-tertiary corresponds to Levels 3A, 3B, 3C long programmes, and Level 4; and tertiary corresponds to Levels 5A, 5B and 6.

This publication features data on 20 OECD countries: Australia, Austria, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, the Netherlands, Norway, Poland, the Slovak Republic, Spain, Sweden and the United States. Two OECD sub-national entities include: Flanders (Belgium) and England/Northern Ireland (United Kingdom). In addition, one country that is not member of the OECD participated in the survey and is included in this publication: the Russian Federation.

About the data from the Russian Federation it should be highlighted the following:

Readers should note that the sample for the Russian Federation does not include the population of the Moscow municipal area. The data published, therefore, do not represent the entire resident population aged 16-65 in Russia but rather the population of Russia excluding the population residing in the Moscow municipal area. More detailed information regarding the data from the Russian Federation as well as that of other countries can be found in the Technical Report of the Survey of Adult Skills (OECD, 2014).

1.2 Model

1.2.1 Model description

Based on the scoping paper presented at the February 2014 LSO meeting and feedback received from the working group, it was decided to explore the impact of skills on labour market outcomes using the following types of model:

- Earnings model: Ordinary Least Squares (OLS) regression model which estimates the percentage point impact of improvements in skills and education on (log hourly) earnings by country, in the form:

$$\log(earnings)_c = \alpha_c + \beta_c X_c + \gamma_c Y_c$$

  where c represents the country, X represents the set of included skill x education interaction terms with associated coefficients in vector β; Y represents the control variables with associated coefficients in vectors γ, and α represents baseline log earnings.

- Employment model: Logistic regression model which estimates the impact (in terms of odds ratios) of improvements in skills and education on the probability of employment by country, in the form:

$$\text{logit}(\pi)_c = \delta_c + \theta_c X_c + \rho_c \bar{Y}_c$$

  where π represents the probability of employment (upon which a logit or log-odds function is applied); c represents the country; X represents the set of included skill x education interaction terms with associated coefficients in vector θ; $\bar{Y}_c$ represents the

control variables with associated coefficients in vectors ρ; and δ represents the baseline log-odds of employment.

The main independent variables of interest in both types of model are the interactions between skill and education levels. The impact of each type of skill (literacy, numeracy and skills and readiness in using ICT for problem solving) on earnings and employment are examined and estimated using separate models.

For each type of skill, skill proficiency was interacted with the highest level of education achieved so that the impact of the skill could be isolated from the effect of formal education and vice versa. In the literacy model, for example, we included a total of 11 interaction terms (4 literacy categories x 3 education levels minus the baseline group that must be excluded from the model specification) plus controls for numeracy skills and skills and readiness in using ICT for problem solving.

1.2.2 Key variable construction

Dependent variables

The dependent variables (earnings and employment) were constructed as follows:

1. The earnings variable is constructed from the *earnhr* variable in the dataset. The earnings variable was 'trimmed' so that the highest and lowest one per cent were excluded, thereby removing outliers. The log was then taken to generate the dependent variable.
2. Employment status was taken from the *c_d05* variable in the dataset, which represents employment status. Individuals classified such that *c_d05* = 1 were considered to be employed (and coded 1 in the dependent variable). Individuals classified as *c_d05* = 2 or *c_d05* = 3 were categorised respectively as being unemployed or out of the labour force (economically inactive). These are coded as 0 (not employed) in our dependent variable. Those with *c_d05* = 4 (i.e. employment status not known) or a missing value were coded as missing in our employment variable.

Independent variables

Skills classification

Proficiency levels for numeracy and literacy were defined using the standard approach. Six proficiency levels are defined (Levels 1 through 5 plus below Level 1) and each proficiency level is described in terms of the characteristics of the types of tasks that can be successfully completed by adults with proficiency scores in the rage of scores that defines a level (OECD, 2013; Tables 2.2 and 2.3). In addition, to resolve the computational issues described in the previous section, we combined the two groups with the highest proficiency scores and the two groups with the lowest proficiency scores to produce the following categories:

- proficiency at or below Level 1 (score of 0 to less than 226 points)
- proficiency at Level 2 (score of 226 to less than 276 points)
- proficiency at Level 3 (score of 276 to less than 326 points)
- proficiency at Level 4 or 5 (score of 376 points or higher).

Proficiency groups for skills for using ICT for problem solving were based on the approach developed by LSO members, Ms Tiina Annus and Ms Aune Valk, from the Estonian Ministry of Education and Research and presented at the February 2014 LSO meeting. Each group is described in terms of the characteristics of the types of tasks that can be successfully completed by adults, and the related scores in the assessment of problem solving in technology-rich environments in the Survey of Adult Skills. The skill groups are classified as follows:

- group 0 (no computer experience) and Group 1 (refused the computer-based assessment)
- group 2 (failed ICT core stage 1 or minimal problem-solving skills – scored below Level 1 in the problem solving in technology-rich environments assessment)
- group 3 (moderate ICT and problem-solving skills – scored at Level 1 in the problem solving in technology-rich environments assessment)
- group 4 (good ICT and problem-solving skills – scored at Level 2 or Level 3 in the problem solving in technology-rich environments assessment).

Since the skills in the PIAAC dataset are reported using 10 plausible values, all 10 plausible values were used in the analysis for robustness. This meant that individuals were assigned to a skill category 10 times (i.e. once for each plausible value).

Education classification

We combined the lowest two and highest two educational attainment groups so that the education variable consists of 3 categories:

- below upper secondary
- upper secondary or post-secondary non-tertiary
- tertiary.

For each of the three skill types and each of the plausible values for skills, the education variable (with three categories) was interacted with the skill variable (four categories). For example, for the modelling relating to the impact of literacy proficiency on earnings or employment, there were 12 interaction terms of interest (4 literacy categories x 3 education levels).

Since each individual in the dataset is assigned to just one skill x education interaction cell, for each of the skills and each of the plausible values, it is necessary to exclude one interaction term from the model specification to avoid the dummy variable trap. The excluded interaction term is defined as the baseline group against which the impact of other interaction terms can be interpreted (e.g. percentage point impact on earnings associated with a particular skill x education level relative to the baseline group).

For the purpose of presenting the results, we have selected the interaction of the lowest skills category and the lowest education level as the baseline reference group. We consider that this is the optimal reference group in terms of (the ease of) interpretation of results, as the coefficients represent the impact of *moving up* a skill or education level might be (rather than the impact of *moving down* a skill or education level)[1].

1.2.3 Model specification

Demographic and socio-economic control variables

In order to determine which demographic and socio-economic variables should be included in the models as control variables, an initial list of candidate variables was drawn up based on the statement of work, previous experience in education research, and literature on the impact of skills on employment outcomes.

This list included the following:

- Age (and age^2)
- Gender
- Whether cohabiting
- Whether foreign born
- Years working*
- Years in current job*
- Parental education level
- Number of children
- Part-time or full-time*
- Age of youngest child
- Whether in temporary work*
- Whether has children
- Whether test language same as native language
- Whether test language same as language spoken at home
- Whether work in public sector*
- Geographical region
- Industry of work

Naturally, any variable related to work (those marked with *) would not be an appropriate predictor of employment status, and is therefore only included in the earnings model. Otherwise, we use a common set of variables for both employment and earnings models.

An exploration of the data revealed poor coverage for some variables. As a regression cannot include any individuals for which any dependent variable has a missing value, we made the decision

[1] In light of the (legitimate) argument in favour of selecting the largest cell as the reference group, then analysis was replicated and coefficients were estimated on this basis. Comparing the results, the coefficients on the demographic and socio-economic control variables were the same as were the coefficients on the interaction terms when scaled relative to the base case. The only exceptions to this are some coefficients associated with a sample of below 30 (which are not reported in any case).

to exclude variables with poor coverage to ensure a healthy sample for the analysis. An example of this was the number of children which was missing for a third of those that said they had children.

Examination of these candidate variables using the PUF showed that some were highly correlated with others. Since the inclusion of two or more correlated variables can complicate interpretation of regression estimates, we chose to only include one of the correlated variables. The selection of the variable was based on coverage and on correlation with the employment outcomes. An example of this was the variables relating to language and country of birth, which were correlated. It was decided to only include the variable indicating whether the respondent was foreign born or not, since this had better coverage and was more highly correlated with earnings. The table overleaf shows the initial list of candidate variables, with a note indicating whether they were included in the extended form models, and the reason for exclusion if they were not.

Table 1. Candidate variables

PIAAC variable considered	Codebook description	Note	Include? yes/no	Reason for exclusion
age_r	*person resolved age from bq and qc check (derived)*		y	
gender_r	*person resolved gender from bq and qc check (derived)*		y	
j_q02a	*background - living with spouse or partner*		y	
j_q04a	*background - born in country*		y	
c_q09_c	*current status/work history - years of paid work during lifetime*	Recode to get tenure	n	Correlated with age
d_q05a1	*current work - start of work for employer - age*		y	
pared	*highest of mother or father's level of education (derived)*		y	
j_q03b	*background - number of children*		n	Poor coverage - n/a for 1/3 of those with children
d_q10_c	*current work - hours/week (top-coded at 60)*	Recode to get part-time/fulltime	y	
j_q03d1_c	*background - age of the youngest child (categorised, 4 categories)*		n	Poor coverage - n/a for 1/4 of those with children
d_q09	*current work - type of contract*		n	Poor coverage - n/a for 1/3 of those employed
j_q03a	*background - children*		y	
nativelang	*test language same as native language (derived)*		n	Correlated with foreign born
homlang	*test language same as language spoken most often at home*		n	Correlated with foreign born
d_q03	*current work - economic sector*	Recode to get public sector	y	
reg_tl2	*geographical region - respondent (oecd tl2) (coded)*		n	Poor coverage - n/a for 1/2 of sample
isic1c	*industry classification of respondent's job at 1-digit level*		n	Poor coverage - n/a for 1/3 of sample

Source: London Economics (2015). Variable descriptions from PIAAC International Codebook (www.oecd.org/site/piaac/).

Using models with 12 skill x education interaction terms, we considered whether the control variables contribute to our understanding of employment and earnings. This was done by examining the statistical power attributed to the coefficients under regression analysis over the PUF dataset. We considered both the employment and earnings models for all skills.

Estimating the earnings models with 12 skill x education interactions, the result was that all control variables had coefficients that were statistically significant, except the foreign born variable.

However, all of the variables (including the foreign born variable) were statistically significant when we considered the corresponding employment models. Since there is no candidate variable with a coefficient that is consistently statistically insignificant, the recommendation was that all candidate variables remain in the models. Given this, the final set of control variables for the extended form models was:

- Age (and age^^{2})
- Gender
- Whether cohabiting
- Whether foreign born
- Years in current job*
- Parental education level
- Part-time or full-time*
- Whether has children
- Whether work in public sector*

The models were estimated in both reduced (i.e. without demographic and socio-economic control variables) and extended form (i.e. including a selection of control variables). The purpose of this exercise was to see what the effect of the controls has been on the estimated impact of skills. The findings were as follows:

- In a few cases (i.e. ICT earnings and literacy earnings models), the extended form model seemed to maintain the expected order of the estimates better, e.g. higher skills associated with superior outcomes. The extended form model seemed to do no worse than the reduced form in the other models in this regard.
- The estimates differed between the extended and reduced from model but no broad pattern (e.g. reduced model estimates consistently larger or smaller) was evident across the models.

Ultimately, it was decided to report the extended form model results as the use of control variables decreased the risk of omitted variable bias.

