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In 2006 all ECB publications will feature a motif taken from the €5 banknote.

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CONTENTS

Abstract:

Composition of the euro area workforce evolves over time and in response to changing labour market conditions. We construct an estimate of growth in euro area labour quality over the period 1983-2004 and show that labour quality has grown on average by 0.6% year-on-year over this time period. Labour quality growth was significantly higher in the early 1990s than in the 1980s. This strong increase was driven by an increase in the share of those with tertiary education and workers in prime age. Growth in labour quality moderated again towards the end of the 1990's, possibly reflecting the impact of robust employment growth resulting in the entry of workers with lower human capital. Labour quality growth has on average accounted for nearly one third of euro area labour productivity growth. The results point to a significant decline in the contribution of total factor productivity to euro area growth.

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

Non-technical summary

The composition of the euro area workforce in terms of the personal characteristics of persons employed, such as average educational attainment and labour market experience, evolves over time and in response to changing labour market conditions, resulting in changes in available human capital. As a result, the euro area stock of human capital and the associated returns to human capital also change over time, thus contributing to changes in aggregate labour productivity. However, standard unadjusted measures of labour input 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 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.

We present evidence of changes in human capital in the euro area by constructing an estimate of euro area labour quality over the period 1983-2004. We construct this estimate by combining longitudinal data on individual wages and personal characteristics from the European Community Household Panel and aggregated data on hours worked by worker groups from the European Labour Force Survey. The estimate of labour quality is constructed in two steps. In a first step we use microdata to derive weights for a number of worker groups with different characteristics. The weights reflect differences in productivity across worker groups, e.g. those with university level education or more are on average more productive that those with only primary education and are thus given a larger weight. In a second step we use these weights to adjust data of total hours worked by worker-country groups to arrive at an index of labour quality adjusted labour input. Labour quality growth is estimated as the difference between quality adjusted and raw total hours worked. While no previous euro area estimate exists, estimates for some euro area countries suggest that excluding changes in labour quality indeed result in a significant underestimation of the contribution of labour input to productivity growth. In addition to our benchmark calculation for the whole time period we explore the robustness of our results by taking advantage of available microdata to estimate the contribution of changes in labour quality over the late 1990's using a direct regression based approach. We also construct partial labour quality indices to show what changes in the composition of the euro area workforce have driven changes in overall labour quality. Finally, we use the series to illustrate the impact of changes in quality on labour productivity growth using a standard growth accounting framework.

The results suggest that euro area labour quality has increased continuously since the early 1980s, growing on average by approximately 0.6% year-on-year. As a result, improvements in human capital have on average accounted for nearly one third of euro area labour productivity growth. As regards changes over time, labour quality growth was significantly higher in the early 1990s than in the 1980s. The strong increase in the early 1990's appears to have been driven by an increase in the share of those with tertiary education and in the share of workers in prime age during this time period. Growth in labour quality moderated again towards the end of the 1990's, possibly reflecting the impact of robust employment growth resulting in the entry of workers with lower human capital. Accounting for positive labour quality growth lowers existing estimates of total factor productivity growth and points to a significant decline in the contribution of total factor productivity to euro area growth over time.

The results show that the main drivers of changes in observed labour quality are tertiary education and labour market experience. 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, to avoid over-education, both education and training should be geared towards the needs of the job market. In this respect, changing demographics are likely to also 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. At the same time, the results of the accounting exercise point 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.

1. Introduction

The composition of the euro area workforce in terms of the personal characteristics of persons employed, such as average educational attainment and labour market experience, evolves over time and in response to changing labour market conditions. As a result, the euro area stock of human capital and the associated returns to human capital also change over time, thus contributing to changes in aggregate labour productivity. However, standard unadjusted measures of labour input 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 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).

