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NEW MEASURES OF WORKFORCE SKILLS IN THE EU

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This paper presents new data series designed to yield a more complete picture of the growth in average skill levels embedded in the EU workforce, comparing with competitor countries such as the US and China. Harmonised data from EU surveys are employed to extend coverage in existing databases to more countries, to cover the period of the financial crisis, and to skills acquired through informal workforce training. The results indicate growth in labour quality in the EU15 marginally below the US, convergence of the group of new member states to the EU15 but no sign of convergence of China to more developed regions. There is evidence of a pronounced rise in labour quality in most countries after 2007, consistent with theories of labour hoarding, but with some notable exceptions. Expanding the conventional measures of labour quality to include informal training leads to small but significant increases in the growth of human capital in some EU15 member states.

Keywords: Workforce skills; training; financial crisis

JEL classifications: I25, J24, O15

1. Introduction

There is ample evidence in the economics literature that achieving sustained economic growth is intrinsically linked to human capital accumulation. Many key papers place human capital at the core of the growth process (e.g. Lucas, 1988; Benhabib and Spiegel, 1994; Glaeser *et al*., 2004; Galor, 2004). Human capital stocks are built up through countries' willingness to invest in educating their early age population who subsequently use the knowledge acquired in the workplace. The knowledge obtained through general schooling may be topped up through work experience and continuous training. Although estimates exist for human capital stocks for a few selected countries, in general the approach taken to estimate the impact of human capital on growth or productivity is to estimate flows of labour services from workers with different skill levels – this is the method adopted for the US in Jorgenson, Gollop and Fraumeni (1987) and in the EU KLEMS project for EU countries (see Timmer *et al*. 2011).[1] These estimates do not adequately take account of additions to workforce skills from additional informal training – this aspect is addressed in O'Mahony (2012).

The purpose of this paper is to present new estimates that draw from the previous literature but are more complete in their country coverage and extend to the period of the global financial crisis. The paper presents the results of work carried out for the INDICSER project,[2] designed to yield a more complete picture of the growth in average skill levels embedded in the EU workforce than available to date. This employs harmonised data from EU surveys to extend coverage in EU KLEMS to more countries and to skills acquired through informal workforce training.

The paper begins with a brief description of the methodology employed, drawing from O'Mahony and Timmer (2009) for measures of labour services and O'Mahony (2012) for measures of training. This is followed by a description of the data employed (section 3) and the choices made in order to construct the human capital measures. Measures of labour quality growth based on education/certified qualifications are presented in section 4 for the EU and for two competitor countries, the US and China, with a focus on trends before and after the financial crisis. This section also discusses the contributions of individual EU economies to aggregate labour quality growth and estimates by broad sector. Section 5 presents an expanded measure of human capital that incorporates the contribution of workplace training; data restrictions mean that the results in this section are confined to EU countries and to the period up to 2007.

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2. Methodology

2.1 Estimating labour quality based on workforce composition

In this paper we employ the methodology employed in the EU KLEMS database, outlined in O'Mahony and Timmer (2009), to gauge cross-country variations in the extent of upskilling of the labour force. In EU KLEMS aggregate labour input is derived as a Törnqvist quantity index of individual labour types as follows:

$$\Delta \ln L_{jt} = \sum_{l} \bar{w}_{l,jt} \Delta \ln H_{l,jt} \tag{1}$$

where $\Delta \ln H_{l,jt}$ indicates the growth of hours worked by labour type l and weights are given by the period average shares of each type in the value of labour compensation. Assuming that marginal revenues are equal to marginal costs, the weighting procedure ensures that inputs which have a higher price also have a larger influence in the input index. So for example a doubling of hours worked by a high skilled worker gets a bigger weight than a doubling of hours worked by a low skilled worker.

In terms of labour inputs, it is useful to split the volume growth of labour input into the growth of hours worked and the changes in labour composition in terms of labour characteristics such as educational attainment. Let $H_{l,jt}$ indicate the hours worked by labour type l in industry j at time t, and H_{jt} total hours worked by all types (summed over l) then we can decompose the change in labour input as follows:

$$\begin{aligned} \Delta \ln L_{jt} &= \sum_{l} \bar{w}_{l,jt} \Delta \ln \frac{H_{l,jt}}{H_{jt}} + \Delta \ln H_{jt} \\ &= \Delta \ln LC_{jt} + \Delta \ln H_{jt} \end{aligned} \tag{2}$$

with $\bar{w}_{l,jt}$ the period-average share of labour type l in total labour costs in industry j. The first term on the right-hand side indicates the change in labour quality and the second term indicates the change in total hours worked.[3] It can easily be seen that if proportions of each labour type in the labour force change, this will have an impact on the growth of labour input beyond any change in total hours worked. To estimate equation (2) we require information on both hours worked and wages by labour type. In the results below we concentrate on the skill dimension, dividing the labour force into three groups, high, medium and low skilled workers.

2.2 Informal workforce training

The methodology used to include measures of human capital based on post education informal training differs from that outlined in the previous sub-section. This is because training of this nature is often paid for by firms and so the return comes largely through higher profitability rather than increases in the wages paid to those trained. In addition data on the increment to wages from training are not readily available. The methodology employed is set out in detail in O'Mahony (2012); this section sketches the approach adopted in that paper.