1.2.4 Other skills control variables

In addition to demographic and socio-economic control variables within the model for a particular skill, it was also decided to control for other skill types. For example, in the model for examining the impact of literacy skills on earnings, we chose to control for the effect of numeracy skills and skills and readiness in using ICT for problem solving. The rationale for controlling for other skills is that if we do not, for example, control for numeracy in the literacy-earnings model, then we can expect omitted variable bias. In other words, since numeracy is positively correlated with literacy and is also positively correlated with earnings, we will overestimate the effect of literacy in this case because no effort is made to distinguish between the direct impact that literacy has on earnings and the indirect impact it has through its correlation with numeracy.

An earlier scoping paper discussed the choice of whether to include the other skills as control variables. The point was made that because of the high correlation between skills, we are likely to be either underestimating (because of multicollinearity) or overestimating the skill impact (because of omitted variable bias) depending on whether controls for other skills are included or excluded. The rationale for choosing one type of bias over the other was that if we other skills are not controlled for, the coefficients on each of the skills might be very similar (reflecting a return to

overall skills rather than to any one specific skill) and the value in producing separate models (and separate estimates) for each skill would be diminished.

Ultimately, the decision of whether to control for other skill variables depends on the exact policy question that the analysis is trying to answer. For instance, if the aim of the analysis is to estimate the return (in terms of employment outcomes) from investing in improvement in overall skills, it may be preferable to not control for other skills. If the aim of the analysis is to compare the return to the public purse from investing in one skill (literacy) relative to another skill (ICT), then it is preferable to control for other skills. On this basis, the decision was made to control for other skills.

1.3 Regression analysis

1.3.1 Analytic tools

The regression analysis was carried out based on the piaacreg command which is part of the PIAACTOOLS set of commands for Stata[2]. The advantage of this command is that it allows easy calculation of robust estimates and standard errors across multiple plausible values using replication over each of the plausible values. One limitation of this command was that it only allowed a maximum of three variables with plausible values to be included in the model specification. As the model specification for this research includes several interaction terms (each with plausible values), the piaacreg code was amended from its published version to allow for additional commands. With the amendment, the command could be used for up to 13 variables with plausible values.

1.3.2 Interpretation of coefficients

In the case of the earnings model, the interpretation of the (exponentiated) coefficients is that they represent the marginal (i.e. percentage point) effect on earnings associated with a particular skill x education interaction *relative* to the baseline group, i.e. those with below upper secondary education or below and with skill proficiency at or below Level 1.

The interpretation of the coefficients in the employment models (estimated using logistic regression) is different to the interpretation of marginal effects. The coefficients produced in the employment models are *odds ratios*. This is a feature of logistic regression which results from the underlying logit function. The odds ratio associated with a particular skill x education interaction represents the odds of employment for those with that particular skill x education level over the odds of employment for those in the reference group. As an example, an odds ratio of 1.2 would indicate that the *odds of employment* within one group are 20% higher than the *odds of employment* in the reference group. The *odds of employment* are not the same as the *probability* or *rate of employment* although there is a correspondence between the measures, as explained in more detail in Section 3.4.

[2] Documented at: www.oecd.org/site/piaac/PIACTOOLS_16OCT_for_web.pdf

1.3.3 Model variations

Great care was taken to implement the same methodology across different skill types and across different countries to ensure comparability. Exceptions had to be made in the case of France, Italy and Spain because PIAAC respondents were not tested in Problem Solving in Technology-Rich Environments (PS-TRE), on which the measure of skills and readiness in using ICT for problem solving is based. As such, there are no scores for skills and readiness in using ICT for problem solving associated with respondents in these countries and the impact of these skills on earnings and employment outcomes cannot be estimated for these countries. The lack of scores for skills and readiness in using ICT for problem solving also affects the (comparability of the) literacy and numeracy models for these countries as these skills cannot be used as a control variable. As a consequence, unlike the model specifications for all other countries, the literacy and numeracy models for France, Italy and Spain exclude a variable representing skills and readiness in using ICT for problem solving. The size of the effect that this modification would have on the interaction term coefficients was tested by simulating the same change on a selection of other countries (Denmark, England/N. Ireland [UK]) which did test skills and readiness in using ICT for problem solving. The results were as follows:

- Exclusion of the control for skills and readiness in using ICT for problem solving did have a consistent effect on the size of the coefficients.
- The direction of the effect was that coefficients were larger when the control for skills and readiness in using ICT for problem solving was excluded (which is what we would be expected given positive correlation between skills and readiness in using ICT for problem solving and other skills).
- However, the effect was not dramatic and did not change the patterns observed.

For Denmark and England/N. Ireland (UK), the difference in the size of the coefficients between the model excluding skills and readiness in using ICT for problem solving and the extended form model was in the order of:

- From 1 to 6 percentage points (Denmark) and from 1 to 10 percentage points (England/N. Ireland [UK]) for the literacy-earnings models, depending on the exact coefficient examined.
- From 0 to 7 percentage points (Denmark) and from 0 to 19 percentage points (England/N. Ireland [UK]) for the numeracy-earnings models, depending on the exact coefficient examined.
- From 0 to 0.5 (Denmark) and from 0.1 to 0.4 (England/N. Ireland [UK]) point difference in odds ratio for the literacy-employment models, depending on the exact coefficient examined.
- From 0 to 1.7 (Denmark) and from 0.1 to 1.5 (England/N. Ireland [UK]) point difference in odds ratio for the numeracy-employment models, depending on the exact coefficient examined.

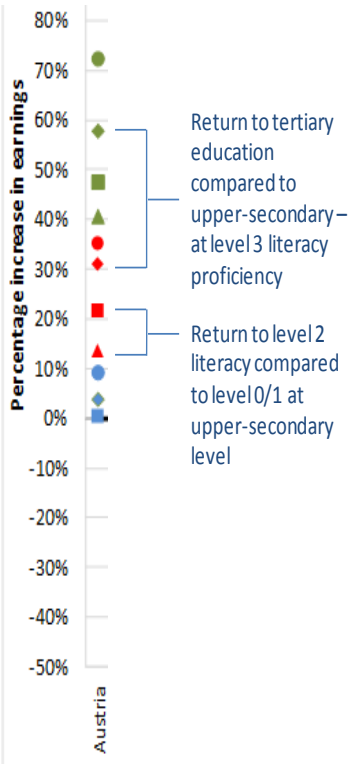
It seems reasonable to conclude that the coefficients for France, Italy and Spain could be overestimated to a similar order.

3. ANALYTICAL FINDINGS

1.4 The impact of literacy skills on earnings

In Figure 1, we present information on the hourly earnings premium associated with literacy skills levels and education levels controlling for other personal and socioeconomic characteristics. The information on the impact of literacy skills is presented by education level, where the impact of different skills levels on earnings for those with low levels of education (i.e. below upper secondary) are presented in blue; while for those individuals with intermediate level of education (i.e. upper secondary or post-secondary non-tertiary) the associated earnings returns are presented in red, and for those individuals in possession of tertiary level education, the returns to different skills levels are presented in green. Within this colour coding, we can identify the different skills levels with those in possession of literacy skills at Level 0/1 (i.e. Level 1 or below) characterised by triangles ▲▲▲; those with literacy skills at Level 2 characterised by squares ■■■; those with skills at Level 3 characterised by diamonds ◆◆◆; and those with literacy skills at Level 4/5 characterised by circles ●●● .

Comparing similar shapes of different colour allows assessment of the impact of education levels on earnings holding literacy proficiency constant, while comparing different shapes with a particular colour allows for the assessment of the returns to (incremental) literacy skills proficiency levels holding qualification constant (presented to the left in the case of Austria). However, it is important to note that in relation to the control variables, some countries did not participate in ICT proficiency testing (France, Italy, and Spain), which results in earnings outcomes being marginally higher than if ICT proficiency was controlled for. In addition, the findings do present some outlying results, with the results relating to the Russian Federation being significantly different from the general trends presented for other countries (for which there is no immediate explanation).



The analysis demonstrates a number of key findings:

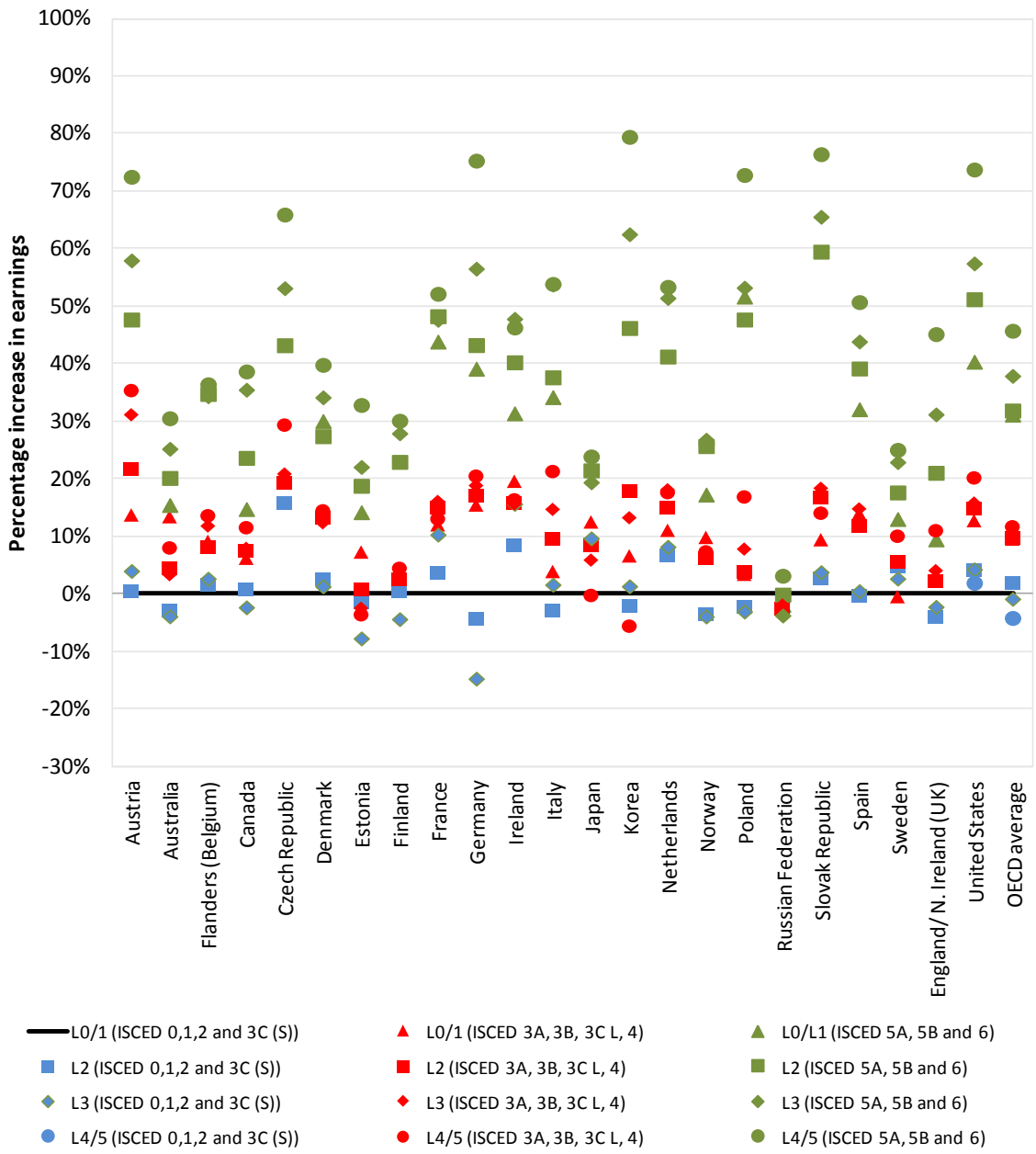
- There are significant positive earnings returns to education. Across all skills proficiency levels, the earnings achieved by those in possession of lower levels of formally recognised education and training are generally lower than for those individuals in possession of intermediate levels of education (i.e. the blue shapes lie below the red shapes), which are in turn below those returns achieved by individuals in possessions of the highest levels of qualification (i.e. the red shapes lie below the green shapes).