The need for understanding developments in euro area labour quality is strengthened by recent developments in labour productivity. In particular, the euro area has experienced a sustained decline in labour productivity growth. Existing analysis of the causes of this decline suggests that lower productivity growth is due to both a decline in capital deepening and lower total factor productivity growth over this time period (see ECB, 2005). At the same time, 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 have resulted in a shift in the composition of the workforce towards workers with lower human capital. However, we are not aware of attempts to quantify the growth in euro area labour quality and its contribution to the decline in labour productivity growth. In the meantime, the central role of human capital in contributing to productivity growth has been acknowledged in key European economic policy recommendations. In particular, further improving knowledge and innovation is one of the key areas identified in the mid-term review of the Lisbon agenda.[2]

Human capital is also given 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

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

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. 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). Relating these results from microdata to the lack of evidence from aggregate data, Krueger and Lindahl (2001) argue that measurement error in aggregate measures of educational attainment in particular attenuates estimates derived from aggregate data.

In this paper we present first evidence of changes in labour quality in the euro area and evaluate the significance of changes in human capital for recent developments in productivity growth. We construct a quality-adjusted index of labour input in the euro area covering the period 1983-2004 using a methodology that is similar to that used by the US Bureau of Labor Statistics (BLS, 1993). While no previous euro area estimate exists, estimates for some euro area countries suggest that excluding changes in labour quality indeed result in a significant underestimation of the contribution of labour input to productivity growth (Jorgenson, 2004). In addition to our benchmark calculation for the whole time period we explore the robustness of our results by taking advantage of available microdata to estimate the contribution of changes in labour quality over the late 1990's using a direct regression based approach suggested in Aaronson and Sullivan (2001). We also construct partial labour quality indices to show what changes in the composition of the euro area workforce have driven changes in overall labour quality. Finally, we illustrate the usefulness of the index of quality adjusted labour input 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 using a standard growth accounting framework.[3] We also use the index to explore the role of changing human capital composition on wage costs and calculate a quality adjusted measure of the total labour force.

The results suggest that euro area labour quality has increased continuously since the early 1980s, growing on average by approximately 0.6% year-on-year. As a result, improvements in human capital

[3] For a general description of the growth accounting framework, see Barro and Sala-i-Martin (2004). Within the framework growth on real GDP can be decomposed into three main components: population growth, growth in labour productivity (real GDP per hour worked) and growth in labour utilisation (total hours worked). Labour productivity growth can be further decomposed into capital deepening, growth in labour quality and growth in TFP. For a more detailed description and an application of the growth accounting framework to euro area data see Musso and Westermann (2004).

have on average accounted for nearly one third of euro area labour productivity growth. As regards changes over time, labour quality growth was significantly higher in the early 1990s than in the 1980s. The strong increase in the early 1990's appears to have been driven by an increase in the share of those with tertiary education and in the share of workers in prime age during this time period. Growth in labour quality moderated again towards the end of the 1990's, possibly reflecting the impact of robust employment growth resulting in the entry of marginal workers with lower human capital. Accounting for positive labour quality growth lowers existing estimates of total factor productivity growth and points to a significant decline in the contribution of total factor productivity to euro area growth over time.

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, show main results and analyse the robustness of the results. In section 4 we provide descriptive evidence about the composition of the euro area labour force in terms of the main factors influencing labour quality. In section 5 we use the newly-constructed index to 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 conclusions for economic policies.

2. Literature

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.

Using this approach 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.

Alternative estimates for the US using different methodologies are provided by the Bureau of Labor Statistics (BLS) (1993) and by Aaronson and Sullivan (2001). The 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.[4]

Aaronson and Sullivan (2001) extend the regression approach taken by the BLS to calculate the labour quality measure 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.

[4] 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).

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.

Changes in labour quality growth also 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.

Evidence for countries other than the US is limited, and in particular no estimate exists for the euro area as a whole. 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.[5] The results also suggest that growth in labour quality was strongest in the period 1989-1995, mainly due to 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

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

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).

Further evidence is available for some euro area countries. In particular, 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.[6]

Measuring labour quality growth relies on the assumptions that individual characteristics reflect differences in productivity and that wages are a good proxy of productivity. 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

[6] Scarpetta *et al.* (2000) also construct very crude measures of labour quality growth for some euro area countries.

internationally comparable categories of educational attainment based on three levels of education: lower secondary, upper secondary and tertiary education.[7] 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).[8]

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,

[7] A detailed description of national educational systems and the ISCED classification can be found in Annex 3 of OECD, 2004. 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.