The methodology employed draws from a recent literature focusing on unmeasured intangible investments as sources of growth. The pioneering work in this respect is by Corrado, Hulten and Sichel (2005; 2009) who attempted to measure investments in intangible assets for the US. These authors defined a number of types of intangible investments including software, scientific and non-scientific R&D, brand equity and firm specific expenditures such as on-the-job training and managing organisational changes. Subsequent research produced estimates of intangible investments for other countries, e.g. Giorgio Marrano, Haskel and Wallis (2009) for the UK, Javala, Aulin-Amhavarra and Alanen (2007) for Finland, van Rooijen-Horsten, den Bergen and Tanriseven (2008) for the Netherlands, Fukao, Sumio, Tsutomu and Konomi (2009) for Japan and Jona-Lasinio, Iommi and Roth (2009) for EU countries. This literature treats training as an activity largely undertaken by firms who pay the direct costs of training programmes and indirect costs in terms of production output foregone. The issue then becomes one of separating human capital formation where returns go to workers from those where firms enjoy the benefits. If this can be achieved, then changes in human capital formation arising from activities of firms can be added to those measured using the 'labour quality' approach outlined in the previous section.

Estimating investments in continuous training requires a monetary valuation of the number of hours of training received by workers. To achieve this, hours trained, calculated as numbers of workers trained times average duration of training, are multiplied by the average hourly cost of this training. Hence investments in continuous training in industry j and time period t are calculated by:

$$TI_{jt} = HTR_{jt} C_{jt} \tag{3}$$

where TI = nominal expenditures on investments in training, HTR = total hours spent training per worker and C is the cost of an hour's training. Since, in the data used here, average durations are reported for the

previous four weeks, this is converted to an annual basis, allowing for time lost due to holidays and other forms of absence.

Hourly costs C will have two elements, the direct costs of training (costs of running courses or external fees) and the indirect or 'opportunity' costs of the production foregone due to time spent on training. Time away from production is valued at the market wage, as in Jorgenson and Fraumeni (1992). In this analysis hourly costs were estimated as:

$$C_{jt} = DR_{jt} + \bar{w}adj_{jt} \quad (4)$$

where DR is the direct cost per hour trained, $\bar{w}$ denotes average hourly wages and adj is an adjustment for the skill composition of those trained (which differs from the skill composition of the workforce).

The methodology set out above can be employed to estimate annual nominal investments in informal training. However for these estimates to be useful in estimating the impact of human capital on growth, a few additional steps are required. First, as a consequence of the additional training received, those trained may receive some additional wages. As training is more concentrated in high skill individuals, to avoid double counting it is necessary to adjust for this before combining with the labour quality estimates. Since there is no information on the direct wage benefits of training, O'Mahony (2012) employed a proxy measure based on the extent to which training occurs during working time to divide out the part of training paid for by firms. Thus equation (3) is replaced by

$$TI^{*}_{jt} = HTR_{jt}C_{jt}P_{jt} \quad (5)$$

where P is the proportion of training that occurred wholly or mainly during working hours.

Second, nominal investments need to be deflated to constant price series – average earnings was used as the deflator since the indirect cost element is measured by hourly wages. Finally, using the investment series to construct capital stocks requires a number of assumptions including the form of the depreciation function (assumed to be exponential), the depreciation rate (assumed to equal 25 per cent) and estimates of the starting stock (assumed equal to the reciprocal of the depreciation rate).[4] A discussion of the sensitivity of the intangible training capital stock estimates to the underlying assumptions is given in O'Mahony (2012). This suggests that use of a wage rather than GDP deflator tends to lead to lower growth in training capital while the 25 per cent depreciation rather than the 40 per cent employed in other studies (e.g. Corrado *et al.*, 2009) leads to marginally higher growth.

3. Data

3.1 Division of the workforce and wage bill shares by skill

The primary data source for shares of hours worked by worker characteristic is the quarterly EU LFS harmonised microdata, available from Eurostat. In this paper we report results for data extracted for the period 2002 to 2009, although for some countries data are available for earlier years.[5] In terms of the division by skill group, we employ three groups using the International Standard Classification of Education (ISCED) designed by UNESCO. The three groups are High (ISCED 5+6, first and second stage of tertiary education), Medium (ISCED 3+4, upper secondary and post-secondary, non-tertiary education) and Low (ISCED 1+2, lower secondary and primary education). Estimates of hours worked for comparable skill groups in the US come from the Current Population Survey (CPS).

We use the number of employed persons[6] to calculate the labour composition index for China. The China Labour Statistical Yearbook provides information on education levels for employed persons during 2002–9, which can be classified into three groups: High education (College, University, Graduate and Higher Level), Medium education (Senior Secondary school) and Low education (Junior Secondary School, Primary school and below).

Proportions of the workforce in the three skill groups, averaged across the period 2002–9, are shown in Appendix table A1. This shows that in the EU24 about 25 per cent of the workforce had high level qualifications, with the proportion in the EU15 group of countries a little higher (27 per cent) than the new member states (21 per cent). Over the same time period the comparable figures for the US were 49 per cent, so the EU appears to be a long way behind the US in terms of the high skill proportion of the workforce, despite the convergence among young age cohorts outlined in the paper by Barslund in this issue (Barslund, 2012). Workers with medium qualifications make up about 50 per cent of the workforce in the EU24, a little higher than in the US (47 per cent). This skill group represents a higher proportion of the workforce in the EU9 countries (69 per cent) than in the EU15 (46 per cent) with a corresponding

smaller proportion (9 per cent) with low skills in the EU9 relative to the EU15 (28 per cent). Over the same period the proportion of the workforce with low skills in the US had fallen to just under 5 per cent. In China, about 7 per cent of the workforce had high level qualifications, 13 per cent had medium qualifications, while workers with low qualifications make up about 80 per cent of the workforce.