- On average, the earnings return across the OECD to upper secondary education are approximately 10% while the returns to tertiary education stand at approximately 37% (compared to below upper secondary education).

- In general, within each specific education level, there are positive returns associated with increased literacy skills proficiency. It appears to be the case (unsurprisingly) that there is a greater return associated with increasing an education level than increasing a skills proficiency level. In many countries, especially when comparing individuals in possession of upper secondary and tertiary education, an individual with upper secondary education and the highest level of skills proficiency posts a lower earnings return than an individual with tertiary education and the lowest skills proficiency level.

Source: (OECD, 2013), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*, http://dx.doi.org/10.1787/9789264204256-en.

Figure 1. Impact of literacy level on earnings outcomes - by education level



Note: Coefficients for cells with fewer than 30 observations are not reported as they may not be reliably estimated. Coefficients for France, Italy and Spain have been estimated without controlling for ICT skills since PS-TRE was not tested in these countries. Since there is positive correlation between ICT skills and numeracy, literacy and education, the effect of excluding ICT is likely to be that the coefficients on the skill x education variables are overestimated, relative to the results for other countries. Average (OECD) results exclude France, Italy and Spain as a different model specification was used for these countries.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

- In absolute terms, the possession of incremental literacy skills (from Levels 0/1 to Levels 4/5) adds up to 10% *on average* to hourly earnings for those in possession of the lowest levels of formally recognised education or upper secondary education, while

incremental literacy proficiency adds approximately 15% on average to hourly earnings for those in possession of tertiary education. In particular, for those in possession of tertiary level education, the earnings premium associated with Level 2 literacy skills is approximately 31% higher than that of an individual in possession of below upper secondary education and Level 0/1 literacy skills and the individuals in possession of Level 4/5 literacy skills command a 46% premium.

However, it is important to note that these estimates are averages and there is significant variation across the OECD.

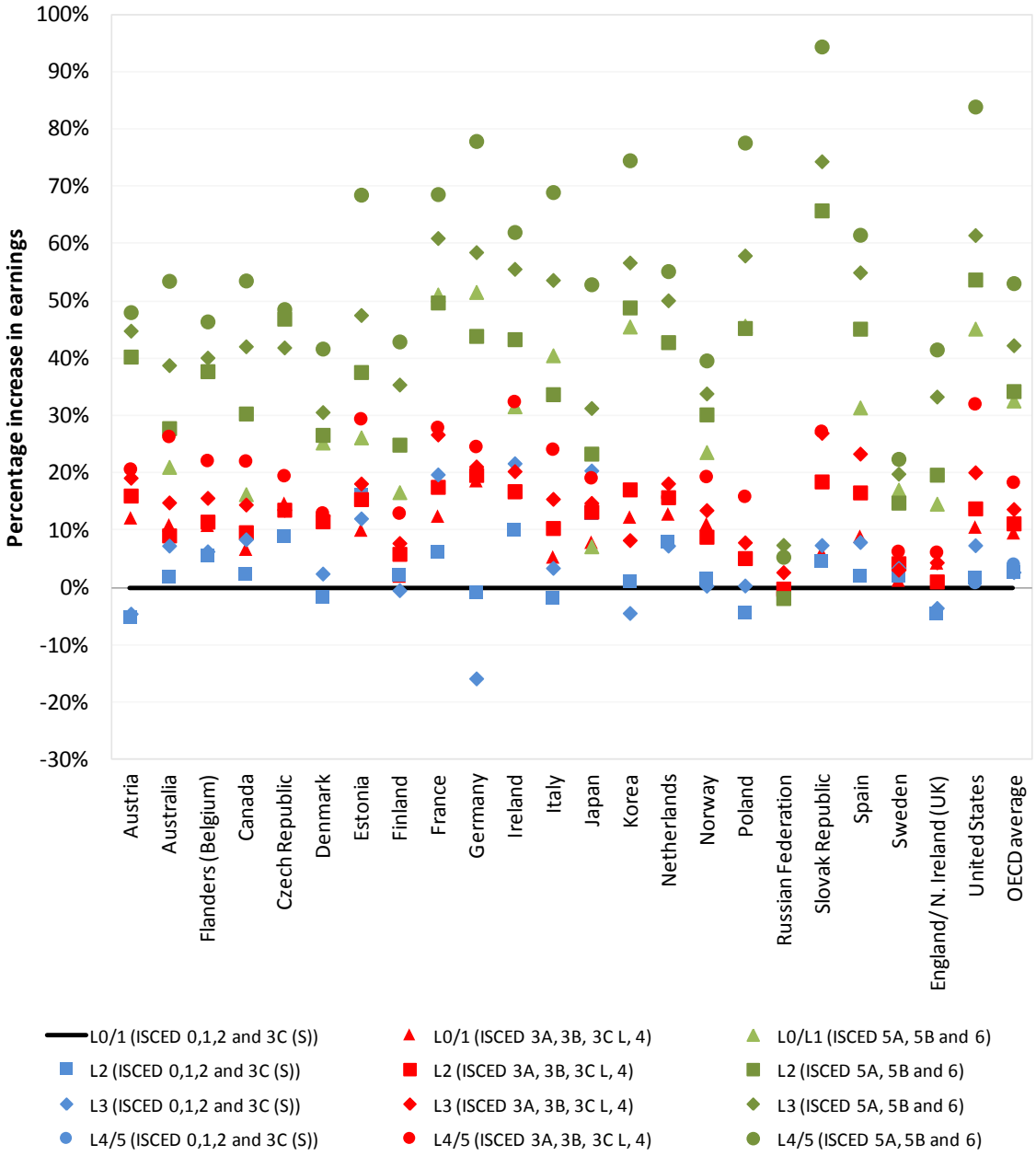
1.5 The impact of numeracy skills on earnings

The analysis of the returns to numeracy proficiency (presented in Figure 2) show the same patterns as those presented in relation to literacy. As before the returns to education level (holding numeracy proficiency constant) are increasing, while the earnings benefit associated with increased numeracy proficiency (holding education level constant) are also generally increasing. Again, and unsurprisingly, the analysis demonstrates the relative importance of formal education levels on earnings compared to numeracy proficiency.

Across the OECD, the average return to below upper secondary education stands at approximately 2.5% (ranging from 0% for those in possession of the Level 0/1 numeracy proficiency to approximately 4% for those in possession of Level 4/5 proficiency, while at upper secondary, the range of earnings outcomes (compared to an individual with the lowest level of formally recognised qualifications and numeracy skills) stands at approximately 10% (upper secondary and Level 0/1 numeracy) to 18% (upper secondary and Level 4/5 numeracy). At tertiary level, the earnings outcomes (compared to the reference group) range from approximately 33% (tertiary and Level 0/1 numeracy) to 53% (tertiary and Level 4/5 numeracy).

The analysis can also demonstrate the relative importance of numeracy and literacy skills at particular qualification levels. The analysis shows that in the majority of OECD countries, numeracy skills are associated with higher earnings compared to equivalent literacy levels (at each level of education). For example, in Canada, at Level 0/1, there is a negligible difference between literacy and numeracy skills (0.4%); however, following an increase in skills proficiency to Level 2, Level 3 and Level 4/5, the difference in earnings between numeracy and literacy increases to 2.2%, 6.5% and 10.5% respectively. In contrast, in Austria, the Czech Republic (and a lesser extent England/N. Ireland [UK], Sweden and Korea) the labour market appears to reward literacy proficiency to a greater extent than numeracy proficiency.

Figure 2. Impact of numeracy level on earnings outcomes - by education level



Note: Coefficients for cells with fewer than 30 observations are not reported as they may not be reliably estimated. Coefficients for France, Italy and Spain have been estimated without controlling for ICT skills since PS-TRE was not tested in these countries. Since there is positive correlation between ICT skills and numeracy, literacy and education, the effect of excluding ICT is likely to be that the coefficients on the skill x education variables are overestimated, relative to the results for other countries. Average (OECD) results exclude France, Italy and Spain as a different model specification was used for these countries.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

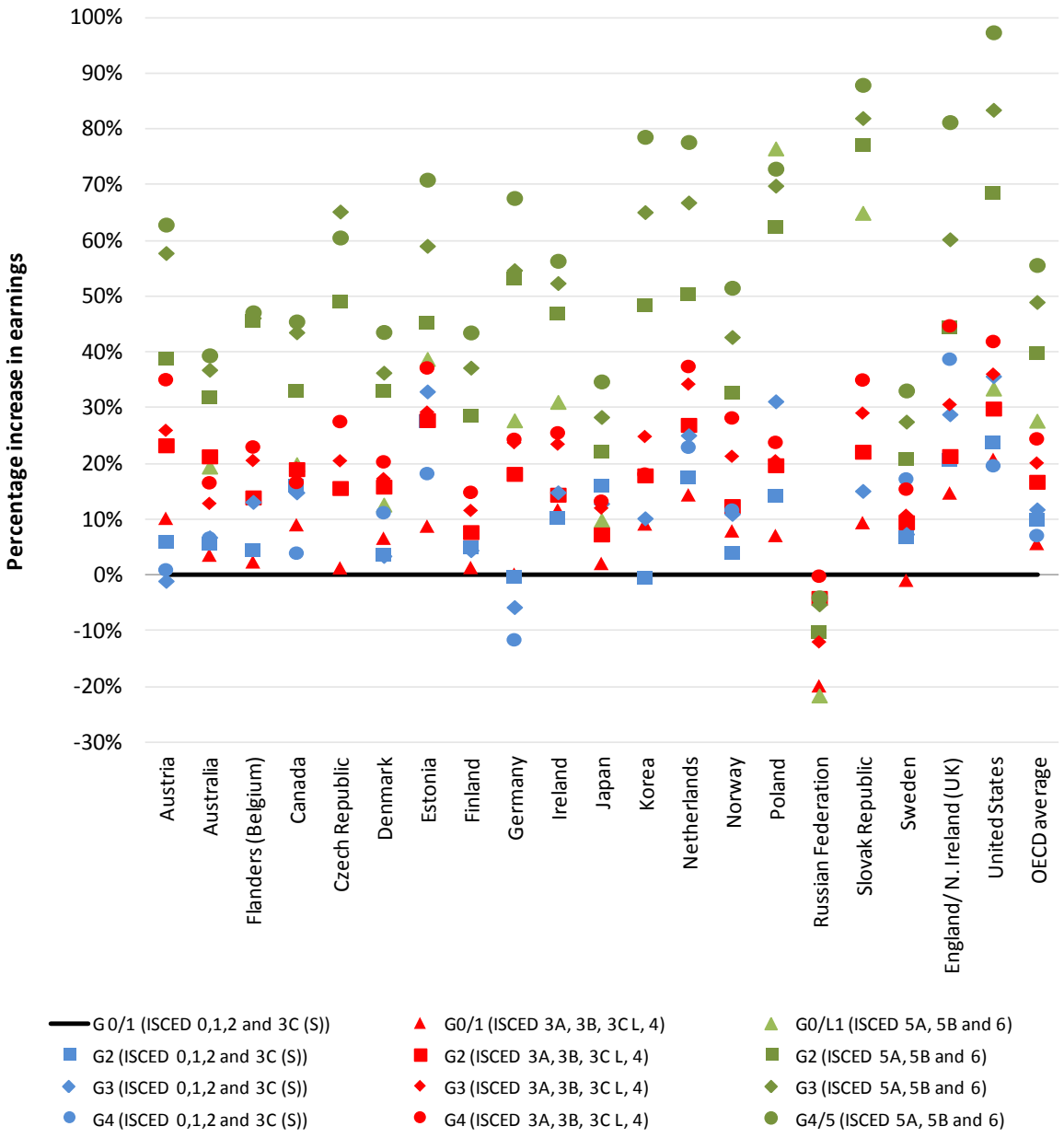
1.6 The impact of skills and readiness in using ICT for problem solving on earnings

In Figure 4, we present information on the earnings returns associated with skills and readiness in using ICT for problem solving. Similar to the returns associated with literacy and numeracy, the analysis demonstrates that for those individuals in possession of *tertiary* education, there are very significant benefits associated with the incremental acquisition of skills and readiness in using ICT for problem solving (with the notable exception of Sweden). In particular, compared to Group 2 proficiency in using ICT for problem solving, individuals in possession of Group 3 proficiency achieve a premium of approximately 15 percentage points in Austria, the Czech Republic, Estonia Korea, the Netherlands, and the United States, and approximately 10 percentage points in England/N. Ireland (UK), Norway and Finland.