[8] Some alternative measures of human capital have been derived, e.g. using data on internationally comparable test scores (see Hanushek and Kimko, 2000 and Barro and Lee, 2001). Some commentators have also noted that type of schooling may matter for explaining cross country differences in the adoption of new technologies. For example Krueger and Kumar (2005) argue that compared to 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.

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, 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 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.

3. Measuring Euro Area Labour Quality

3.1. Methodology

We follow the BLS approach to estimate changes in labour quality in the euro area. The final choice of a version of the BLS methodology as the main approach to calculating a labour quality index is largely dictated by the availability of data. In particular, good quality microdata covering the whole of the euro area is available only for a short time 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. The control 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. They include those with lower secondary education (ISCED categories 0-2), those with upper secondary education (ISCED categories 3 and 4) and those with tertiary education (ISCED categories 5-6). Note that this combination of classifications results in 36 times 12 worker-country groups.

Detailed information on individuals, their wages and individual characteristics in euro area countries is available from the ECHP. The ECHP is a survey of households in all EU countries that includes detailed information about individual characteristics, including earnings. The data also includes detailed information about households and supplementary information at the country level (e.g. PPP, CPI and Population information). The survey begins in 1994 (Austria and Finland join in 1995 and 1996, respectively) and continues until 2001. Sampling weights are available for calculating summary statistics and for performing weighted regression analysis. Wages are originally reported in the ECHP as net wages (including bonuses) in the previous month in national currency.[9] 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, wages are converted to PPP units using the PPP exchange rates provided by the ECHP and deflated by the consumer price index. In order to derive hourly wages we divide the monthly wage by monthly hours worked.

In a second step 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:

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

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

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. Note that in calculating the weights we assume that returns to skills for different groups of workers have remained unchanged at their 1994-2001 levels over the whole sample period. This assumption is necessary because we only have consistent microdata to calculate weights for this shorter time period. We evaluate the robustness of this assumption in section 3.3.

We use data from the LFS to construct measures of hours worked for worker groups.[10] 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.[11] The calculation of total hours does not take into account the possible impact of different number of working days within a year. However, the shares of total hours across groups are not likely to be affected by calendar effects. 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.[12] 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.

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

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

[11] 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.

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.[13]

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

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

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

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

3.2. Main 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.[14] 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).[15] These results illustrate that in the calculation of labour quality, the hours of

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

[13] 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.

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

[15] The 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

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.[16]

Estimates of labour quality indicate a continuous increase in euro area labour 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-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. Figure 1 shows a decomposition of the index into a trend and cyclical component. Correlations of the cyclical measure of labour quality with a corresponding measure of

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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.

[16] Note also that the intercept is different for men and women, reflecting a wage gap between genders. This wage gap is likely to reflect factors that are not related with productivity. In line with previous work on labour quality, we nevertheless include gender as a determinant. However, it turns out that it plays a minor role in the final results (see section 4 for a discussion).

real GDP shows only a weak, lagged negative association between the two. Nevertheless, 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. However, this period was also characterised by labour market reforms in a number of euro area countries that were specifically aimed at increasing the employment of lower skilled workers. Most recently, estimated cyclical growth in labour quality has increased significantly, suggesting that the recent slow growth period may have been characterised by some "up-skilling".

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.[17] 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 2). 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.

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.[18] The extended measure is informative about the quality of the available labour force. 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

[17] Timmer, Ypma and van Ark (2003), University of Groningen, Appendix Tables, updated June 2005.

[18] 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.

larger difference in quality growth between the two groups of workers in the late 1990s may also reflect cyclical factors.

3.3. Robustness

A comparison with existing country results, as well as testing for sensitivity of the results to differences in data and methods provide a useful test of robustness of the euro area estimate. First, the country results for the three largest euro area countries, Germany, France and Italy, are broadly in line with results in Jorgenson (2004) (see table 4). For the 1984-2004 period the country results suggest that among these three countries labour quality growth has been strongest in France and weakest in Germany. 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 for the whole of the euro area.