These levels estimates are however sensitive to the matching of education/qualifications across countries. For example, high school graduation in the US (included in ISCED 3), is basically an attendance measure, whereas in many EU countries this group includes students who have attained higher qualifications through national exams. Also many of the low skilled workers in China are farmers and their families working in rural areas. Differences in industrial structure will therefore affect the comparison between China and more developed countries. The Chinese Health Nutrition Survey (CHNS) database suggests that in the non-farm labour force the proportions in high, medium and low skills are about 15, 39 and 46 per cent, respectively, averaged over the period 2000–9. Thus, even excluding farmers, the low skill proportion is still much greater than in the EU or US. Finally ISCED group 5 includes university degrees of at least three years duration (ISCED 5A) but also some tertiary qualifications of shorter duration (ISCED 5B) which might be more comparable to medium qualifications in some countries – see Mason *et al*. (2012) for a discussion of the division of ISCED 5. This is especially important in comparing Europe with the US since two-year degrees are much more common in the US which, to some extent, accounts for its much higher high skill share. Given these difficulties, the estimates in the next section concentrate on labour quality change rather than levels.

The EU LFS has earnings data only for a handful of countries and this information is not in any case available in the microdata. Two alternative harmonised databases are available which contain earnings information: the Survey on Income and Living Conditions (EU SILC) and the Structural Earnings Survey (EU SES). EU SILC is a survey of individuals and is, at least in this sense, compatible with EU LFS but has a relatively small sample size (422,747 in 2008 compared to 5,495,461 in LFS). EU SILC is available annually from 2005–9. In contrast, EU SES has a much larger sample size (9,589,512 in 2006), but is a survey of firms, is only available for 2002 and 2006, and excludes small firms employing less than ten persons. Ideally we would use a combination of both sources to derive annual series but this is only feasible if they suggest similar relative wages by worker characteristic.

Appendix table A2 presents the returns to High and Medium skills (relative to Low skills) from Mincer wage regressions for countries where micro data were available in both EU SILC and EU SES in 2006. The results are reasonably close for most countries and show similar cross-country relative positions in the two surveys. Discrepancies tend to be larger for small countries, although they are also relatively large for the UK. However for the latter we use the earnings data from the UK LFS since annual microdata series are available. In general we opted to base the relative earnings by skill group on EU SES given its much larger sample size, interpolating between 2002 and 2006, and used EU SILC to update to 2008.[7] Estimates were constructed for 1-digit industry groups but only the results for the total economy and broad sector are presented in this paper. As the 2009 wage data are classified according to NACE rev2, we opted to use 2008 relative wages also for 2009 to avoid breaks in the series.

The CPS is again employed to derive earnings by skill group for the US so that for the US (as for the UK) the employment and earnings data come from a consistent source. In the case of China, we derive the average hourly wage rates for the three education levels of employed persons from the micro Chinese Health Nutrition Survey (CHNS)[8] data in nine provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou) in 2000, 2004, 2006 and 2009. We consider urban and rural areas separately and then weight them by the urban–rural ratios of employed persons; the urban share increased from about 25 per cent in 2002 to nearly 30 per cent in 2009.[9]

3.2 Data for estimating training capital

The EU LFS quarterly microdata also provide the basic data on hours spent in informal training. This uses the variable COURATT in the survey which asks respondents "did you attend any courses, seminars, conferences or receive private lessons or instructions outside the regular education system in the past 4 weeks?". Appendix table A3 shows the per cent of the workforce receiving training for the EU as a whole and by country. This shows a marked difference between the EU15, with 11.2 per cent receiving training, and the EU9, where only 3.4 per cent of the workforce received training. The variation by country is also very pronounced even within the EU15. Around 20 per cent or more workers receive training in the UK, Denmark, Sweden and Finland, while in some small countries, such as Portugal and Ireland, the figure is 5 per cent or less. Similarly the new member states show large variation including a higher per cent trained

in Slovenia than many EU15 countries. Data are not available to construct comparable measures of training for the US and China.

The EU LFS also provides information on the duration of training (in hours) and the proportion of training wholly or mainly undertaken during normal working time. Information on hourly direct costs (DR) was taken from the Eurostat Continuous Vocational Training Surveys (CVTS) surveys, which were carried out in 1999 and 2005. The second term in the hourly costs equation is the indirect cost. This is set equal to the average wage but adjusted for the skill composition of those being trained. This recognises that, in the EU as a whole, and each individual country, on average training is concentrated more on those with higher skill levels and hence on those who receive higher wages (see further discussion of training by skill type below).

4. Labour quality growth from general education

This section reports the estimates of labour quality growth arising from qualifications achieved through the general education system; estimates incorporating informal training are discussed in section 5. Estimates for the total economy are presented first for aggregate EU and compared with the US and China. This is followed by a discussion of within EU changes in labour quality by country and broad sector.

Table 1 shows the annual average per cent change in labour quality for the EU as a whole, the division between EU15 and EU9 and comparisons with the US and China. This shows estimates for the entire period 2002–9 and dividing into the years before and after the financial crisis. Over the entire period labour quality in the total EU grew by just under 0.5 per cent per annum, a little below that achieved in the US, although not significantly so. The growth rates for the new member states far exceed those for the aggregate EU15, suggesting some convergence of education levels in the workforce across the two regions. The growth in labour quality in China, by contrast, was relatively low in this period, reflecting its small share of workers in relatively high paid jobs and lack of any significant increase in skilled labour use, especially graduates.