In contrast to the analyses of earnings returns associated with literacy and numeracy skills, the analysis also demonstrates a degree of levelling out in the labour market for those in possession of either intermediate or low levels of formal education. Specifically, unlike the previous analyses relating to literacy and numeracy where the returns to education dominated the returns to literacy or numeracy skills (i.e. the green shapes lay above the red shapes and subsequently the blue shapes), there is much less of a distinction between the returns to ICT proficiencies at upper secondary and below upper secondary level. This is illustrated by the fact there are many situations where individuals with low levels of formal qualifications and (relatively) high skills and readiness in using ICT for problem solving outperform individuals with higher levels of formally recognised qualifications but lower levels of ICT skills. This phenomenon is particularly apparent in the United States, England/N. Ireland (UK), Poland, Estonia and Japan. More generally, across the OECD as a whole, there is a 10-12 percentage point return to Group 2 proficiency in using ICT for problem solving (compared to Group 0/1) irrespective of the level of formal education.

An interpretation of this finding is that there is significant blurring of the lines between the acquisition of skills and readiness in using ICT for problem solving and those skills that are acquired during formal schooling. In particular, where an individual might be expected to be in possession of *representative* literacy and numeracy skills on completion of different levels of formal schooling (and different levels of schooling signal these skills), the acquisition of skills and readiness in using ICT for problem solving is more stand-alone and may or may not be acquired in general schooling, and their associated high reward is in part independent of the level of schooling achieved.

Figure 3. Impact of skills and readiness in using ICT for problem solving on earnings outcomes - by education level



Note: Coefficients for cells with fewer than 30 observations are not reported as they may not be reliably estimated. Coefficients for France, Italy and Spain were not estimated since PS-TRE was not tested in these countries.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

1.7 The impact of skills on employment

The use of the piaacreg commands restricts the estimation of the impact on employment outcomes to odds ratios. It is important to note that the *odds of employment* are not the same as the *probability of employment* although there is a correspondence between the measures.

$$Odds = \frac{Probability}{1 - Probability} \qquad \text{and conversely,} \qquad Probability = \frac{Odds}{1 + Odds}$$

The odds of employment can be defined as the probability of employment over the probability of non-employment so, for example, a probability of 50% corresponds to odds of 1. As a further example, in Flanders (Belgium) the probability of being employed stands at 47% for the baseline group (i.e. those in possession of below upper secondary education and Level 0/1 literacy skills) corresponding to employment odds of 0.89 (= 0.47/(1.0 - 0.47)).

To compare the employment outcomes of different groups of individuals, we estimate the odds ratio, which is the employment odds of the group in question divided by the employment odds of the baseline group. Therefore, taking the previous example, if the employment odds of the baseline group stands at 0.89 and the odds ratio is 6 for those in possession of tertiary education and Level 4/5 literacy skills, then the odds of employment for this (second) group are 6 times the odds of employment for the baseline group (i.e. 5.34 = 6 * 0.89). Using this figure, we could convert back to probabilities and say that the employment rate for this (second) group is approximately 84% (= 5.34/(1+5.34)).

The rationale for adopting this reporting approach rests with the inability to model marginal employment effects directly, but also the fact that odds ratios have been the main approach for reporting employment effects within previous OECD analyses relating to skills outcomes. In other respects, the different approaches are comparable, as long as the information relating to the employment rate achieved by the baseline group is reported (which we present in Figure 5).

For Korea and Japan, improvements in neither education nor literacy are consistently associated with better employment outcomes. A simple examination of the raw data shows that employment in Korea is negatively correlated with literacy and skills and readiness in using ICT for problem solving. The counter-intuitive relationship between literacy and employment in Korea and Japan were also noted in the OECD Skills Outlook report 2013 (OECD, 2013; see footnotes in pages 225 and 231), where the authors attributed the anomaly to the low number of unemployed people surveyed in these countries. The report did not focus on numeracy or skills and readiness in using ICT for problem solving.

It is the presentation of the baseline incidence of employment that in part explains some of the very substantial variation in the employment returns to different education and skills levels. For instance, in Japan, the baseline level of employment for individuals in possession of below upper secondary education and Level 0/1 literacy skills stand at 74%, which given the relative employment odds ratio of approximately 1 associated with possession of tertiary education and Level 2 literacy skills, implies that the probability of being employed for this group also stands at 74%. In contrast, in the Slovak Republic, the employment odds ratio for this group of individuals stands at 6.9 (compared to a baseline employed rate of 20%), which implies that the probability of being employed for those in with possession of tertiary education and Level 2 literacy skills stands at 63%. Therefore, although the odds ratio does accurately demonstrate the relative likelihood of being employed compared to the baseline group (within a particular country), in absolute terms, the adoption of odds ratios may provide a slightly less than intuitive indication of the absolute

likelihood of being employed across countries for particular levels of education and skills (unless the baseline probability of being employed is relatively comparable).

A useful *rule of thumb* is that if the baseline probability of being employed stands at 50% (corresponding to odds of 1), then an odds ratio of 1.5 suggests that there is a 10 percentage point increase in the probability of being employed for the group under consideration, with an odds ratio of 2.0 implying that there is a 17 percentage point uplift in employment and an odds ratio of 2.5 implying a 21% uplift. These are presented in Table 2 below.

Table 2. Indication of relative odds ratios and employment probabilities

	Relative odds ratio								
	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
	Probability of being employed								
30%	30%	35%	39%	43%	47%	49%	52%	54%	56%
40%	40%	45%	50%	54%	57%	60%	63%	65%	67%
50%	50%	56%	60%	64%	67%	69%	71%	73%	75%
60%	60%	65%	69%	72%	75%	77%	79%	80%	82%
70%	70%	74%	78%	82%	82%	84%	85%	87%	88%

Source: London Economics.

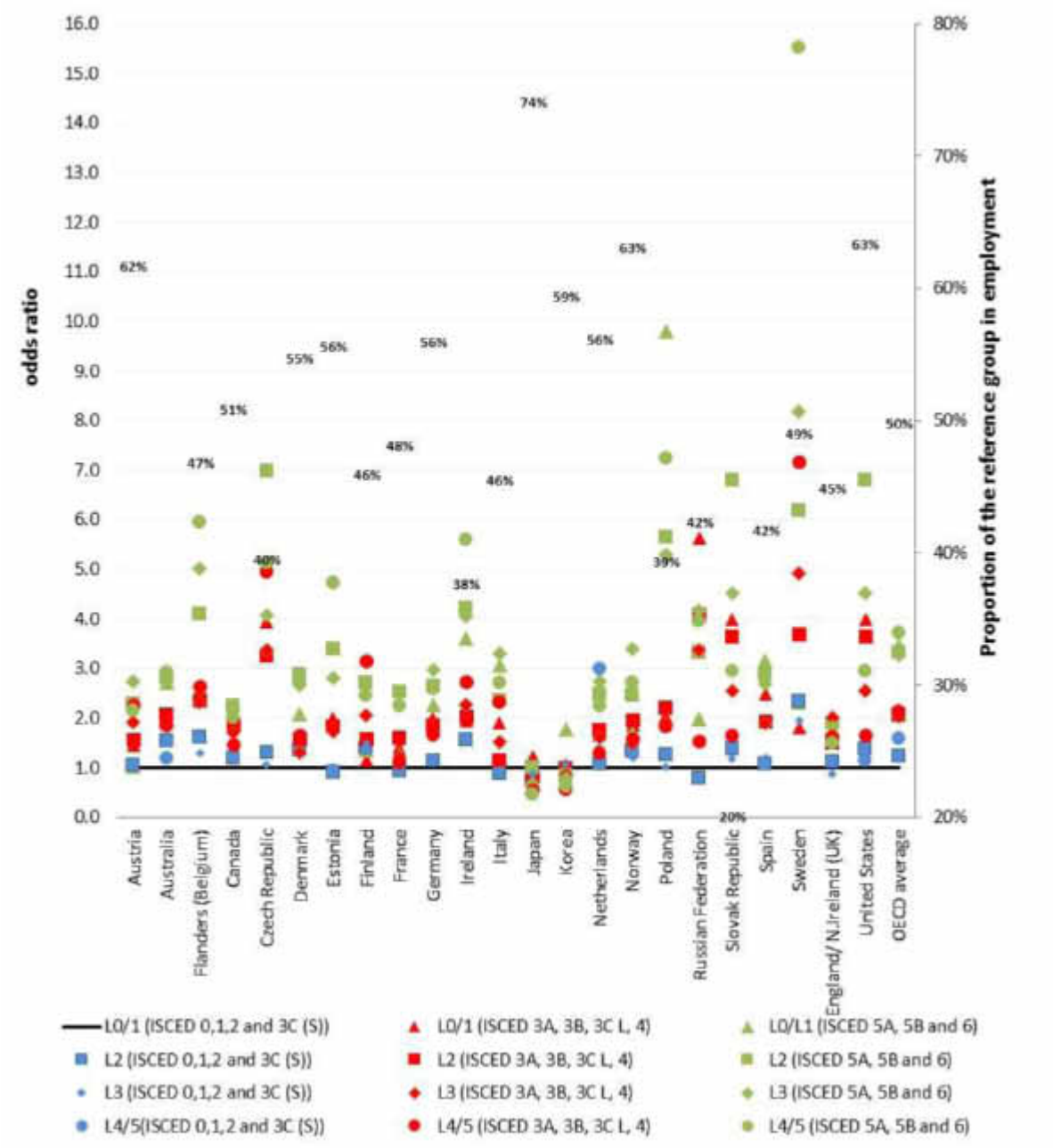
1.8 The impact of literacy skills on employment

However, with these caveats in mind, the analysis indicates that as before, there are strong positive employment returns to higher levels to formally recognised qualification at different literacy skills proficiency levels. Across the OECD as a whole, individuals in possession of upper secondary qualifications are approximately 12 percentage points more likely to be employed compared to those in possession of below upper secondary education, while individuals in possession of tertiary level qualifications are approximately 10 percentage points more likely to be employed compared to upper secondary.

