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Changes in Human Capital: Implications for Productivity Growth in the Euro Area

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Abstract

The euro area has experienced a sustained decline in labour productivity growth since the 1980s. In the economic literature this phenomenon is commonly explained by a decline in capital deepening and lower total factor productivity (TFP) growth. However, the decline in labour productivity growth might partly also reflect a lower contribution of labour quality growth. We present evidence of changes in human capital in a number of euro area countries based on a fixed-weight index for labour quality growth for both the employed population and the labour force. We then evaluate the significance of these changes for recent developments in productivity growth. Our findings suggest that euro area labour quality has indeed moderated towards the end of the 1990's, but the impact on labour productivity growth is small compared to the overall decline in capital deepening and total factor productivity growth.

JEL Code: E24, J24, O47.
Keywords: Human capital, labour quality, total factor productivity, growth accounting.

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1. Introduction

Productivity growth is the main source of increases in economic welfare, as measured by real output per capita, in the long run. In this respect, the recent evolution of euro area productivity growth has been disappointing. In particular, the euro area has experienced a sustained decline in labour productivity growth since the 1980s. Existing analysis of the causes of this decline suggests that lower productivity growth has been due to both a decline in capital deepening and lower total factor productivity (TFP) growth over this time period (see for example Gomez-Salvador et al., 2006). However, the same analysis suggests that over the last ten years, the observed slowdown in capital deepening appears to be linked mainly to stronger employment growth. Robust euro area employment growth in the late 1990's together with economic policies aimed at encouraging employment of lower skilled workers in many euro area countries may also have resulted in a shift in the composition of the workforce towards workers with lower human capital. If this were the case, the sustained decline in euro area labour productivity growth could, in part, also reflect a lower contribution of labour quality growth to labour productivity growth. Standard unadjusted measures of labour input used so far in analysing euro area productivity growth ignore changes in human capital – changes in average labour quality – leading to an underestimation of the contribution of the labour input to economic growth. Best practise in the area of productivity measurement suggests instead that changes in labour quality should be taken into account by using a quality-adjusted number of hours actually worked as a measure of labour input (OECD, 2001).

We present evidence of changes in labour quality in the euro area and a number of euro area countries and evaluate the significance of changes in human capital for recent developments in productivity growth. We do this by constructing a quality-adjusted index of labour input in the euro area covering the period 1983-2004. In particular, we use averages of the relative returns across different human capital characteristics within euro area countries over the time period 1994 to 2001 to construct appropriate weights for different types of labour input. Changes in human capital are therefore captured completely by changes in total hours worked by workers with different levels of education and labour market experience. We illustrate the usefulness of the index of quality adjusted labour input based on fixed relative e returns by documenting the macroeconomic importance of changes in labour quality in various dimensions. In particular, we use the series to illustrate the impact of changes in quality on labour productivity growth. We also use calculate a quality adjusted measure of the total labour force (i.e. including the unemployed).

We find that euro area labour quality has increased continuously since the early 1980s and that improvements in human capital have accounted for an increasing share of euro area labour

productivity growth. Country results show some variation in labour quality growth across euro area countries. In line with the view that stronger employment growth may have resulted in the entry of workers with lower human capital in the late 1990s, we find that growth in labour quality moderated again towards the end of the 1990's. While these results suggest that lower labour quality growth has contributed to the decline in labour productivity growth in the late 1990s, the impact is small compared to the overall decline in capital deepening and total factor productivity growth.

The rest of this paper is organised as follows. In section 2 we survey the existing literature on calculating measures of labour quality and the methodological issues involved. In section 3 we describe the data sources and methodology that we use to construct a quality-adjusted index of labour input in the euro area covering the period 1983-2004. In section 4 we discuss the main results for the euro area and a number of euro area countries. In section 5 we provide descriptive evidence about the composition of total hours worked in the euro area labour force by worker groups with different human capital and estimate the contribution of changes in labour quality to the labour productivity growth over this time period. Finally, we conclude in section 6 with a summary and implications for economic policies.

2. Survey of literature

Human capital has a prominent role in modern growth theory. Endogenous growth models suggest that human capital may generate economic growth in the long term (see Barro and Sala-i-Martin, 2004). These theories interpret capital broadly to include human capital and incorporate mechanisms such as innovation and learning-by-doing that can generate non-diminishing returns to capital and thus a positive contribution to long-term growth. Nevertheless, empirical evidence from aggregate data on the role of human capital in explaining growth is somewhat mixed. For example, Bils and Klenow (2000) argue that schooling may have only a limited impact on growth. Other studies, focussing on alternative measures of education such as test scores, suggest that differences in the quality of education are likely to have a significant role in explaining cross-country differences in growth (see Hanushek and Kimko, 2000). In contrast, a large body of evidence using microdata has shown that investment in education does result in increased individual earnings, suggesting that the social return to schooling is also positive (Krueger and Lindahl, 2001).

The literature on measuring labour quality is based in disaggregate measures of returns to individual characteristics and hours worked by worker groups. First estimates of labour input holding labour quality constant were constructed by Denison (1962) and Jorgenson and Griliches (1967) using US data. A seminal study in this literature, Jorgenson *et al.* (1987) contains a detailed examination and

estimates of labour quality for the US. This work has been recently updated by Ho and Jorgenson (1999). Ho and Jorgenson construct a quality-adjusted measure of labour input for the US based on a cross-classification of hours worked into a number of cells by observed worker characteristics (sex, age groups, education and self-employment status). They then compute changes in the aggregate labour input as a weighted average of the change in hours worked for each cell and time period, where the weights are given by the average share of compensation attributable to each cell in two adjacent years. Finally, Ho and Jorgenson calculate growth in labour quality as the difference between growth in this aggregate labour input and growth in a raw measure of hours worked.