Of particular interest are the trends comparing the position up to 2007 with the years most affected by the financial crisis. In the EU, the US and China there has been a pronounced rise in labour quality after the financial crisis so that labour quality growth appears to follow a countercyclical pattern. The underlying figures show a rise in the employment share of high skilled workers at the expense of the low skilled in the EU, with the medium share largely unaffected. In the US the rise in labour quality growth in the final two years is even more pronounced, with high skill employment shares rising at the expense of both medium and low skilled. China's labour quality index increases sharply during 2007–9, which is due to the rising unemployment rates of low skilled workers after the financial crisis. The difference between the two time periods in China is higher than in the EU countries, but lower than in the US.

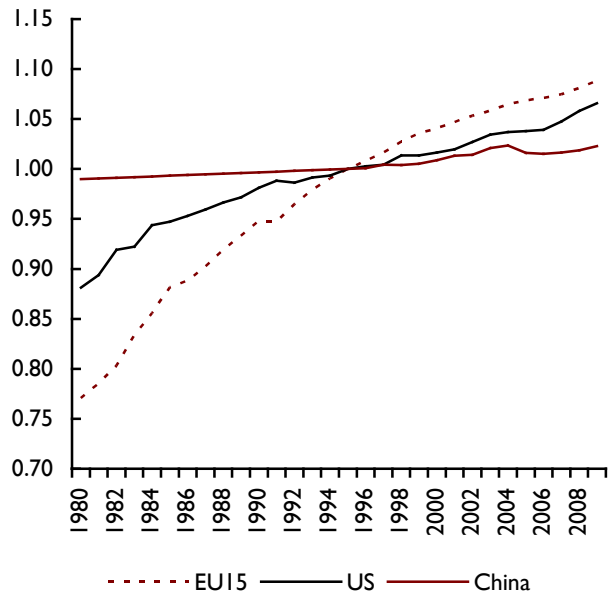
Table 1. Growth in labour quality, 2002–9

	Growth in labour quality			
	2002–9	2002–7	2007–9	Growth 2007–9 minus 2002–7
EU24	0.48	0.42	0.63	0.21
EU15	0.47	0.41	0.63	0.22
EU9	0.83	0.79	0.93	0.14
US	0.53	0.39	0.87	0.48
China	0.12	0.04	0.33	0.29

Before examining the results for individual countries within the EU, it is useful to extend backwards for aggregate regions to examine how the increases in labour quality since 2007 compare to previous downturns. Figure 1 shows the long-term trends for the EU15, the US and China, employing similar data as for the estimates for more recent years; long time-series calculations are not feasible for the new member states.[10] This illustrates both the catch-up of the EU15 to the US and the lack of significant progress in China. This figure also shows that there is no apparent upsurge in labour quality growth in the downturns in the early 1990s or in 2000–1. As the timing of recessions across the regions differs, it is difficult to pinpoint exactly which years should be compared. For the EU15, growth in labour quality over the period 1991–4 was lower than in the boom years 1984–90 and similarly there is a slight reduction in 2001–2 comparing 1995–2000. The correlation between growth in labour quality and growth in real GDP across the entire time period since 1980 is slightly positive, although not significant. For this region, however, the expansion of higher education provision in the past three decades is likely to swamp any cyclical factors.

In the US there is more evidence that labour quality growth follows a countercyclical pattern. The US witnessed a small increase in the growth of labour

Figure 1. Long-term trends in labour quality: EU15, the US and China, 1995=1



quality comparing the downturn in 1990–91 with its boom period from 1983 to 1989, from 0.79 per cent to 0.86 per cent. The acceleration in the recession years 2000–2, compared with the period 1992–2000, is proportionally greater (growth in labour quality rose from 0.31 per cent to 0.51 per cent), but far less than experienced during the 2008–9 downturn. In the US there is a negative correlation, equal to –0.27, between the growth in real GDP and the growth in labour quality over the entire period.

It is difficult to pinpoint downturns in China, given very high growth in Chinese GDP since the freeing up of markets from the late 1970s. The comparisons with other countries/regions in table 1 are affected by the very high share of unskilled workers mostly in rural areas. If we ignored the rural skill composition and instead used the proportions of workers by skill type from the CHNS survey, the growth in labour quality across the entire period would be about 0.27 per cent per annum, which remains a long way below that achieved by either the EU or the US. Thus there is little evidence of convergence of the quality of the Chinese workforce to the levels enjoyed in the EU or the US.

Turning now to variation within the EU, table 2 shows the estimates by country. Labour quality change over the entire period is highest in Luxembourg, followed by Slovenia, Poland and Ireland. The growth rates are relatively low in Finland and Sweden and are negative in Denmark, where the share of the lowest skill group in employment was rising in the early years of the time period considered in this paper. In addition the extent of the difference between the two time periods varies by country. Greece and Italy and the Netherlands have lower growth post 2007, with Sweden also showing a small dip. However, most countries show similar pronounced increases in labour quality growth after the onset of the financial crisis; this is especially the case for the larger countries. In the EU9, Cyprus, Poland and Slovenia show a reduction in the growth of labour quality after 2007. The remaining six countries experienced accelerations, with the Czech Republic, Hungary and Latvia showing pronounced increases in the growth in labour quality since the financial crisis.