At country level, with the exception of Sweden, the Czech Republic and the Slovak Republic, where there are very substantial employment effects associated with upper secondary education compared to below upper secondary education, the findings demonstrate relatively modest *well behaved* returns to upper secondary education with the odds ratio standing between 1.5 and 2.5 (corresponding to an employment effect of between 10 and 17 percentage points for countries with a baseline probability of employment of 50%).

However, there appears to be limited additional returns associated with literacy skills acquisition within education levels. Specifically, across all education levels, there is a minimal difference between those in possession of Level 2 and Level 3 literacy proficiencies (approximately 1 percentage point across the OECD in aggregate), while a shift in literacy skills from Level 3 to Level 4/5 stands at 7 percentage points (across the OECD as a whole) at below upper secondary; -0.5 percentage points at upper secondary, and 2.3 percentage points at upper secondary respectively; and -0.2 percentage points at tertiary, and 2.3 percentage points at tertiary respectively). Therefore, the analysis demonstrates that in general incremental increases in the level of formally recognised levels of education have much more significant effects on the employment outcomes of individuals compared to changes in literacy proficiency.

Figure 4. Impact of literacy level on employment outcomes - by education level



Note: Coefficients for cells with fewer than 30 observations are not reported as they may not be reliably estimated. Coefficients for France, Italy and Spain have been estimated without controlling for ICT skills since PS-TRE was not tested in these countries. Since there is positive correlation between ICT skills and numeracy, literacy and education, the effect of excluding ICT is likely to be that the coefficients on the skill x education variables are overestimated, relative to the results for other countries. Average (OECD) results exclude France, Italy and Spain as a different model specification was used for these countries.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

1.9 The impact of numeracy skills on employment

Compared to literacy skills, numeracy skills are demonstrated to have a much more significant impact on employment outcomes, and at low and intermediate levels of education are comparable with the employment effect associated with incremental increases in formally recognised education. Across all skills levels, the probability of being employed in possession of upper secondary education is approximately 5 percentage points greater than if in possession of below upper secondary education, while those in possession of tertiary education receive an additional 9 percentage point boost.

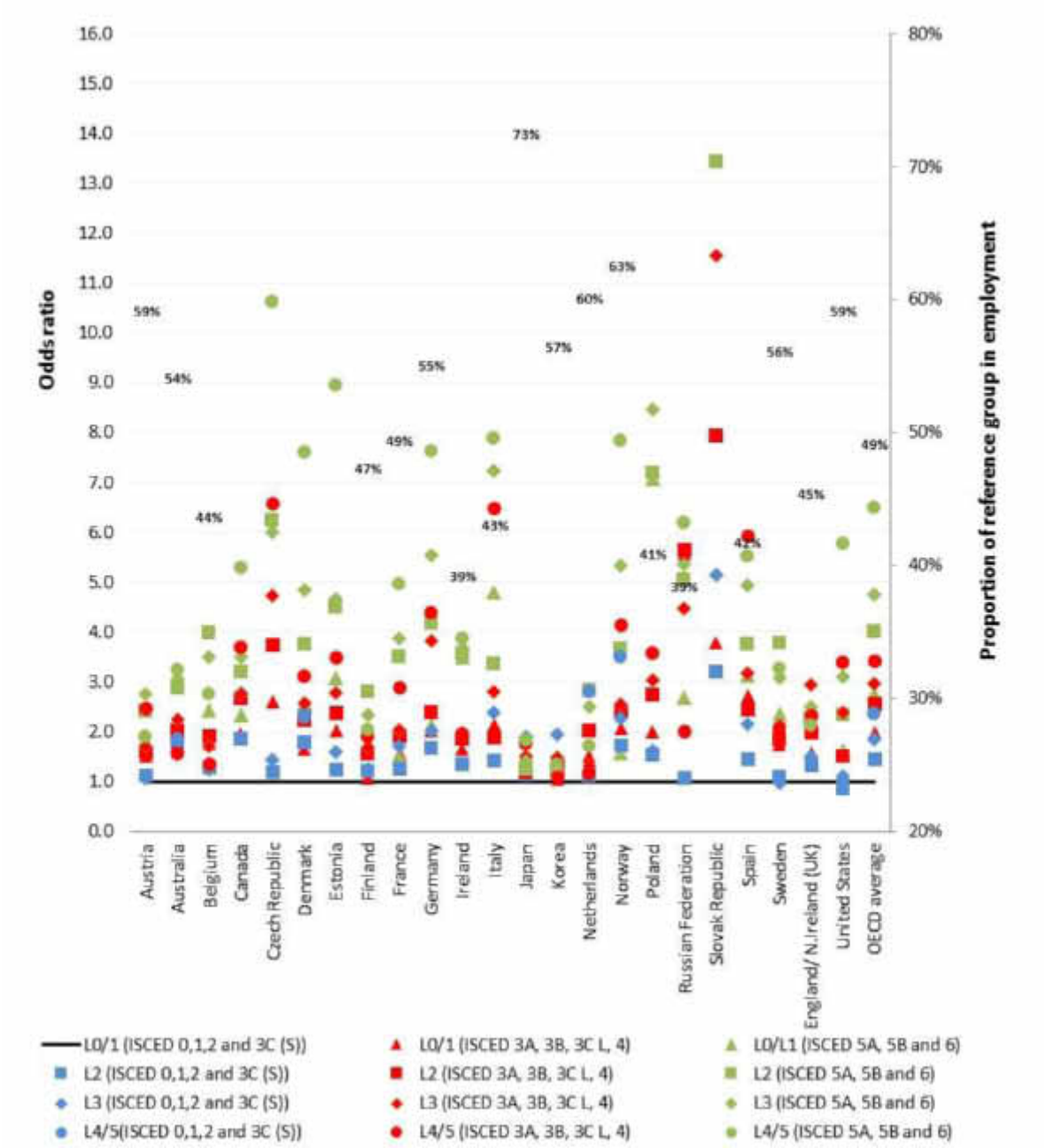
Looking at numeracy skills, incremental improvements in numeracy are estimated to have almost universal statistically significant positive employment effects at all education levels. At below upper secondary level, an increase in numeracy proficiency from Level 0/1 to Level 2 improves the probability of being employed by 9 percentage points, compared to a 5.9 percentage point employment boost between Level 2 and Level 3 (and a 5.3 percentage point effect between Level 3 and Level 4/5. At upper secondary level, corresponding increases in numeracy proficiency improve the probability of being employed by 5.4 percentage points and 3.0 percentage points (as well as a 2.6 percentage point employment boost associated with numeracy skill acquisition between Level 3 and Level 4/5). Similarly, at tertiary-level, increases in numeracy proficiency improve the probability of being employed by 6.9 percentage points, 2.6 percentage points and 4.1 percentage points for incremental increases in proficiency between Level 0/1, Level 2, Level 3 and Level 4/5 respectively.

1.10 The impact of skills and readiness in using ICT for problem solving on employment

While literacy skills were demonstrated to have strong employment effects at below upper secondary education levels, and numeracy skills were seen to be associated with consistently positive employment effects at all education levels and at all proficiency levels, the employment effects associated with skills and readiness in using ICT for problem solving are concentrated at the lower end of the skills distribution. In particular, incremental increases in skills and readiness in using ICT for problem solving between Group 0/1 and Group 2 were estimated to have an 8.1 percentage point employment effect at below upper secondary, a 7.3 percentage point employment effect at upper secondary, and a 5.2 percentage point employment effect at tertiary level. The only other education-skills proficiency combination where employment effects were identified related to an increase in proficiency in using ICT for problem solving between Group 2 and Group 3 at below upper secondary, which was associated with a 5 percentage point employment boost. These skills improvements compare to the impact of gaining an upper secondary level of education of approximately 10 percentage points and a further 6 percentage points on moving to tertiary level education (across all proficiencies in using ICT for problem solving).

As in the analysis of the earnings returns associated with skills and readiness in using ICT for problem solving, the estimates of the employment returns indicate that there is a large degree of overlap between employment levels for different ICT skills and education combinations. This again suggests that skills and readiness in using ICT for problem solving are seen (at least to some extent) as independent or mutually exclusive of the level of formally recognised education and/or that possession of skills and readiness in using ICT for problem solving are strongly rewarded in the labour market (or the lack of ICT skills is associated with severe penalties).

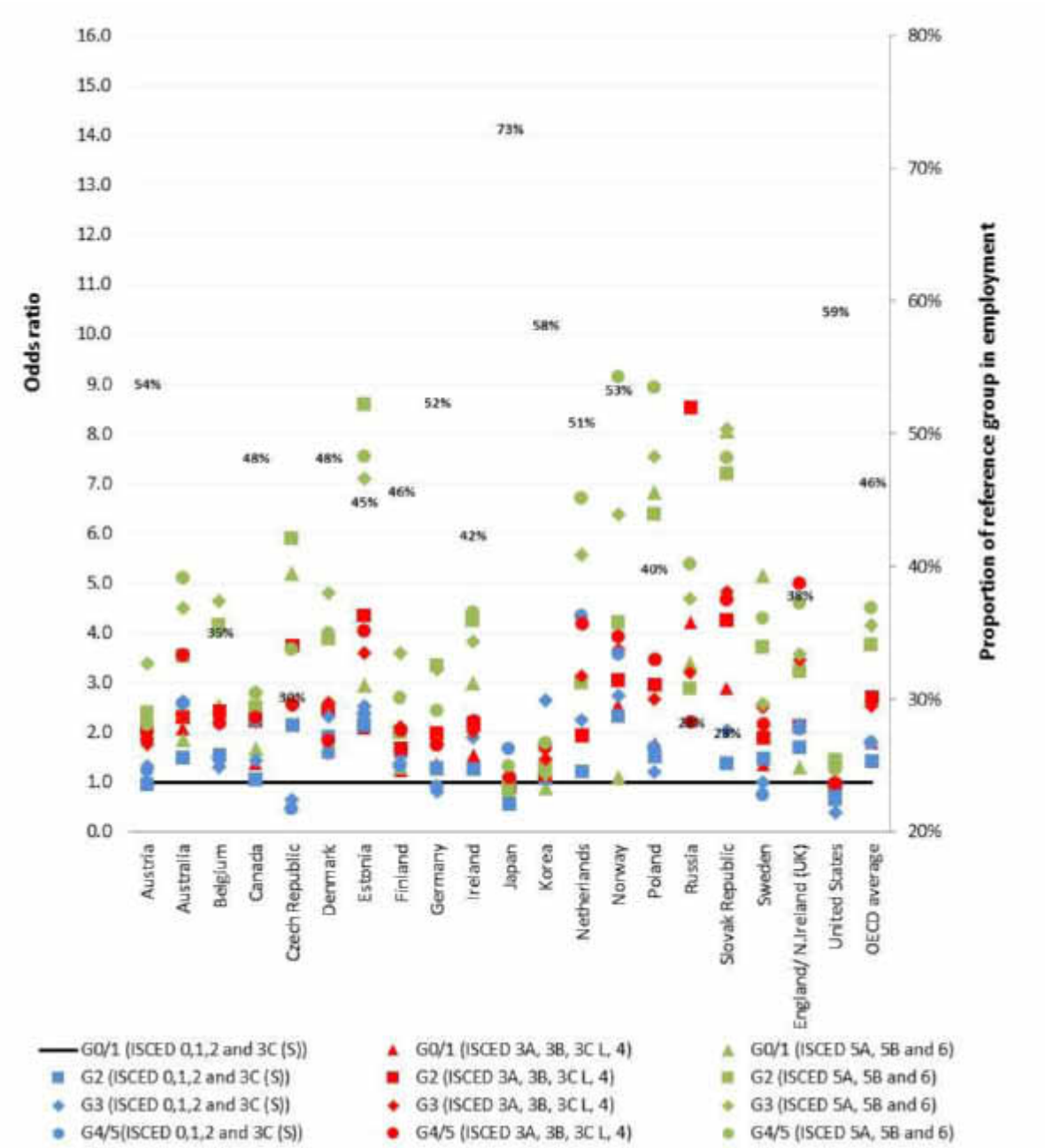
Figure 5. Impact of numeracy on employment outcomes - by education level



Note: Coefficients for cells with fewer than 30 observations are not reported as they may not be reliably estimated. Coefficients for France, Italy and Spain have been estimated without controlling for ICT skills since PS-TRE was not tested in these countries. Since there is positive correlation between ICT skills and numeracy, literacy and education, the effect of excluding ICT is likely to be that the coefficients on the skill x education variables are overestimated, relative to the results for other countries. Average (OECD) results exclude France, Italy and Spain as a different model specification was used for these countries.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

Figure 6. Impact of skills and readiness in using ICT for problem solving on employment outcomes - by education level



Note: Coefficients for cells with fewer than 30 observations are not reported as they may not be reliably estimated. Coefficients for France, Italy and Spain were not estimated since PS-TRE was not tested in these countries.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

1.11 Optimal earnings returns to skills proficiencies

In addition to the analysis of the returns to the different skills proficiencies, we also chose to undertake a relative assessment of where the greatest marginal earnings and employment benefits are accrued across skills proficiencies by education level.