Ho and Jorgenson (1999) find that in 1948-1995 labour quality grew on average by 0.6% per year in the US. Furthermore, they identify three different periods in the evolution of labour quality in the US: first a continuous robust increase until the late 1960s, followed by a period of stagnation between late 1968 to 1980, and finally resumed growth from 1980 onwards, albeit at a lower rate than in the early period (on average 0.4% per year). In terms of the determinants of labour quality growth Ho and Jorgenson find that the rise in average level of educational attainment is the main driver of the increase in quality. Furthermore, according to Ho and Jorgenson the period of stagnation in the 1970s is explained by the entry of a large inexperienced cohort (the “baby boomers”) into the labour force.

While the results in Ho and Jorgenson still provide the benchmark methodology and results for the US, recent studies have expanded this work. The Bureau of Labor Statistics (BLS) uses a slightly modified version of the Ho and Jorgenson method to estimate labour quality in the United States (see BLS, 1993). The method differs mainly in the estimation of the weights. In particular, instead of calculating simple averages of compensation for each cell, the BLS uses a regression approach to estimate cell means. This involves using microdata to estimate earnings equations with a number of individual characteristics, including education and work experience, as explanatory variables, and using the predicted wages obtained from these regressions for each worker group as the weights to calculate aggregate labour input. Compared to the approach in Ho and Jorgenson (1999), the BLS approach allows for estimating the weights using a larger number of observations, thus improving the robustness of the results. Furthermore, the BLS uses more detailed information about actual work histories provided by matching the Current Population Survey with data from the Social Security Administration. This allows the BLS to estimate actual work experience, instead of relying on a proxy of potential work experience (BLS, 1993).

Aaronson and Sullivan (2001) calculate a labour quality measure for the US using microdata of individuals only. Similar to the BLS, they obtain predicted wages for each individual using a regression approach. However, instead of using the predicted wages and hours data for each aggregate

worker group, Aaronson and Sullivan combine predicted wages with actual individual data on hours worked. Compared to the Ho and Jorgenson and BLS methods this allows for more flexibility in the measurement of changes in skills, effectively extending the number of cells to equal the number of individuals that are observed in the microdata. However, this approach also requires good quality microdata of individuals for an extended time period.

Estimates of labour quality growth differ somewhat between these studies. In particular, BLS (1993) finds a lower average growth rate of labour quality since the late 1940s in the US than those presented in Ho and Jorgenson (1999). However, since the 1980s the results in the two studies are similar. The results in Aaronson and Sullivan (2001) confirm the decline in labour quality growth in the last two decades. In terms of the determinants of quality growth they also confirm earlier results, but additionally find that the business cycle has a significant impact on labour quality growth through the entry and exit of low education and low experience workers. Furthermore, using projections for demographic developments they forecast a significant decline in labour quality growth in the US.

Recent studies using more detailed data have tended to find that the contribution of human capital on labour productivity growth may go beyond previous estimates. In particular, changes in labour quality growth figure prominently in the recent discussion of the increase in US labour productivity growth in the late 1990's. In particular, Jorgenson *et al.* (2005) find that the increase in the employment of college-educated workers contributed significantly to the increase in US productivity growth since 1995. Taking a different methodological approach Abowd *et al.* (2005) also derive measures of human capital. Their methodology relies on a novel and data intensive combination of comprehensive firm level and household level data sources for the US. Their results suggest that compared to measures derived in Jorgenson *et al.* (2005) average growth in human capital in all industries has been significantly higher in the late 1990's period.

Some limited evidence of labour quality growth exists for other countries. Jorgenson (2004) provides evidence of labour quality in G7 countries, including estimates for three large euro area countries, i.e. France, Germany and Italy. The results are based on the method used in Ho and Jorgenson (1999) and use a number of different data sources. His estimates for these three countries suggest that labour quality growth in the euro area has been positive between 1980-2001, ranging from approximately 0.45% annual growth in Germany to 0.86% in France (Table 12, Jorgenson, 2004). For the euro area as a whole this suggests that labour quality grew on average by approximately 0.57% per year.[3] The results also suggest that growth in labour quality was strongest in the period 1989-1995, mainly due to

[3] This rough estimate is based on a weighted average of the country estimates using labour force weights.

robust improvement in labour quality in France. Furthermore, growth in labour quality declined somewhat in all three countries in 1995-2001. While the contribution of labour quality to labour productivity growth is smaller than the contribution of the other two components of labour productivity growth, i.e. capital deepening and total factor productivity growth, it is significant. For the euro area aggregate based on France, Germany and Italy the results suggest that the contribution of labour quality growth was always positive and accounted for just below one fifth of the growth in labour productivity (Jorgenson, 2004). In addition, Melka and Nayman (2004) estimate labour quality growth in France, Card and Freeman (2004) in Germany and Brandolini and Cipollone (2001) in Italy. O'Mahony and van Ark (2003) calculate sectoral measures of labour quality for France, the Netherlands and Germany. While the estimates in O'Mahony and van Ark (2003) are based on relatively limited data sources and thus are only indicative of developments in labour quality growth, they provide some additional insight into sectoral diversity. Their findings suggest that labour quality growth has been larger in sectors that produce information and communication technology (ICT). In addition, the slowdown in labour quality growth in 1995-2000 appears to have been most relevant in non-ICT sectors. Scarpetta et al. (2000) also construct very crude measures of labour quality growth for some euro area countries.

Measuring labour quality growth relies on a number of important assumptions. In particular, all labour quality studies assume that individual characteristics reflect differences in productivity and that relative wages are a good proxy of relative productivities. In the empirical exercises surveyed here, a number of individual characteristics are used to control for the composition of the aggregate workforce. These include education, age or labour market experience, sex and other individual characteristics (such as employment status). The choice of these individual characteristics is largely determined by economic theory on human capital as well as empirical results that document the impact of these variables on individual wages. In some cases, data limitations result in the use of proxy variables for capturing the impact of an underlying characteristic that matters for human capital.