Figures 2a and 2b show the contributions of individual countries to labour quality growth, in the EU15 and EU9, respectively. This is calculated by multiplying growth in labour quality in each country by their shares in their respective aggregates (EU15 or EU9) labour compensation. These clearly show that the larger countries in the EU15, unsurprisingly, had the highest contributions from 2002–7. However, whereas

Table 2. Growth in labour quality, 2002–9, EU countries

	Growth in labour quality			
	2002–9	2002–7	2007–9	Growth 2007–9 minus 2002–7
Austria	0.31	0.10	0.83	0.73
Belgium	0.38	0.14	0.98	0.85
Denmark	–0.11	–0.24	0.22	0.47
Finland	0.21	0.18	0.29	0.11
France	0.38	0.30	0.58	0.28
Germany	0.37	0.20	0.79	0.59
Greece	0.40	0.46	0.24	–0.22
Ireland	0.91	0.70	1.45	0.75
Italy	0.54	0.60	0.39	–0.21
Luxembourg	1.68	0.95	3.52	2.57
Netherlands	0.46	0.54	0.26	–0.28
Portugal	0.71	0.69	0.78	0.10
Spain	0.51	0.46	0.64	0.17
Sweden	0.25	0.26	0.23	–0.03
UK	0.46	0.37	0.69	0.33
Cyprus	0.43	0.49	0.28	–0.21
Czech Republic	0.41	0.27	0.77	0.50
Estonia	0.24	0.12	0.52	0.39
Hungary	0.86	0.71	1.24	0.53
Latvia	0.74	0.17	2.16	1.99
Lithuania	0.78	0.77	0.81	0.04
Poland	1.13	1.19	0.99	–0.20
Slovakia	0.46	0.42	0.54	0.12
Slovenia	1.20	1.36	0.80	–0.56

Figure 2a. Country contributions to labour quality growth, EU15, 2002–7 and 2007–9, percentage points

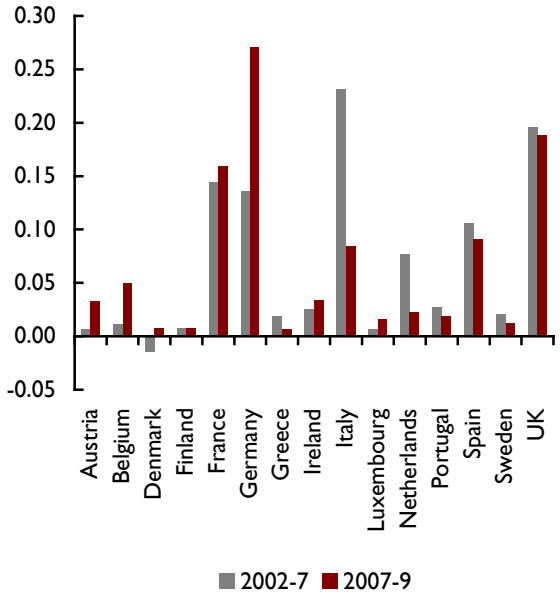
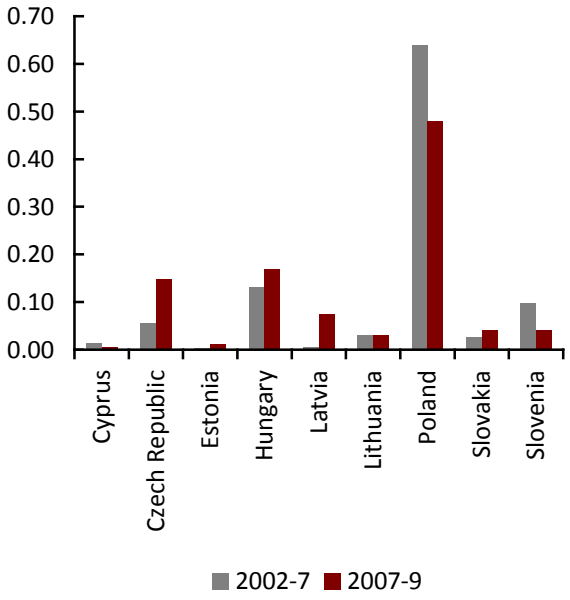


Figure 2b. Country contributions to labour quality growth, EU9, 2002–7 and 2007–9, percentage points



Germany, and to a lesser extent France, increased their contributions post 2007, Italy showed a pronounced decrease and Spain and the UK showed a small decrease. Poland clearly dominates in the early period in the EU9 region, accounting for almost two thirds of labour quality growth. In the period of the financial crisis, however, Poland accounts for less than one half, compensated by increased contributions from the Czech Republic and Hungary.

In summary, these new measures of labour quality growth allow us for the first time to compare the EU with countries such as the US and China. They suggest some convergence across regions and similar responses to the current downturn, with labour quality growing during the recession. These results are consistent with the vast literature on procyclical productivity and skilled labour arising from Walter Oi's seminal paper that treats labour as a quasi-fixed factor with costs associated with hiring and firing (Oi, 1962). Nevertheless the increases in the period of the financial crisis appear unusually large, although this might be due to the severity of the downturn. More puzzling is the deceleration in labour quality growth in some countries, notably Greece, Italy and Poland. This might reflect the difficulties firms may face in paying for the costs of holding on to high skilled workers but might also be due to reductions of relatively high skilled and high paid workers in the public sector. An analysis by industry might shed some light on this.

Table 3 presents labour quality growth divided into three broad sectors: production industries (agriculture, mining, manufacturing, utilities and construction- NACE Rev. 1, A–F), market services (distribution, hospitality, transport, communications, financial, business and personal services – NACE Rev. 1, G–K, O) and non-market services (public administration, health and social services and education – NACE Rev. 1, L–N). Data constraints prevented a similar division for the US and China.

In the EU as a whole, all three sectors show increases in labour quality growth since 2007 with the increase proportionally greater in market services than in production or non-market services. A similar pattern is apparent in the EU15 group but the acceleration in labour quality growth in the EU9 is higher in production than market services, with no change in the non-market services.