To achieve this, we estimated the percentage point effect on earnings of moving from Level or Group 0/1 to Level or Group 2 in each skill (literacy, numeracy, skills and readiness in using ICT for problem solving) at each level of education (below upper secondary, upper secondary or post-secondary non-tertiary, tertiary) followed by the corresponding percentages associated with improvements in skills proficiency between Level or Group 2 and Level or Group 3, and between Level or Group 3 and Level or Group 4/5. These movements are denoted by 'Low', 'Intermediate' and 'High' respectively. Note that the comparison is only between literacy and numeracy proficiency in France, Spain and Italy given the fact that no ICT proficiency test was administered in these jurisdictions.

Figure 7. Areas of skills offering highest earnings returns - by education level

	ISCED 0,1,2 and 3C (S)	ISCED 3A, 3B, 3C L, and 4	ISCED 5A, 5B and 6
Australia	ICT Low	ICT Low	Numeracy High
Austria	ICT Low	ICT Low	ICT Intermediate
Flanders (Belgium)	ICT Intermediate	ICT Low	Numeracy High
Canada	ICT Low	ICT Low	Numeracy Low
Czech Republic	Literacy Low	ICT Low	ICT Intermediate
Denmark	ICT High	ICT Low	ICT Low
Estonia	ICT Low	ICT Low	Numeracy High
Finland	ICT Low	ICT Low	Numeracy Intermediate
France	Numeracy Intermediate	Numeracy Intermediate	Numeracy Intermediate
Germany	ICT High	ICT Low	ICT Low
Ireland	Numeracy Intermediate	Numeracy High	ICT Low
Italy	Numeracy Intermediate	Numeracy High	Numeracy Intermediate
Japan	ICT Low	Numeracy Low	Numeracy High
Korea	ICT Intermediate	Literacy Low	Numeracy High
Netherlands	ICT Low	ICT Low	ICT Intermediate
Norway	ICT Intermediate	ICT Intermediate	ICT Intermediate
Poland	ICT Intermediate	ICT Low	Numeracy High
Russian Federation	ICT High	ICT Low	ICT Low
Slovak Republic	Numeracy Low	ICT Low	Numeracy High
Spain	Numeracy Intermediate	Numeracy Low	Numeracy Low
Sweden	ICT High	ICT Low	ICT Intermediate
England/N. Ireland (UK)	ICT Low	ICT High	ICT High
United States	ICT Low	Numeracy High	ICT Low

Note: ICT model coefficients for France, Italy and Spain were not estimated since PS-TRE was not tested in these countries. Coefficients for cells with fewer than 30 observations are not included in the analysis as they may not be reliably estimated.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

The findings indicate that the development of skills and readiness in using ICT for problem solving offer the greatest earnings return – at least at some education levels – in every country in the analysis that tested ICT. In particular, excluding France, Spain and Italy, across the 20 OECD countries at below upper secondary education level, the greatest earnings return were associated

with improving skills and readiness in using ICT for problem solving between Group 0/1 and Group 2 in nine countries (Australia, Austria, Canada, Estonia, Finland, Japan, the Netherlands, England/N. Ireland [UK] and the United States), while in a further four countries (Flanders (Belgium), Korea, Norway and Poland), the greatest returns were associated with incremental improvements in skills and readiness in using ICT for problem solving at intermediate levels (i.e. between Groups 2 and 3). In contrast, in Ireland and the Slovak Republic, the greatest returns were associated with increases in numeracy.

Very interestingly, a similar outcome appears at upper secondary level. Specifically, of the 20 countries administering the ICT proficiency tests, the analysis suggests that in 14 countries the greatest earnings returns are associated with improvements in skills and readiness in using ICT for problem solving between Group 0/1 and Group 2 (with 'intermediate' or 'high' ICT skills proficiencies occurring in another 2 countries (Norway and England/N. Ireland [UK]). However, the importance of other skills becomes increasingly important at this education level, with the United States, Japan and Ireland offering the greatest return to increments in numeracy proficiency.

This trend towards the increasing importance of numeracy skills becomes more apparent at tertiary level. For those in possession of degree-level education, seven countries' labour markets offer the greatest earnings premium to incremental improvements between Level 3 and Level 4/5 (Australia, Flanders (Belgium), Estonia, Japan, Korea, Poland and the Slovak Republic), while in Finland, the highest earnings returns are associated with improvements in intermediate numeracy skills. However, skills and readiness in using ICT for problem solving are still relatively highly rewarded in the labour market, with improvements between Group 0/1 and Group 2 offering the highest returns in Denmark, Germany, Ireland, the Russian Federation and the United States.

Note also that the analysis controls for the different skills proficiency levels at given education levels, therefore it is **not** possible to say that the relative strength of the returns to increments in skills and readiness in using ICT for problem solving is somehow linked (or negated) by the potential requirement to be in possession of minimum (facilitation) levels of literacy and numeracy. The analysis suggests that over the majority of OECD countries, at different education levels, and controlling for other personal, socioeconomic and skills numeracy and literacy characteristics, moving from one ICT skills level to the next offer the most sizeable earnings rewards.

1.12 Optimal employment returns to skills proficiencies

When considering the impact of increments in different skills proficiencies on employment outcomes, the analysis was replicated as above, although to assess the greatest employment effects, we converted the various odds ratios to percentage point changes in the probability of being employed (given the various issues highlighted in Section 3.4).

The analysis indicates that in many countries at below upper secondary level, the greatest employment effects to incremental changes in the proficiency levels are again associated with attainment of skills and readiness in using ICT for problem solving between Group 0/1 and Group 2 (the Czech Republic, Denmark, Estonia, Finland and Norway), with attainment of skills and readiness in using ICT for problem solving at intermediate level (Group 2 to Group 3) offering the greatest employment boost in Austria, Japan, and Korea. In contrast, in Australia, Canada, Germany Poland, the Slovak Republic, the greatest employment impacts amongst those with below upper secondary education are associated with improvements in low level numeracy (Group 0/1 to Group 2), while incremental numeracy proficiency between Group 3 and Group 4/5 offers the greatest employment impact in the Netherlands.

At upper secondary level, the greatest employment effects to incremental changes in the proficiency levels are to an even greater extent associated with attainment of skills and readiness in using ICT for problem solving between Group 0/1 and Group 2 (Austria, Flanders (Belgium), Canada, the Czech Republic, Denmark, Estonia, Germany, Ireland and Poland), with ICT skills attainment at intermediate level (Group 2 to Group 3) offering the greatest employment boost in Korea, the Netherlands and England/N. Ireland (UK). In contrast, in Finland and the Slovak Republic, the greatest employment impacts amongst those with upper secondary education are associated with improvements in low level numeracy (Level 0/1 to Level 2), while incremental numeracy proficiency between Level 2 and Level 3 offer the greatest employment impact in Japan and the United States.

At tertiary level, the greatest employment effects from incremental changes in the proficiency levels are associated with attainment of skills and readiness in using ICT for problem solving between Group 0/1 and Group 2 (Australia, Canada, Denmark, Estonia, Germany, Ireland, Norway and England/N. Ireland [UK]) and between Group 3 and Group 4/5 (Austria, Flanders (Belgium), the Czech Republic, Finland, Japan, Korea, Netherlands, and the Slovak Republic). However, numeracy skills increments again offer the greatest employment effects in a number of countries including Poland, the Russian Federation and the United States.

Figure 8. Areas of skills offering highest employment returns - by education level

	ISCED 0,1,2 and 3C (S)	ISCED 3A, 3B, 3C L, and 4	ISCED 5A, 5B and 6
Australia	Numeracy Low	ICT high	ICT Low
Austria	ICT Intermediate	ICT Low	ICT high
Flanders (Belgium)	Literacy Low	ICT Low	ICT high
Canada	Numeracy Low	ICT Low	ICT Low
Czech Republic	ICT Low	ICT Low	ICT high
Denmark	ICT Low	ICT Low	ICT Low
Estonia	ICT Low	ICT Low	ICT Low
Finland	ICT Low	Numeracy Low	ICT high
France	Numeracy Intermediate	Numeracy High	Numeracy Low
Germany	Numeracy Low	ICT Low	ICT Low
Ireland	Literacy Low	ICT Low	ICT Low
Italy	Numeracy Intermediate	Numeracy High	Numeracy Intermediate
Japan	ICT Intermediate	Numeracy Intermediate	ICT high
Korea	ICT Intermediate	ICT Intermediate	ICT high
Netherlands	Numeracy High	ICT Intermediate	ICT high
Norway	ICT Low	Numeracy High	ICT Low
Poland	Numeracy Low	ICT Low	Numeracy High
Russian Federation	ICT High	ICT High	Numeracy Low
Slovak Republic	Numeracy Low	Numeracy Low	ICT high
Spain	Numeracy Intermediate	Numeracy High	Numeracy Intermediate
Sweden	Literacy Low	Literacy Low	Literacy Low
England/N. Ireland (UK)	ICT Low	ICT Intermediate	ICT Low
United States	ICT high	Numeracy Intermediate	Numeracy High

Note: ICT model coefficients for France, Italy and Spain were not estimated since PS-TRE was not tested in these countries. Coefficients for cells with fewer than 30 observations are not included in the analysis as they may not be reliably estimated.