Education is the key determinant of human capital. In terms of economic theory, formal education is the main source of general human capital (as opposed to job-specific human capital), with the basic proposition that investment in education results in higher human capital and productivity (see Becker, 1993). This assumption is confirmed by an extensive literature on returns to education that documents gains to education in terms of higher individual earnings (for surveys see Card, 1999 and Ashenfelter *et al.*, 1999). Empirical work at the aggregate level is largely based on educational attainment (such as the share of those with tertiary or university level education) as a proxy for the stock of human capital obtained through schooling (see OECD, 2004 and Barro and Lee, 2001). This is also the case for the

studies of labour quality surveyed above that decompose the work force into those with different levels educational attainment. The international classification of education (ISCED) allows for constructing internationally comparable categories of educational attainment based on three levels of education: lower secondary, upper secondary and tertiary education. A detailed description of national educational systems and the ISCED classification can be found in Annex 3 of OECD, 2004. The specific education categories used in this study are shown in the Appendix. Country differences in educational systems complicate complete harmonisation of the measurement of educational attainment at a more detailed level. Generally, internationally comparable data on more detailed classifications are not available for longer time periods. Fosgerau et al. (2002) study the impact of extending the number of educational categories on measures of human capital in Denmark. Their results suggest that a relatively small set of educational categories is sufficient for measuring aggrerate labour quality.

It should be noted that the level of education is a limited proxy for general human capital. For example, the level of education does not take into account the impact of possible differences in the quality of schooling or the type of education (see Barro and Lee, 2001). Alternative measures of general human capital have been derived recently, e.g. using data on internationally comparable test scores (see Hanushek and Kimko, 2000 and Barro and Lee, 2001).

In addition to formal education, workers gain human capital after finishing school through increased labour market experience and on-the-job training. Some of this human capital is likely to be specific to the job or industry where the worker has gained experience. Again, substantial evidence exists to suggest that general labour market experience and job-specific experience contribute positively to individual wages and productivity (see e.g. Katz and Murphy, 1992). However, compared to education, measuring experience is significantly more complicated and the empirical literature largely relies on incomplete proxies. The BLS is the only labour quality study to measure actual labour market experience. They use detailed information obtained from matching work histories from the Current Population Survey and data from the Social Security Administration to construct a measure of actual work actual experience (BLS, 1993). When data on actual work histories are not available, a common approach to measure experience used extensively in the labour literature is to approximate labour market experience with age minus years spent in schooling (minus the school starting age). This approach is adopted in several studies of labour quality (for example in Ho and Jorgenson, 1999 and Aaronson and Sullivan, 2001). An alternative approach is to acknowledge that experience can not be measured accurately and to use age as a proxy for human capital gained after school. In fact, by construction, measures of estimated experience and age are strongly correlated. Furthermore, a large body of empirical evidence suggests that similar to experience, earnings are a concave function of age,

i.e. earnings increase but at a diminishing rate with age (see Murphy and Welch, 1990). Part of the explanation for this profile lies in the tendency for the young to invest more in human capital, while at the same time foregoing some current earnings. Older workers invest less, and thus forego less current earnings, but earn returns from previous investment in human capital.

Other individual characteristics that are commonly included in the estimation of labour quality include sex, employment status (such as part-time employment) and industry. The inclusion of these variables largely reflects empirical findings that they matter for individual wages. In general, different labour market experiences for men and women result in significant differences in the accumulation of human capital and their returns between sexes. For example, it is likely that using estimated experience or age as a proxy for actual labour market experience results in different experience-earnings profiles for men and women. Finally it should be noted that a number of unobserved human capital characteristics of workers are likely to matter for their productivity.

As mentioned above, estimation of labour quality relies on wages as a measure of worker productivity. The underlying assumption, based on a model of competitive labour markets, is that relative wages are equal to the relative marginal products of labour. Various characteristics of actual labour markets, such as discrimination, union bargaining, signalling and mismatch, may result in violations of this assumption (for a more detailed discussion see Ho and Jorgenson, 1999). Furthermore, some of these characteristics, such as the relative importance of union bargaining, may be more relevant in the European context than is the case in the US. However, due to lack of more direct measures, wages remain the best available proxy of worker productivity. For reasons of data availability we also assume here that the relative returns to individual characteristics, such as education and labour market experience within each country remain unchanged at their average level for the 1994 to 2001 period. At first sight, this may seem like a relatively strong assumption. However, empirical evidence for European countries suggests that returns to skills may indeed be more stable in the euro area than in other economic areas. For example, in their review of the literature on returns to education Ashenfelter et al. (2000) find that while there has been a significant upward shift in returns to education in the US, studies for non-US countries do not show such a shift. Similarly, Brunello and Lauer (2004) find a statistically significant, but modest effect of cohort size on the earnings of different worker groups. These results suggest that relative wages (between groups of workers) may be relatively rigid in European countries and necessary adjustments take place mainly in terms of the quantities. This conjecture is supported by empirical evidence on group-specific unemployment rates in Europe. For example, Biagi and Lucifora (2005) find that changes in the age and education structures (such as the

increase in middle-aged and more educated workers) have different implications for unemployment rates for different age and education groups.

3. Data and methodology

We largely follow previous literature in calculating our estimates for changes in labour quality in the euro area and in euro area countries. As mentioned above, however, for reasons of data availability we assume that the relative returns to individual characteristics, such as education and labour market experience within each country remain unchanged at their average level for the 1994 to 2001 period. Our measure of quality adjusted labour input is constructed as follows. First, using available microdata for individual workers (see below), we estimate wage equations separately for each country and for males and females:

$$W_{it} = \alpha_{it} + EDU_{it}\beta_e + AGE_{it}\beta_a + \varepsilon_{it} \qquad (1)$$

Where the subscript *i* refers to the individual and *t* to time. These equations are estimated using weighted OLS, using sample weights provided with the microdata. The dependent variable is measured as the gross real wage in PPP units. We use the PPP conversion rates based on consumer goods prices provided by Eurostat to do the conversion across countries. The right hand side variables include two education categories EDU (with secondary education as the omitted category) and five age categories AGE (with those between 34 and 45 as the omitted category). The education categories are constructed using the ISCED97 classification (see the Appendix for more details). Note that this combination of classifications results in 36 times 12 worker-country groups.