The results by country are very mixed. Taking first the EU15 countries, seven of these countries show a reduction in labour quality growth since 2007 in production industries; this includes large countries such as France, Spain and the UK that experienced accelerations for the total economy. In contrast the acceleration in labour quality growth was pronounced in Germany in production industries. Only Italy, the Netherlands and Spain experienced reductions in labour quality post 2007

in market services and for many countries the acceleration was proportionately much larger in this sector than in production industries. In non-market sectors there is greater variation comparing before and after the crisis than in market sectors. Some countries, such as Portugal and Spain and, to a lesser extent, the Netherlands, appear to be reducing the employment share of high skilled labour in absolute terms and some others, such as Italy and Finland, significantly reduced the extent to which they were employing high skilled workers in the public services. In contrast, many countries, especially France, Germany and the UK, accelerated the rate at which they were employing relatively more high skilled workers after the crisis.

In the EU9 group of countries there is more uniformity across sectors. In production industries Lithuania, Poland, Slovakia and Slovenia showed a deceleration in labour quality growth whereas other countries, such as the Czech Republic and Hungary, showed pronounced accelerations. Similarly, in both market and non-market services, decelerations occurred for Poland, Slovakia and Slovenia, while again the Czech Republic and Hungary experienced accelerations.

Returning to the three countries highlighted earlier as showing a large deceleration of labour quality growth, Greece, Italy and Poland, the industry analysis does not suggest a common explanation. Thus in the case of Italy the deceleration occurs in both market and non-market services with production industries showing increased use of high skill labour following the financial crisis. Greece in contrast shows almost no growth in labour quality after 2007 in production industries, compared to positive growth in the previous period, but a small increase in labour quality growth in the two services sectors. Poland shows a deceleration in all three sectors.

The analysis of labour quality growth by industry comparing the periods before and after the financial crisis suggests a complex picture and one that needs a more thorough analysis to understand the labour market forces underlying the varying use of different types of workers across the two time periods. At best we can say that the results are suggestive of greater hoarding of high skill labour in services than in production industries but a reverse finding for countries more focused on production such as Germany, the Czech Republic, Hungary and Italy. However there are a number of exceptions to this general conclusion.

This descriptive analysis highlights some interesting divergences both across country and sector in the use of different types of labour following the upheaval following the financial crisis. Factors that might explain this are differences in the relative costs of hiring and firing as well as government budgetary constraints in the case of the non-market services. One factor that impacts on the costs of firing labour is the extent to which firms have invested in training of their workers. This naturally leads on to an examination of training provided by firms.

Table 3. Growth in labour quality, 2002–7 and 2007–9 by broad sector

	Production		Market services		Non-market services	
	2002–7	2007–9	2002–7	2007–9	2002–7	2007–9
EU24	0.46	0.54	0.38	0.56	0.31	0.38
EU15	0.47	0.62	0.38	0.55	0.28	0.37
EU9	0.61	0.72	0.81	0.86	0.81	0.81
Austria	0.41	0.34	0.29	1.31	–0.57	0.29
Belgium	0.18	0.31	0.19	1.02	–0.04	1.58
Denmark	–0.13	0.45	–0.53	0.11	–0.04	0.07
Finland	0.09	0.46	0.19	0.28	0.33	0.04
France	0.53	0.49	0.35	0.77	–0.02	0.35
Germany	0.13	1.01	0.19	0.72	0.18	0.69
Greece	0.23	0.02	0.28	0.31	0.26	0.30
Ireland	0.39	1.10	0.87	1.05	0.49	0.92
Italy	0.36	0.47	0.45	0.18	0.89	0.41
Luxembourg	0.34	2.82	1.26	3.04	0.34	2.91
Netherlands	0.56	0.03	0.54	0.47	0.52	–0.03
Portugal	0.06	0.18	1.19	1.58	0.61	0.21
Spain	3.01	2.14	0.45	0.26	0.26	–0.20
Sweden	0.26	0.12	0.35	0.39	0.27	–0.08
UK	0.26	0.11	0.27	0.77	0.07	0.56
Cyprus	0.04	0.12	0.54	0.12	0.46	0.31
Czech Rep.	0.19	0.58	0.33	1.10	0.32	0.58
Estonia	0.07	0.13	0.07	0.31	0.55	1.31
Hungary	0.59	1.53	0.93	1.01	0.57	0.71
Latvia	0.01	1.08	0.09	2.27	0.91	2.04
Lithuania	0.65	0.41	–1.05	–1.34	1.05	0.90
Poland	0.95	0.78	1.34	0.93	1.26	0.95
Slovakia	0.38	0.37	0.57	0.49	0.51	0.42
Slovenia	0.82	0.60	1.51	0.77	1.22	0.37

5. Expanded measures of human capital

This section presents estimates of informal training for EU countries over the period 2002–7; the required data to extend to the period of the financial crisis are not yet available. Table 4 presents investments in continuous training as a share of value added, averaged across the years 2002–7 for EU aggregates and individual countries. In the EU15 investments in continuous training account for 1.3 per cent of GDP but the share of these investments in GDP is about one fourth the size in the new member states. The variation across countries is very large, even within each country grouping. Hence in the EU15 training investment as a share of GDP is highest in the

Table 4. Training investments, average 2002–7

	Investments in training as a % of GDP		
EU 24	1.20		
EU15	1.29	EU9	0.29
Austria	0.69	Cyprus	0.28
Belgium	0.52	Czech Republic	0.32
Denmark	2.43	Estonia	0.47
Finland	2.35	Hungary	0.11
France	1.05	Latvia	0.38
Germany	0.74	Lithuania	0.56
Greece	0.07	Poland	0.25
Ireland	0.37	Slovakia	0.88
Italy	0.11	Slovenia	0.66
Luxembourg	0.80		
Netherlands	1.92		
Portugal	0.27		
Spain	0.99		
Sweden	1.96		
UK	2.94		

UK, the Scandinavian countries and the Netherlands, and these shares are up to or more than ten times the shares in Italy, Greece and Portugal. The variation in training investments share of GDP across countries is less in the EU9 group of countries but is still eight times higher in Slovakia than in Hungary. Appendix table A4 shows the training investment share of GDP by broad sector. Training is more pervasive in market services than in production sectors and highest of all in non-market services.