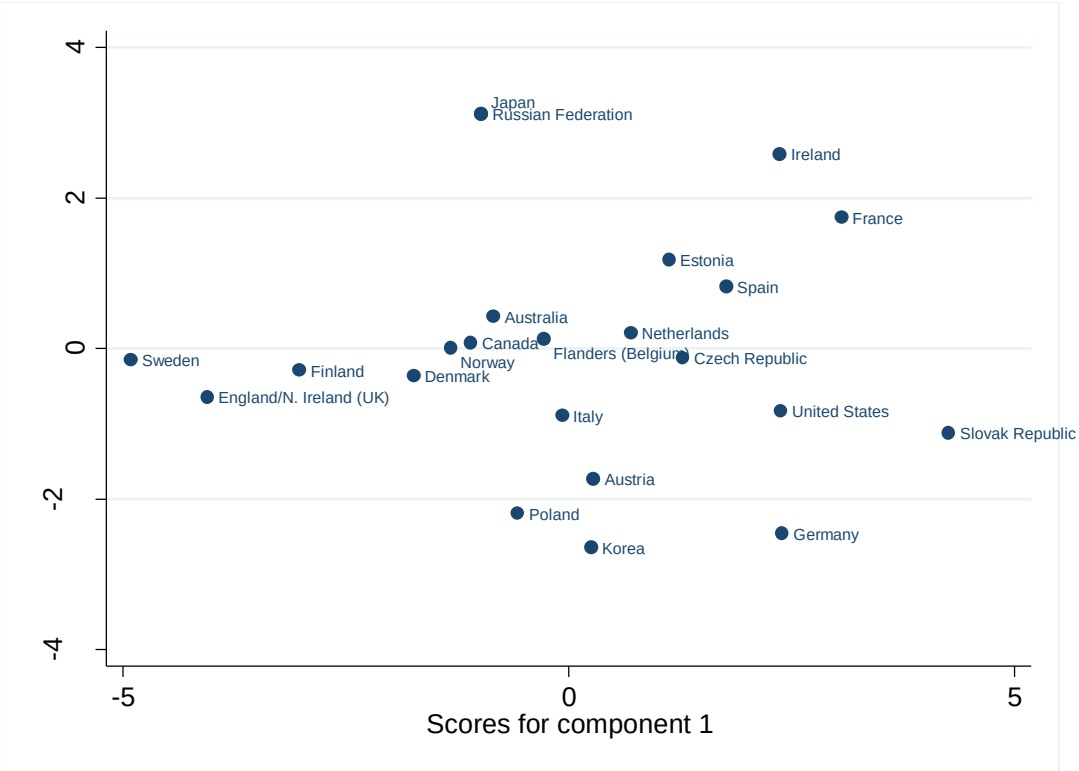
Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

4. EXPLORATORY ANALYSIS OF COUNTRY GROUPINGS

Having been tasked by the LSO Network to consider whether it is possible to 'group' countries with similar 'patterns', in this section, we present some *exploratory* analysis of country groupings. For illustration, this analysis is undertaken using the coefficients that derive from the earnings and employment models described previously, and adopts a *mechanistic* approach of assessing how similar or dissimilar countries are to each other based on the information provided.

Principal Component Analysis (PCA), a dimension reduction technique, can be used to extract two variables from a larger dimension dataset that represent a large proportion of the variance of the larger dataset. Examining these two variables – for instance, using a simple two-way plot – can often reveal additional information about the underlying structure of the data. In this case, the dataset comprising the set of coefficients from the analysis described previously is reduced to two *principal components* that are uncorrelated linear combinations of the original coefficients.

Figure 9. Scatter plot of principal components - impact of numeracy on earnings



Note: The values on the axes (or their signs) should not be directly interpreted as indicators of the magnitude of the impact of numeracy on earnings

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

Figure 10 in Annex 1 shows a simple two-way scatter plot of two principal components which together represent 71% of the variance in the set of coefficients[3] from the *numeracy-earnings* model.

The values on the axes (or their signs) should *not* be directly interpreted as indicators of the magnitude of the impact of numeracy on earnings. Instead, they provide a way of grouping countries in terms of the structure of the dataset, i.e. the overall effect of or contrast between groups of variables.

In this case, component one is a linear combination all of the numeracy x education interaction coefficients of the model where each coefficient enters the component with a positive sign. It can be interpreted as the overall impact of education and numeracy on earnings, implying that countries such as the Slovak Republic, France, the United States and Germany are associated with overall high earnings returns education and numeracy relative to the baseline group. This is consistent with the findings presented in Figure 2.

In contrast, *component two* compares these countries according to differences in the relative returns to tertiary level education compared to lower levels of formally recognised qualification. Specifically, in countries such as Korea, Poland and Germany, there is a high relative return to tertiary education compared to upper secondary or below upper secondary education, whilst the relative returns in Japan and the Russian Federation to tertiary education compared to other levels of education are more modest. The information presented in Figure 2 supports this interpretation.

Although presented for just two components in Figure 10, it is possible to examine further principal components to assess those characteristics of the returns to skills proficiencies and formally recognised education levels that make countries more or less similar or dissimilar. However, the analysis presented above illustrates the 'groupings' of countries based on the earnings returns to numeracy, and clearly further analysis could be undertaken to assess the extent to which countries are clustered based on the earnings and employment returns to other skills proficiencies and education levels. In addition, to contextualise the analysis, it would also be beneficial to include other characteristics of the countries under consideration including information on the distribution of educational outcomes and skills proficiencies, as well as information on baseline earnings and employment rates (and other characteristics that might be of importance, such as the absolute or relative level of funding associated with different levels of education for instance (purchasing power adjusted).

[3] The coefficient on the interaction of lower secondary or below education and the highest literacy level has been excluded from the analysis as the cell has fewer than 30 observations in every country, and may not therefore produce a reliable estimate.

5. CONCLUSIONS AND RECOMMENDATIONS

1.13 Conclusions

Having undertaken a detailed analysis of the labour market returns to education and skills, the results confirm the fact that, both across the OECD as a whole and for the overwhelming majority of individual countries, there are significant higher earnings and employment returns to both increasing levels of formally recognised education, as well as to increasing levels of numeracy skills, literacy skills and skills and readiness in using ICT for problem solving.

Unsurprisingly, the labour market returns for changes in formally recognised levels of education in general exceed the returns associated with increasing levels of skills proficiency (at given education levels). Focusing on employment outcomes specifically, this may result from the fact that employers can more easily assess a candidate's qualifications when hiring, and not their skills.

Furthermore, in the case of literacy and numeracy proficiencies, it is often the case that individuals in possession of higher levels of formally recognised qualifications and low levels of skills proficiency achieve superior labour market return compared to individuals in possession of lower levels of formally recognised qualification alongside higher skills proficiencies. In other words, literacy and numeracy skills narrow the labour market outcomes gap between individuals with different levels of education – but do not close it completely.

In contrast, the analysis demonstrates a substantial return to skills and readiness in using ICT for problem solving – at all levels of formally recognised qualification; however, in addition, the possession of higher levels of skills and readiness in using ICT for problem solving at lower levels of qualification are often associated with higher returns than individuals with higher levels of formally recognised education but lower ICT proficiency levels. An interpretation of this finding is that there may be a significant blurring of the lines between the acquisition of skills and readiness in using ICT for problem solving and those skills that can be acquired during formal schooling. In particular, where an individual might be expected to be in possession of representative literacy and numeracy skills on completion of different levels of formal schooling (and different levels of schooling signal these skills), the acquisition of skills and readiness in using ICT for problem solving appear more stand-alone and may or may not be acquired in general schooling, and their associated high reward is in part independent of the level of schooling achieved. This outcome might pose some challenges to policy makers in relation to the delivery of targeted interventions to improve skills and readiness in using ICT for problem solving.

In terms of the optimal point of investment (in other words, at given education levels, where are the greatest labour market returns to potential changes in skills proficiencies?), improvements in skills and readiness in using ICT for problem solving at low and intermediate levels demonstrated the greatest earnings gains at low and intermediate levels of education, while numeracy had an increasingly important earnings impact at tertiary level. Similar results were demonstrated in relation to employment although the importance of higher levels of skills and readiness in using ICT for problem solving at tertiary level was more apparent.

1.14 Recommendations for further analysis

Although the analysis of the labour market outcomes associated with different skills and education levels was successful, there are a number of further analytical exercises that might be considered:

- The analyses were undertaken at aggregate OECD and country level, but it is always of interest to consider whether there are differential impacts for different population groups (gender, foreign born etc.).
- Originally, the scope of the project was to consider the impact of skills proficiencies and education level at the most disaggregated level. Due to the methodological issues relating to the use of piaacreg commands, education levels and skills levels needed some degree of aggregation. Further work on the piaacreg commands might be considered worthwhile to allow for a fully disaggregated analysis (subject to sample size).
- Further investigation of the heavily outlying results in some countries is warranted.
- Exploratory analysis of country groupings was undertaken. However, this was a very initial mechanistic and data driven approach. We believe that serious consideration might be given to further exploring similarities between countries in terms of the return to skills and education using clustering techniques. Matching or grouping approaches could also be applied to raw PIAAC data to reveal the underlying structure of the data and to develop more meaningful classification or clustering of countries.

ANNEX 1 COUNTRY LITERACY AND NUMERACY PROFILES

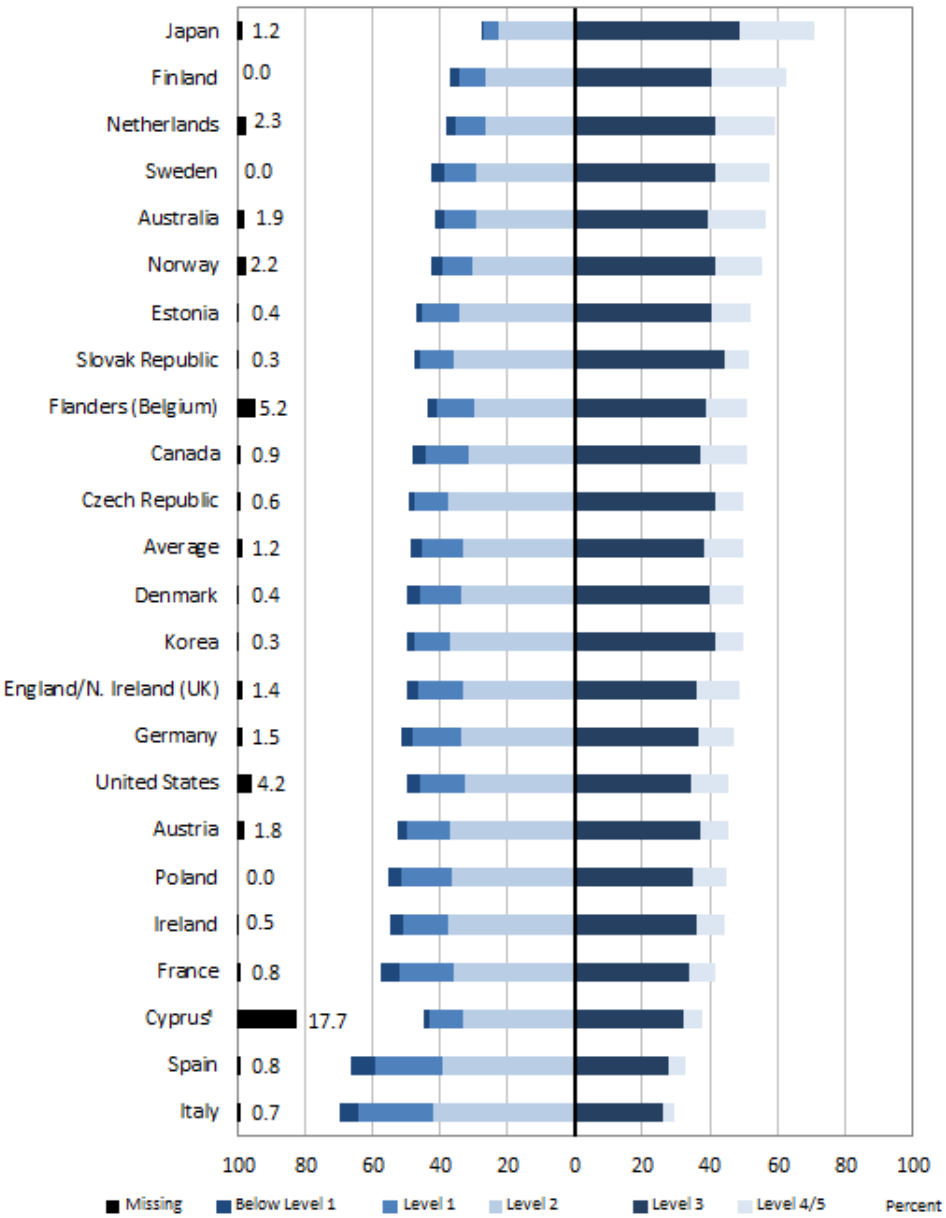
It is interesting to note the variation in skill distribution across countries for two key reasons related to our analysis:

- Firstly, it should be noted that depending on the distribution of proficiency scores in each country, the step change from one skill level to another might represent a very different 'distance travelled' in each jurisdiction. For instance, in England/N. Ireland (UK), the mid-point Level 2 literacy proficiency score stands at 251 points (which corresponds to the 32nd percentile), while the lowest Level 3 literacy proficiency level stands at 276 (which corresponds to the 50th percentile). Therefore, the movement from the middle of literacy proficiency Level 2 to the bottom of literacy proficiency Level 3 (25 points) corresponds to an 18 percentile movement. In contrast, the equivalent literacy point score improvement (25 points) in the Netherlands and the Slovak Republic represents a 17 and 22 percentile move respectively.
- Secondly, the skill distribution provides some context in which to consider the magnitude of the impact of skill improvements on the outcome variables. For example, if a movement from one skill level to the next is particularly large for a certain country, the impact may indicate that that skill improvement is highly valued in that country. It may also result from a shortage in that particular skill in the country.