The European Community Household Panel (ECHP) provides detailed information on individuals, including their wages and human capital characteristics. The ECHP is a survey of households in all EU countries that includes detailed information about individual characteristics, including earnings. Wages are originally reported in the ECHP as net wages (including bonuses) in the previous month in national currency.[4] From this information gross wages are constructed using the gross/net ratio provided by the survey. The use of gross wages is motivated by the use of the labour quality estimate primarily as an input to productivity analysis within a growth accounting framework (see OECD, 2001). Finally, in order to derive hourly wages we divide the monthly wage by monthly hours worked.

[4] Except for France and Finland where wages are reported as gross wages.

We use the predicted wages $\tilde{W}_j$ based on coefficient estimates from equation (1) to construct weights for each worker-country group *j* as the average of the share of each worker group in total compensation in adjacent years:

$$\bar{s}_{j,t} = \frac{1}{2}\left(s_{j,t} + s_{j,t-1}\right) \qquad (2)$$

Where the share $s_{j,t}$ is given by:

$$s_{j,t} = \frac{\tilde{W}_j H_{j,t}}{\sum_j \tilde{W}_j H_{j,t}} \qquad (3)$$

Where *H* refers to total hours worked.

We use data from the European Labour Force Survey (LFS) to construct measures of hours worked for worker groups.[5] Eurostat collects data from national labour force surveys and provides estimates for aggregate indicators, such as hours worked cross-classified for different age-gender-education groups for each euro area country. Total hours worked have been calculated from the LFS source data using information on employment and usual weekly hours.[6] The time span of these data varies somewhat across euro area countries, but with the exception of data on educational attainment, the cross-classifications are currently available for most countries from 1983 until 2004.[7] In the years when LFS data is not available for all countries, growth rates for the euro area are computed using information on the available countries. [8]

Using these data the change in aggregate labour input in the euro area is then calculated as:

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[5] The LFS data used in this paper were extracted in July 2005.

[6] Total hours usually worked were utilised for data availability reasons. Only for the post 1992 period complete information is available on usual as well as on actual hours worked. Results for this period do not differ significantly when actual hours are used instead of usual hours.

[7] Lack of education data in the LFS prior to 1992 requires the use of additional data sources to estimate the full cross-classification of total hours worked for the pre 1992 period. We use information from the Luxembourg Income Study (LIS) and the German Socio-Economic Panel (GSOEP) to fill this gap. LIS is a non-profit organisation that collects and provides access to cross section data from household income surveys from a number of countries. The GSOEP is a large longitudinal survey of German households that is available from the early 1980s onwards. Both LIS and GSOEP provide information that is similar to the ECHP. We combine LFS hours data for the less complete age times sex cross classifications with data on hours for the complete age times sex times education cross-classifications from LIS to extrapolate education shares for a number of euro area countries. Furthermore, we use information from the GSOEP to interpolate the pattern of hours worked between LIS data points. While we have information on hours worked cross-classified by gender and age, no information is available along the educational dimension for several data points prior to 1992. For example, total hours worked by 35-44 years old males are known, but information on what share of these hours can be attributed to either of the three educational categories is missing. We fill in the missing data points using predicted values for the respective shares stemming from weighted regressions for each worker-country group. All regression equations include time trends as well as information from the complete GSOEP series.

[8] LFS data for Portugal and Spain is available from 1986 onwards and for Austria and Finland from 1995 onwards.

$$\ln\left(L_t / L_{t-1}\right) = \sum_j \bar{s}_{j,t} \ln\left(H_{j,t} / H_{j,t-1}\right) \qquad (4)$$

Growth in labour quality is equal to growth in aggregate labour input and growth in the raw measure of hours worked:

$$\Delta \ln Q = \Delta \ln L - \Delta \ln H \qquad (5)$$

4. Results

The results from estimating equation (1) for each country, separately for men and women, aggregated to the euro area are shown in Table 1.[9] Note that the aggregated results are shown for illustrative purpose only, and weights derived from regressions at the country level are used in the actual calculations (see below). These results illustrate that in the calculation of labour quality, the hours of those with tertiary education are given a larger weight than the hours of those with only secondary and/or primary education. In addition to this impact of education, the results show that in line with previous evidence earnings generally increase with age and more so for men than women. These results should also not be interpreted e.g. as providing an exact measure of the causal effect of education on earnings in the euro area. For example, the equation does not take into account the possible impact of unobservable individual characteristics on the returns to education. However, for the measurement of average labour quality the exact causal effect of education on individual earnings is less relevant than arriving at a good proxy for the aggregate impact of increased education on human capital. See Card (1999) for a survey of this literature and a discussion of the measurement difficulties related to measuring the causal effect of education.

For the euro area our estimates of labour quality based on fixed returns indicate a continuous increase in quality in the last 20 years (see Table 2). The estimated average growth rate of euro area labour quality in the 1984-2004 period is 0.62% year-on-year. The estimated growth rate for the euro area is higher than a simple aggregation of previous results for Germany, France and Italy presented in Jorgenson (2004) would suggest (averaging 0.40% in 1984-2001). This difference is likely to reflect a number of factors, including differences in data and methods used. Furthermore, in addition to including data from all euro area countries, we also allow changes in the composition of the euro area workforce across countries to influence growth in euro area labour quality. Beyond the average increase in labour quality, our estimate of labour quality shows some variation in labour quality growth over time (see Table 2). In broad terms the data point to three different time periods in terms of longer-

[9] The results from estimating equation (1) directly with euro area data are not identical, but broadly similar to those shown in Table A.

term developments in euro area labour quality. The 1980s were characterised by relatively low growth in labour quality, followed by particularly strong growth in the early 1990s. Average labour quality growth appears to have moderated again somewhat towards the end of the 1990's and during the recent slow growth period. Some of this variation may be associated with the business cycle. Previous evidence suggests that labour quality is likely to be counter-cyclical showing periods of "down-skilling" in upturns and "up-skilling" in downturns as workers with different skills move in and out of the labour force (Aaronson and Sullivan, 2001 and Solon *et al.*,1994). In particular, the share of workers with lower skills tends to increase during periods of stronger growth as firms lower their skill requirements to expand production and more low-skilled workers, faced with a higher likelihood of finding a job and possibly higher wages, are encouraged to enter the labour market. Recent developments, such as the significant increase in labour quality growth in the early 1990's and the subsequent decline in the course of the 1990's -- a period of particularly strong employment growth -- is consistent with the interpretation of countercyclical quality growth.[10]

Combining the estimated series of labour quality with data on total hours worked results in a measure of labour quality adjusted labour input. Consistent with previous work on labour productivity in the euro area the estimate of total hours is taken from the Groningen Growth and Development Center (GGDC) database.[11] Due to continuous increases in quality, labour quality adjusted labour input has increased faster than unadjusted labour input in the last 20 years (see Table 3 and Figure 1). The stronger increase in quality in the early 1990s is also clearly reflected in a significant widening of the gap between the adjusted and unadjusted labour input series.