The underlying data show that training investments are considerably larger for high than low skilled workers. In 2007 the proportions of the workforce in each skill group who received training in the EU24 were 17, 8 and 5 per cent for the high, medium and low skill groups, respectively, and similar patterns of greater training for the more skilled hold true for all individual countries (see the discussion in O'Mahony, 2012). The indirect costs based on hourly wages also increase with skill level. Together these suggest that, in all countries, firms' prior investments in training raise the relative cost of firing the most highly skilled workers. Some of the countries that showed a deceleration in the growth in labour quality from 2007, notably Italy, Greece, Poland and Cyprus, have relatively small training investment to GDP ratios, consistent with the idea that the costs of firing workers with higher skills may be lower in these countries. Against this, training investments are relatively high also in the Netherlands and Sweden, which also experienced a deceleration of labour quality growth after the onset of the financial crisis. More work is needed to disentangle the impacts of training costs from other factors that affect the costs of labour hoarding.

In order to compare with the numbers in the previous section we calculate growth in real intangible training capital. Defining total labour costs (T) as the sum of labour compensation from EU KLEMS (LC) and expenditure by firms on intangible training (TR), an expanded measure of growth in the human capital of the workforce is given by:

$$g^{HC} = \frac{LC}{T} g^{LQ} + \frac{TR}{T} g^{KTR} \qquad (6)$$

where g denotes growth rates, LQ is labour quality from the previous section and KTR denotes training capital. Table 5 shows the labour quality growth rates from the previous section, the expanded human capital growth rates using (6) and the difference between these two measures. This shows that failure to take account of workplace training underestimates the growth in human capital in the EU15 and in many individual countries, especially the UK, France, Spain, The Netherlands and the Scandinavian countries. Overall the impact of including training is zero for the EU9 group and small for all individual countries within that group.

Table 5. Average growth rates in human capital, 2002–7

	(1) Labour quality growth	(2) Expanded human capital growth	Difference (2)–(1)
EU24	0.42	0.50	0.08
EU15	0.41	0.49	0.08
EU9	0.79	0.79	0.00
Austria	0.10	0.14	0.03
Belgium	0.14	0.16	0.02
Denmark	–0.24	–0.08	0.16
Finland	0.18	0.30	0.12
France	0.30	0.42	0.11
Germany	0.20	0.25	0.05
Greece	0.46	0.47	0.01
Ireland	0.70	0.71	0.01
Italy	0.60	0.62	0.01
Luxembourg	0.95	1.02	0.07
Netherlands	0.54	0.77	0.23
Portugal	0.69	0.68	–0.01
Spain	0.46	0.64	0.18
Sweden	0.26	0.46	0.20
UK	0.37	0.74	0.37
Cyprus	0.49	0.53	0.04
Czech Republic	0.27	0.26	–0.01
Estonia	0.12	0.13	0.01
Hungary	0.71	0.71	0.00
Latvia	0.17	0.18	0.02
Lithuania	0.77	0.79	0.02
Poland	1.19	1.19	0.00
Slovakia	0.42	0.39	–0.03
Slovenia	1.36	1.42	0.06

A full growth accounting exercise that compares contributions to labour productivity growth from this expanded measure of human capital with physical capital inputs is presented in O'Mahony (2012). That paper concluded that human capital contributes as much or more than Information and Communications Technology (ICT) capital in a number of countries, including Spain, the Netherlands and the UK. Therefore failure to take account of informal training underestimates the impact of changes to the average skill level of the labour force in explaining productivity.

6. Conclusions

This paper discussed some new estimates of the growth in human capital of the workforce that have been constructed as part of the INDICSER project. It highlighted some interesting differences across regions and countries both through time, focusing on responses to the financial crisis, and in the importance of training investments by firms. It suggests labour quality growth, as measured by increases in the average skill level of the workforce, has been rising marginally faster in the US than in the EU15, mostly due to higher growth in the period of the pronounced economic downturn from 2007. Labour quality growth in China is weak by comparison, suggesting that China is not converging on more developed countries or regions in terms of the skill composition of its labour force. In contrast there is more evidence of convergence of the new member states to the EU15. Training investments were shown to have a small but significant impact on the growth of human capital, especially in a few EU15 countries. The paper also tentatively suggests that there may be links between the changes in labour quality arising from formal education in the period since 2007 and firms' prior investment in training through raising the relative costs of laying off high skilled workers.

This descriptive analysis points to some interesting avenues of further research which will be facilitated by the publication of the new series reported in this paper at the industry and country level as part of the INDICSER project, linked to other measures being developed in the project such as measures of product and labour market regulation, market environment and investment in intangible assets linked to organisational changes.