The distribution of skill proficiencies for each country is presented on succeeding pages. It should be noted that the two highest and two lowest proficiency levels were combined for our regression analysis.

Figure 10. Literacy proficiency of 16-65 year-olds across countries

Percentage of adults scoring at each proficiency level in literacy



Note: Adults in the missing category were not able to provide enough background information to impute proficiency scores because of language difficulties, or learning or mental disabilities (referred to as literacy-related non-response).

1. Note by Turkey:

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

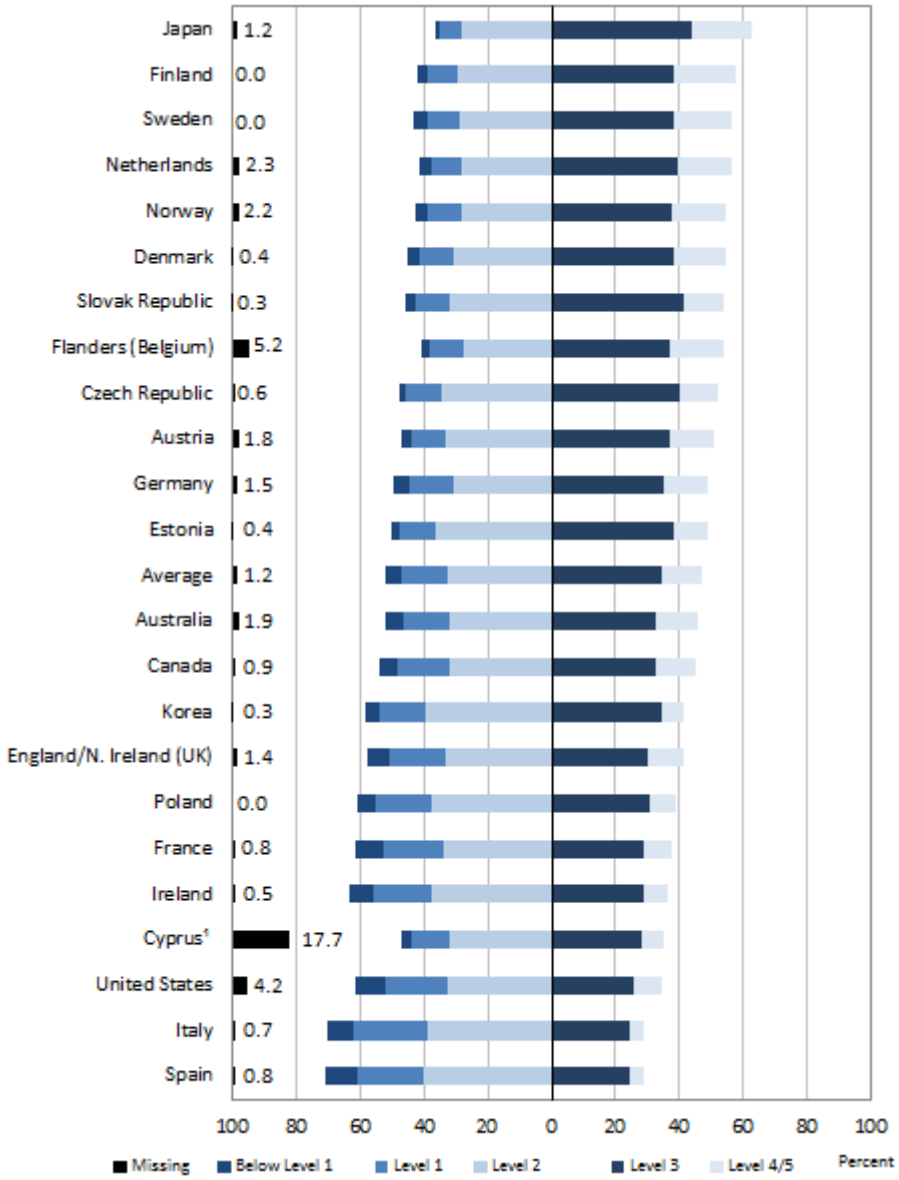
Note by all the European Union Member States of the OECD and the European Union:

The Republic of Cyprus is recognised by all members of the United Nations with the exception of Turkey. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Source: (OECD, 2013), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*, http://dx.doi.org/10.1787/9789264204256-en.

Figure 11. Numeracy proficiency of 16-65 year-olds across countries

Percentage of 16-65 year-olds scoring at each proficiency level in numeracy

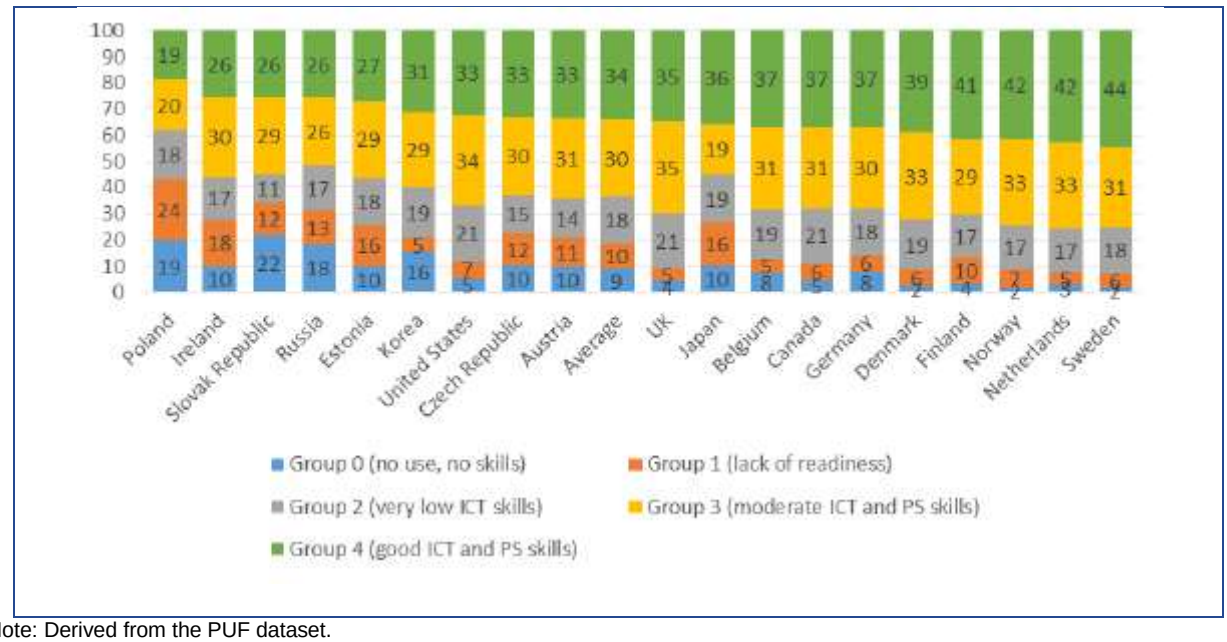


Notes: Adults in the missing category were not able to provide enough background information to impute proficiency scores because of language difficulties, or learning or mental disabilities (referred to as literacy-related non-response).

1. See Figure 10, note 1.

Source: OECD (2013), *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills,* http://dx.doi.org/10.1787/9789264204256-en.

Figure 12. Skills and readiness in using ICT for problem solving of 16-65 year-olds



Note: Derived from the PUF dataset.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by Ms Tiina Annus and Ms Aune Valk presented at the February 2014 LSO meeting.

ANNEX 2 DEMOGRAPHIC CONTROL VARIABLES

Table 3 shows the estimated coefficients on the demographic control variables for each regression model. These coefficients relate to the OECD aggregate models. Most of the variables are statistically significant at the 5% confidence level (indicated by *) across all models. Note that the impact of each demographic variable converges for each outcome measure (earnings and employment) and does not vary much depending on the skill of interest. We attribute this to the fact that other skills are included as controls in each model specification (e.g. skills and readiness in using ICT for problem solving and numeracy skills are included as controls in the literacy model).

The coefficients of the earnings models can be treated as marginal effects in percentage terms. For example, the interpretation of the impact of age on hourly earnings is that each year of age increase hourly earnings by 4%.

As expected, earnings are increasing with age, parental education and tenure. Cohabiting, part-time employment (note that earnings are hourly) and private sector employment status also have positive relationships with earnings. The variables representing female, foreign born and whether the individual has children all have negative effects on hourly earnings.

As the employment model is estimated using logistic regression, the coefficients are odds ratios and have a different interpretation to those of the earnings models (see section 3.4 of the main report for a full description). Employment is increasing with the variables with a coefficient greater than 1, including age, cohabiting, parental education and has children. By contrast, employment is lower for women and those born in other countries[4].

[4] Note that odds of employment have a different interpretation to probability of employment. See Section 3.4 for the correspondence. As an example, an odds ratio of 1.34 will have the effect of raising the probability of employment from 50% to 57% with an additional year of age. Also, note that the marginal effects associated with coefficients estimated using logistic regression will depend on the value of the variable at which the effect is estimated.

Table 3. Impact of control variables on outcome measures by model – OECD aggregate

	Earnings			Employment		
	Numeracy	Using ICT for problem solving	Literacy	Numeracy	Using ICT for problem solving	Literacy
Age	0.040*	0.040*	0.040*	1.342*	1.337*	1.342*
Age^2	0.000	0.000	0.000	0.996*	0.996*	0.996*
Female	-0.154*	-0.155*	-0.155*	0.476*	0.479*	0.477*
Foreign born	-0.026	-0.023	-0.025	0.684*	0.682*	0.683*
Cohabiting	0.075*	0.075*	0.075*	1.194*	1.194*	1.196*
Parental education	0.043*	0.043*	0.043*	1.023*	1.020*	1.022*
Has children	-0.018*	-0.019*	-0.018*	1.503*	1.509*	1.509*
Tenure	0.009*	0.009*	0.009*			
Part-time	0.064*	0.064*	0.064*			
Private sector	0.007	0.009	0.008			

Note: Tenure, part-time and private sector were not included in the employment model as their availability is dependent on employment.

Source: Survey of Adult Skills (PIAAC) (2012), calculation by London Economics.

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