We have also estimated labour quality indices for each euro area country separately (see Table 4).[12] The results suggest that the average annual growth in labour quality for the 1984-2004 period was lowest in Germany and strongest in France, Ireland and Luxembourg. Labour quality grew strongly also in Spain and Austria. All other euro area countries have moderate growth rates at around 0.5%. While the contribution of changes in the workforce composition along the gender dimension was negligible in all countries, the first order index of age grew steadily at modest rates in all euro area countries and with little variation across countries. The big gap in average growth rates of labour quality between low- and high-performers can almost entirely be attributed to different developments in the share of total hours worked by education groups. Germany, for example, showed average growth

[10] For more detailed evidence, see Schwerdt and Turunen (2006).
[11] Timmer, Ypma and van Ark (2003), University of Groningen, Appendix Tables, updated June 2005.
[12] Due to implausible values for the year-on-year variation in hours worked by highest level of educational attainment, the year-on-year change for Ireland in 1998, Greece in 2004, Austria in 1999 and Finland in 1998 were dropped form the calculation.

rates of 0.19% for the first order index of age and 0.22% for the first order index of education. France and Ireland, on other hand, have a comparable growth in the first order index of age (both 0.21%) for the 1984-2004 period, but the first order index for education grew at average annual rates of 0.6% and 0.73%, respectively. This strong growth reflects the significant increase in the share of total hours worked by workers with upper secondary and tertiary schooling in France and Ireland.

The estimates for labour quality growth on the country level also allow a comparison with existing country results. Comparing the results reveals that our country results for the three largest euro area countries, Germany, France and Italy, are broadly in line with results in Jorgenson (2004).[13] Both the overall average growth rates and the pattern of average growth rates over time are roughly consistent with results in Jorgenson (2004), with the exception of a somewhat lower estimated growth rate for Germany. However, our lower estimate for Germany is similar to the estimated growth rate of 0.21% for the post 1980 period in Card and Freeman (2004). Overall, the comparison with existing country results supports the robustness of our estimates.

We have also explored using alternative determinants of human capital (not shown). In particular, we constructed an alternative labour quality index including two additional characteristics: part-time versus full-time work and sectors of economic activity (agriculture, industry and services). Both characteristics are potentially important determinants of wages. However, it is not a priori clear what their impact is on human capital. For example, the group of part time workers is likely to be relatively heterogeneous, including workers with both relatively low and high human capital. At the same time, the increase in part time work has generally been associated with the increase in employment of workers with lower skills. Results from including these characteristics increase average labour quality growth slightly, to 0.53% for this time period. The increase is entirely due to a positive contribution from changes in the sectoral composition. Again however, the difference between the alternative results and the benchmark calculation is small.

Similar to estimating the impact of changes in the composition of those employed, it is possible to estimate growth in the quality of the labour force (see Aaronson and Sullivan, 2001 for a similar exercise for the US). We use LFS data of unemployed by age, sex and education for the 1992-2003 time period to extend our benchmark index of labour quality of the employed to cover the whole labour force.[14] The extended measure is informative about the quality of the available labour force.

[13] Jorgenson (2004) reports average growth rates for the 1984-2001 period for Germany of 0.52%, for France of 0.86% and for Italy of 0.51%.

[14] Complete data for 2004 was not yet available. For this exercise, the data for employed and unemployed excludes those over 64 years of age (maximum age for Eurostat definition of labour force). Data for Luxembourg is excluded due to missing data.

The results show that the growth rates of labour quality of employed and the total labour force have been very similar (see Figure 3). This result largely reflects the fact that the employed form a major part of the labour force. Nevertheless, the growth in labour quality of the unemployed has been on average somewhat higher than that of the employed, with a particularly marked difference in the growth rates in the late 1990s to early 2000s period. Assuming that the average level of labour quality of unemployed workers is lower, the higher growth rate thus represents narrowing of the skill differential between workers and the unemployed over the whole time period. At the same time, the larger difference in quality growth between the two groups of workers in the late 1990s may also reflect cyclical factors.

5. Changes in euro area human capital and implications for labour productivity growth

A decomposition of the overall quality index to the contributions of its determinants provides some insight on the factors underlying changes in labour quality growth. We calculate the first order contributions of sex, age and education following the method described in Ho and Jorgenson (1999)[15]. The results show that, as expected, education has been the main driving force of labour quality growth (see Table 1).[16] The contribution of education to labour quality growth was particularly strong in the late 1980s and early 1990s, consistent with an increase in the share of those with tertiary education of total hours worked in the euro area during this time period. Longer term developments in educational attainment in the euro area has been characterised by a secular increase in years spent in schooling. Data on total hours worked from the LFS illustrates the significant increase in average educational attainment over the last 20 years (see Figure 3). The share of those with primary education or less has declined significantly, whereas the share of those with secondary and tertiary qualifications has increased. The recent increase in the share of the population that has tertiary (university level) qualifications has been particularly striking. Overall, the increase in educational attainment amounts to a significant increase in the supply of general skills in the euro area.

The contribution of age to the index of labour quality was also particular strong in the early 1990s. This coincides with an increased share of workers in prime age (aged between 35 and 54). Thereafter the contributions of both characteristics declined in the late 1990s possibly reflecting the impact of continued robust growth in employment and the entry of marginal workers with lower human capital

[15] First order indices are constructed analogously to the main index described in section 3.1. The only difference compared to the full index consists in the choice of worker-country groups, which is determined by the respective cross-classification. For example, the first order contribution of sex requires only a cross-classification along one dimension with two possible worker groups (males and females). Hence, the corresponding index for sex is calculated based on 2 times 12 worker-country groups.