NOTES

1 www.euklems.net
2 www.indicser.com
3 In EU KLEMS the first term is called labour composition rather than the more commonly used 'labour quality' in the growth accounting literature (see e.g. Jorgenson, Ho and Stiroh, 2005), on the grounds that the more standard terminology has a normative connotation, difficult to justify when dividing the labour force according to demographic characteristics such as gender. However, in this paper we only report divisions by skill so we return to the standard usage. Note the data gathered as part of the INDICSER project also divides the workforce by gender and age but only the skill division is used in this paper.
4 The steady state starting stock.
5 EU LFS Microdata were not available for Malta for the time period considered in this paper.
6 Employed Persons refer to persons aged 16 and over who are engaged in gainful employment and thus receive remuneration payment or earn business income. This indicator reflects the actual utilisation of total labour force during a certain period of time and is often used for the research on China's economic situation and national power.
7 EU SES microdata are not available for Denmark, Ireland and Slovenia so our estimates for these three countries are based solely on SILC. For Austria tabulations were acquired from Statistics Austria. German earnings are based on the German Socio-economic panel which underlies the German SILC.
8 For a detailed description of the CHNS data, see Kang (2012) and Kang and Peng (*forthcoming*).
9 The effect of education is significantly different between the urban and rural areas, which results in significant differences in the accumulation of human capital. The China statistics separate the urban/rural numbers of employed persons from 2002 to 2009.
10 The EU15 estimates are extended backwards using the data for the EU15ex group of countries in EU KLEMS, which excludes some member states such as Ireland and Greece.

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APPENDIX TABLES

Table A1. Proportion of employment by skill level, average 2002–9

	High	Medium	Low
EU24	25.7	49.0	25.3
EU15	26.5	45.6	27.9
EU9	21.2	69.4	9.4
Austria	18.3	64.5	17.2
Belgium	17.4	58.5	24.1
Denmark	31.5	46.9	21.6
Finland	35.7	46.3	18.0
France	29.3	44.6	26.1
Germany	26.2	58.5	15.3
Greece	25.4	39.9	34.7
Ireland	33.6	39.7	26.8
Italy	15.3	44.3	40.4
Luxembourg	27.8	42.7	29.5
Netherlands	29.8	43.8	26.4
Portugal	11.3	16.7	72.0
Spain	32.3	22.4	45.4
Sweden	29.6	54.6	15.8
UK	32	45.9	22.1
Cyprus	34.5	38.9	26.6
Czech Republic	14.8	79.1	6.1
Estonia	34.7	55.4	9.8
Hungary	21.2	65.1	13.7
Latvia	24.5	63	12.6
Lithuania	31.5	60.3	8.2
Poland	22	68.7	9.3
Slovakia	15.9	79.2	4.8
Slovenia	22.7	63.2	14.1
US	48.6	46.6	4.8
China	6.8	12.7	80.4

Table A2. Returns to skill level, 2006

	High skill		Medium skill	
	EU SILC	EU SES	EU SILC	EU SES
Belgium	0.357***	0.478***	0.132***	0.141***
Finland	0.384***	0.334***	0.051	0.045***
Italy	0.616***	0.665***	0.298***	0.239***
Luxembourg	0.789***	0.682***	0.354***	0.226***
Netherlands	0.559***	0.530***	0.220***	0.169***
Spain	0.525***	0.483***	0.248***	0.201***
Sweden	0.260***	0.307***	0.078*	0.079***
UK	0.454***	0.616***	0.177***	0.225***
Cyprus	0.604***	0.685***	0.233***	0.220***
Czech Republic	0.788***	0.708***	0.316***	0.219***
Estonia	0.734***	0.557***	0.311***	0.138***
Hungary	0.870***	0.884***	0.274***	0.223***
Lithuania	0.789***	0.588***	0.354***	0.085***
Poland	0.964***	0.886***	0.285***	0.268***
Slovakia	0.685***	0.816***	0.335***	0.313***

Notes: *, **, and *** denote significant at 90%, 95% and 99%, respectively. All regressions results use a Mincer wage specification with controls for gender, age and marital status.

Table A3. Per cent of the workforce receiving training in the previous four weeks, 2007

EU 24	10.2		
EU 15	11.2	EU9	3.4
Austria	11.2	Cyprus	7.2
Belgium	7.2	Czech Republic	5.1
Denmark	24.0	Estonia	3.8
Finland	19.2	Hungary	1.9
France	8.3	Latvia	4.6
Germany	5.7	Lithuania	3.2
Greece	1.6	Poland	3.5
Ireland	5.0	Slovakia	4.4
Italy	3.7	Slovenia	10.8
Luxembourg	7.7		
Netherlands	10.5		
Portugal	1.5		
Spain	15.0		
Sweden	20.7		
United Kingdom	27.6		

Table A4. Investments in continuous training as a % of GDP, by broad sector, average 2002–7

	Production	Market	Non-market services
EU24	1.1	1.5	2.8
EU15	1.2	2.7	2.9
EU9	0.3	0.5	1.3
Austria	1.3	1.8	4.4
Belgium	0.8	0.7	1.5
Denmark	3.1	3.9	6.0
Finland	1.2	2.0	4.3
France	1.5	1.3	2.1
Germany	0.9	1.1	2.3
Greece	0.1	0.1	0.6
Ireland	0.2	0.6	1.6
Italy	0.2	0.2	0.9
Luxembourg	0.8	1.1	1.9
Netherlands	1.4	2.8	3.4
Portugal	0.2	0.3	0.8
Spain	0.9	1.1	2.8
Sweden	1.1	1.3	3.1
United Kingdom	3.1	4.1	7.1
Cyprus	0.4	0.6	1.7
Czech Republic	0.3	0.4	1.1
Estonia	0.2	0.6	2.2
Hungary	0.2	0.4	0.6
Latvia	0.4	0.8	2.9
Lithuania	0.1	0.4	1.4
Poland	0.2	0.3	1.4
Slovakia	0.3	0.8	1.1
Slovenia	1.1	1.3	3.1