[16] This conclusion is robust to the inclusion of other determinants. In particular, the contributions of sector and fulltime versus part-time status for the period 1992 onwards are negligible.

both in terms of education and labour market experience. Most recently, an increase in hours of more educated and experienced workers has contributed to an increase in labour quality in 2003 and 2004.

While acting as proxy for labour market experience, the contribution of age to labour quality changes is largely driven by demographic developments. Overall trends in the euro area working age population over the last 30 years are characterized by the movement of the so-called baby boom cohort (those born in the 1950s and 1960s) through the age distribution (see Figure 4). In particular, the shares of those in prime age, i.e. between 35-54 years of age have been steadily increasing since the early 1990's, whereas the share of younger, less experienced workers, i.e. those between 15 and 34 years of age has declined over the same time period. The increase in the share of hours worked by prime-aged workers and the decline in the share of younger workers is likely to have resulted in an increase in average labour market experience over this time period, as well as lower contemporaneous human capital investment. Compared to the changing contribution of workers below 55, the share of older workers has been relatively steady over this time period. However, the ageing of the baby-boom generation is likely to result in an increased share of total hours worked for this age group in the near future. Finally, the first order contribution of sex to the labour quality index has been quantitatively negligible. The negative contribution reflects the increased share of total hours worked by women (see Genre and Gomez-Salvador, 2002).

Previous growth accounting exercises for the euro area have ignored the role of changes in human capital, thus estimating TFP growth as a residual item including the contribution of labour quality growth (see Gomez-Salvador et al, 2006 and Vijselaar and Albers, 2004). With positive growth in labour quality, this omission results in larger estimates of TFP growth and a possible misinterpretation of the determinants of the sustained decline in labour productivity growth. The results of a more complete decomposition of labour productivity growth, i.e. separating out the impact of labour quality growth from TFP growth point to a significant and increasing role for changes in labour quality in explaining labour productivity growth in the past 20 years (see Figure 7). While in the early 1980's the contribution of labour quality growth accounted for only 15 percent of productivity growth, this share has increased to 35 percent in the early 2000's. However, as discussed above lower labour quality growth in the second half of the 1990s appears to have also contributed somewhat to the decline in labour productivity growth over the same time period. In particular, adjusting for labour quality results in significantly lower estimates of euro area TFP growth than previously estimated. As TFP growth is estimated as a residual, these estimates should be interpreted with some caution. With this caveat in mind, the results suggest that while TFP growth has been slower in the 1990s compared to the 1980s, a

significant further slowdown in TFP growth took place during the recent period of slow growth in the euro area.

6. Conclusions

The results presented in this paper suggest a continuous increase in the human capital composition of the euro area workforce in the last 20 years. Country results show some variation in labour quality growth across euro area countries. In line with the view that stronger employment growth may have resulted in the entry of workers with lower human capital in the late 1990s, we find that growth in labour quality moderated again towards the end of the 1990's. We have illustrated the usefulness of the index in better understanding macroeconomic developments in the euro area. The results of an accounting exercise point to a significant and increasing role for changes in labour quality in explaining labour productivity growth. Accounting for positive labour quality growth lowers estimates of total factor productivity growth in the euro area and points to a possible decline in the contribution of technological progress to growth in the euro area.

The central role of human capital in contributing to productivity growth has been acknowledged in key European economic policy recommendations. Indeed further improving knowledge and innovation remain as one of the key areas for further progress as identified in the mid-term review of the Lisbon agenda.[17] In this context a key indicator of progress is the percentage of the population aged from 20 to 24 who have completed at least an upper secondary education. This share remains well below the 85% target, suggesting that further progress in encouraging higher educational attainment is needed. In this regard, the results in this paper show that higher educational attainment can contribute positively to labour productivity growth. While it is important to recognise that other (not measured) factors, such as quality and type of education are likely to also matter, the results suggest that economic policies designed to promote growth in euro area human capital should be geared towards an increase in educational attainment and increased on-the-job training. Needless to say both education and training should be geared towards the needs of the job market.

In this context, technological progress and other factors, such as globalisation and the ageing of the euro area workforce, are likely to present additional challenges. The results of the accounting exercise in this paper points to a decline in euro area total factor productivity growth. This decline argues for stronger emphasis on economic policies that promote innovation and the use of productivity enhancing technologies, as well as an increased focus on understanding the interactions between human capital and technological progress. In particular, some commentators have noted that type of schooling may

[17] See europa.eu.int/growthandjobs/pdf/COM2005_024_en.pdf and ECB (2005).

matter for explaining cross country differences in the adoption of new technologies. For example Krueger and Kumar (2005) argue that compared to the more general education in the US, European education systems are focussed on specialised vocational training. Wasmer (2003) argues that the structure of European labour markets favours more investment in job-specific versus general human capital. Both arguments suggest that European educational systems may not provide sufficient flexibility for workers in periods of significant structural changes. Looking forward, changing demographics are likely to have a strong impact on growth in labour quality in the future. While ageing of the working age population (until prime-age) generally increases average labour quality due to larger return to previous investment in human capital, it may result in lower incentives for current investment in human capital. Ageing is thus likely to result in downward pressure on the contribution of labour quality to aggregate productivity growth.

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Table 1. Aggregated coefficient estimates

	Female	Male
Age 15-24	-0.44	-0.53
Age 25-34	-0.14	-0.16
Age 45-54	0.06	0.09
Age 55-64	0.03	0.07
Age 65-	-0.12	-0.09
Primary education	-0.24	-0.18
Tertiary education	0.28	0.27
Constant	4.38	4.49

Source: authors' calculation. Note: Age 35-44 and secondary education are the omitted categories. Wages are in logs.

Table 2. Complete results *(index: 1983=100)*

	Total	First order indices			Second order indices			
		S	A	E	SA	SE	AE	SAE
1983	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1984	100.27	99.92	100.23	100.13	100.01	100.06	99.98	99.94
1985	100.94	99.88	100.37	100.62	100.02	100.11	100.02	99.92
1986	101.35	99.83	100.20	101.19	100.05	100.15	100.02	99.92
1987	101.81	99.80	100.18	101.67	100.05	100.16	100.03	99.91
1988	102.66	99.76	100.26	102.45	100.05	100.17	100.05	99.90
1989	103.40	99.73	100.37	103.11	100.06	100.16	100.05	99.90
1990	104.47	99.66	100.44	104.23	100.07	100.12	100.04	99.89
1991	105.70	99.48	100.64	105.46	100.08	100.10	100.04	99.89
1992	105.83	99.47	100.66	105.61	100.08	100.09	100.02	99.90
1993	106.87	99.45	101.12	106.27	100.05	100.03	100.01	99.91
1994	108.14	99.42	101.51	107.17	100.04	100.04	100.01	99.89
1995	108.84	99.40	101.77	107.68	100.01	100.01	100.00	99.90
1996	109.34	99.37	102.10	107.92	99.99	99.98	100.00	99.90
1997	110.16	99.37	102.30	108.55	99.98	99.98	99.99	99.91
1998	110.24	99.36	102.28	108.70	99.98	99.95	99.96	99.91
1999	110.66	99.31	102.26	109.20	99.98	99.95	99.96	99.91
2000	111.33	99.26	102.34	109.82	99.98	99.96	99.95	99.91
2001	111.76	99.22	102.56	110.07	99.97	99.96	99.94	99.92
2002	112.09	99.17	102.74	110.27	99.96	99.97	99.91	99.93
2003	112.81	99.13	103.02	110.72	99.95	99.99	99.91	99.93
2004	113.87	99.13	103.23	111.55	99.94	99.98	99.91	99.93

Source: authors' calculation. Note: S refers to sex, A to age and E to education. SA is the second order contribution of sex and age.

Table 3. Growth in euro area labour quality and labour inputs

(average annual growth rates)

	1984-1989	1990-1994	1995-1999	2000-2004	1984-2004
Labour quality	0.56	0.90	0.46	0.57	0.62
Unadjusted labour input	0.53	-0.48	0.75	0.68	0.38
Quality adjusted labour input	1.09	0.42	1.21	1.25	1.00

Source: authors' calculation. Unadjusted labour input refers to total hours worked from the Groningen Growth and Development Center growth accounting database.

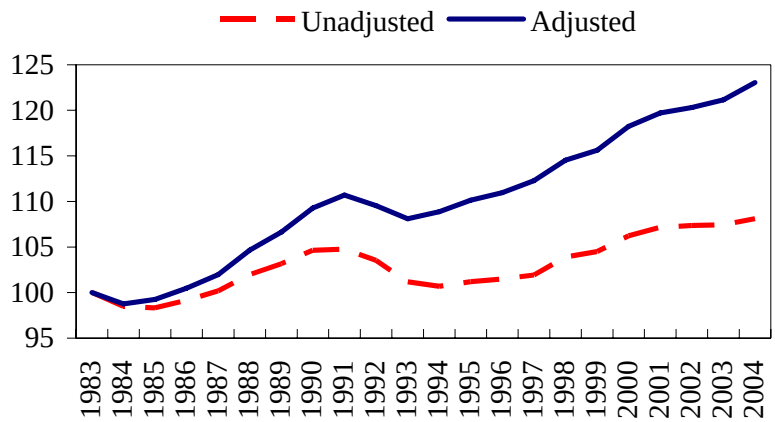
Table 4. Growth in labour quality: country estimates

(average annual growth rates)

	1984-1989	1990-1994	1995-1999	2000-2004	1984-2004
Germany	0.13	0.44	0.15	0.33	0.26
France	1.25	1.35	0.63	0.48	0.94
Italy	0.32	0.35	0.69	0.54	0.47
Spain	*n.a.*	1.09	0.80	0.79	*0.79**
Portugal	*n.a.*	0.90	-0.56	1.70	*0.48**
Netherlands	0.17	0.90	0.38	0.60	0.50
Belgium	0.25	0.47	0.47	0.56	0.43
Greece	0.43	0.70	0.39	0.88	0.58
Ireland	1.28	1.18	0.48	1.24	1.09
Luxembourg	0.67	2.67	0.55	1.69	1.36
Austria	*n.a.*	*n.a.*	0.68	0.76	*0.73***
Finland	*n.a.*	*n.a.*	-0.09	0.39	*0.21***

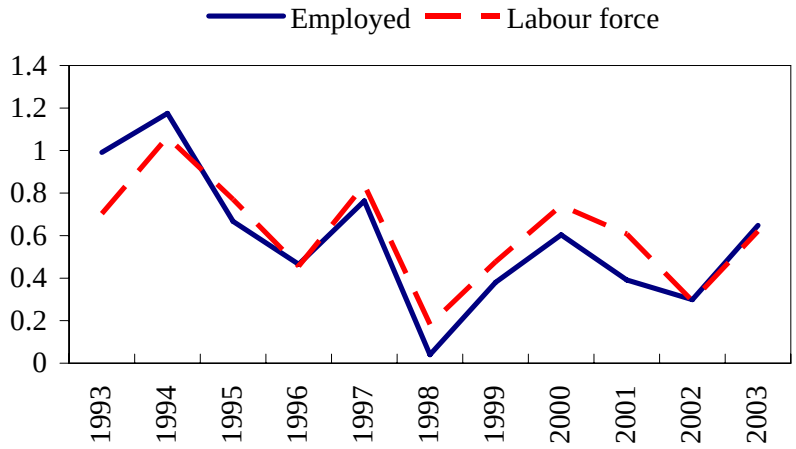
*Note: * 1987-2004, **1995-2004*
Source: authors' calculation.

Figure 1. Labour quality adjusted labour input
(index points: 1983=100)



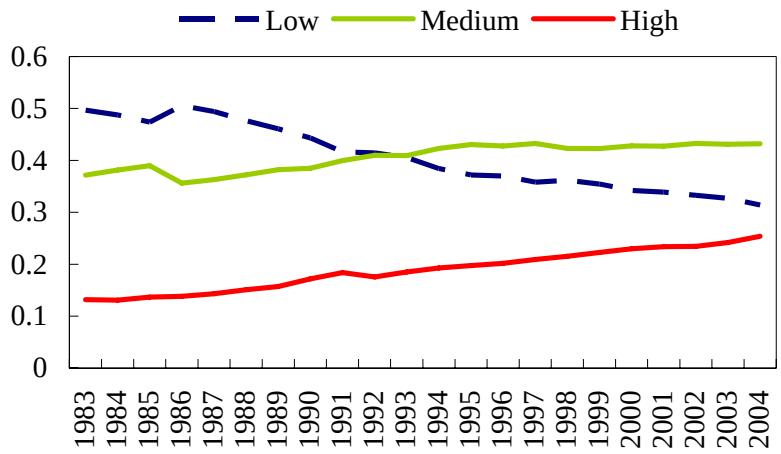
Source: authors' calculation. Unadjusted labour input refers to total hours worked from the Groningen Growth and Development Center growth accounting database.

Figure 2. Growth in the quality of labour force
(annual growth rates)



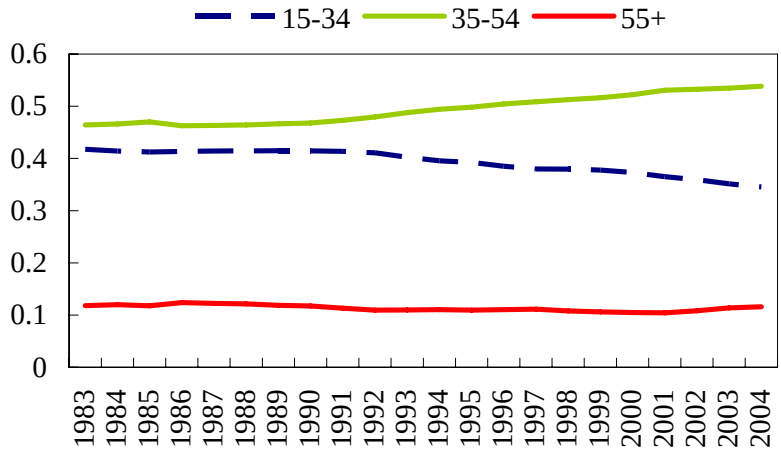
Source: authors' calculation.

Figure 3. Hours worked by educational attainment
(shares)



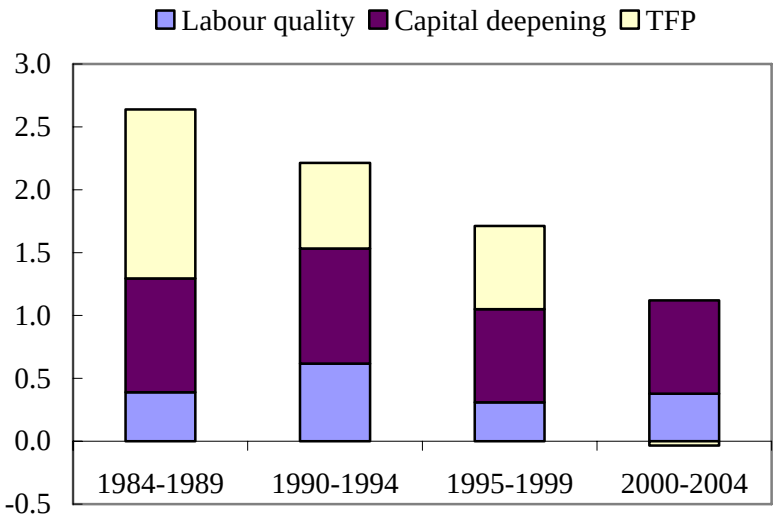
Source: authors' calculation based on the Labour Force Survey. The shift in 1985 reflects the inclusion of Portugal and Spain for which data on hours is not available before 1985. The calculation of the labour quality index takes into account changes in the country composition.

Figure 4. Hours worked by age groups
(shares)



Source: authors' calculation based on the Labour Force Survey.

Figure 5. Decomposition of labour productivity growth
(contributions)



Source: authors' calculation. Except for the estimate of labour quality data are from the Groningen Growth and Development Centre growth accounting database.

Annex I: Reclassification based on ISCED97.

Lower secondary education = Low
ISCED 0 Pre-primary level of education Initial stage of organised instruction, designed primarily to introduce very young children to a school-type environment. **ISCED 1 Primary level of education** Programmes normally designed to give students a sound basic education in reading, writing and mathematics. **ISCED 2 Lower secondary level of education (2A, 2B, 2C)** The lower secondary level of education generally continues the basic programmes of the primary level, although teaching is typically more subject-focused, often employing more specialised teachers who conduct classes in their field of specialisation.
Upper secondary education = Medium
ISCED 3 Upper secondary level of education (3A, 3B, 3C) The final stage of secondary education in most countries. Instruction is often more organised along subject-matter lines than at ISCED level 2 and teachers typically need to have a higher level, or more subject-specific, qualification that at ISCED 2. There are substantial differences in the typical duration of ISCED 3 programmes both across and between countries, typically ranging from 2 to 5 years of schooling. **ISCED 4 Post-secondary, non-tertiary education (4A, 4B, 4C)** These programmes straddle the boundary between upper secondary and post-secondary education from an international point of view, even though they might clearly be considered as upper secondary or post-secondary programmes in a national context. These programmes are often not significantly more advanced than programmes at ISCED 3 but they serve to broaden the knowledge of participants who have already completed a programme at level 3. The students are typically older than those in ISCED 3 programmes. They typically have a full-time equivalent duration of between 6 months and 2 years.
Tertiary education = High
ISCED 5 First stage of tertiary education (5A, 5B) Programmes with an educational content more advanced than those offered at levels 3 and 4. **ISCED 6 Second stage of tertiary education (leading to an advanced research qualification)** This level is reserved for tertiary programmes that lead to the award of an advanced research qualification. The programmes are devoted to advanced study and original research.

Source: Eurostat

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