We have also tested the robustness of our results to differences in data and methods used in two important dimensions. First, in calculating the index above we have kept returns to skills for different groups of workers fixed at their levels for the 1994-2001 period, assuming that the returns to individual characteristics have remained unchanged over the whole sample 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 is 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.[19]

[19] This is supported by empirical evidence on group-specific unemployment rates in Europe. In particular, 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.

In order to evaluate the importance of changing returns to our estimates, we construct an alternative labour quality index allowing returns to vary over time. Due to data constraints we can construct this index only for the 1994-2001 period. Results from applying the Aaronson and Sullivan (2001) regression approach, allowing weights to change suggest that indeed the fixed weights assumption appears to be reasonable (see Figure4). While there are some differences in the pattern of year to year changes, the average for the whole time period at 0.44% from the regression approach is nearly identical to the average from the benchmark approach (0.47%).

Second, we explored using alternative determinants of human capital. 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 (see Figure 4). 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.

4. Explaining changes in euro area labour quality 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)[20]. The results show that, as expected, education has been the main driving force of labour quality growth

[20] 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.

(see Table 1).[21] 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 5). 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 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 6). 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

[21] 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.

negligible. The negative contribution reflects the increased share of total hours worked by women (see Genre and Gomez-Salvador, 2002).

5. Decomposition of productivity growth

Using the quality adjusted measure of labour input in a standard growth accounting framework provides further insight into recent developments in euro area labour productivity growth. In particular, euro area labour productivity growth, measured by real GDP per hour worked, declined from an average annual growth of above 2% in the early 1990s to just above 1% since 1996. Within a growth accounting framework, growth in labour productivity defined as real output per hour worked can be decomposed into three components: capital deepening (i.e. growth in capital per hours worked), growth in labour quality and TFP growth.[22] Due to lack of data on labour quality for the euro area, previous exercises have estimated TFP growth as a residual item including the contribution of labour quality growth (see ECB, 2005 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 the decomposition of labour productivity, 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.

Adjusting for labour quality results in significantly lower estimates of euro area TFP growth than previously estimated (see Table 5). 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. This decline is evident in TFP estimates both before and after adjustment for labour quality growth. The slowdown in TFP growth suggests a

[22] The contributions of capital deepening and labour quality are weighted by the relevant factor shares.. For an application of the growth accounting framework to non-adjusted euro area data see Musso and Westermann, (2004) and ECB (2005).

possible decline in the contribution of technological progress to growth in the euro area.[23] Given that measured TFP growth tends to be pro-cyclical, low TFP growth during this time period is consistent with a cyclical decline in euro area real GDP growth. However, lower TFP growth may also reflect structural adjustment towards an increased use of labour inputs relative to capital in production triggered by wage moderation and labour market reforms. For the most recent years the adjusted data point to negative euro area TFP growth. While it can not be excluded that this reflects real phenomena, negative TFP growth may also be suggestive of remaining measurement problems in euro area data.[24]

6. Conclusions

We have presented first evidence of changes in labour quality in the euro area by constructing a quality-adjusted index of labour input in the euro area covering the period 1983-2004. The index is constructed by combining data on wages and individual characteristics from micro data with data on hours worked for worker groups from the LFS for all euro area countries. A comparison with available country estimates and an analysis of sensitivity of the euro area index to changes in data and calculation methods suggest that the benchmark index provides a good estimate of growth in labour quality in the euro area.

The results show a continuous increase in human capital in the last 20 years. The average growth rate of euro area labour quality in 1984-2004 was 0.6% year-on-year, suggesting that approximately one third of euro area labour productivity growth during this time period was due to improvements in human capital. A strong increase in labour quality growth in the early 1990s was driven by the stronger increase in the share of those with tertiary education, as well as an increase in the share of workers in

[23] While TFP growth is commonly used as an indicator of developments in technological progress it is important to note that measures of TFP growth, such as the Solow residual, do not directly correspond to technological progress when the economy is characterised by frictions such as imperfect competition (for a discussion see Basu and Fernald, 2002).

[24] Similar to the use of an index of labour quality adjusted labour input in productivity analysis, an adjusted measure of real wage growth is informative about the extent of growth in the price of labour input (see Aaronson and Sullivan, 2001). Standard measures of wage growth include changes in both the price of labour input and changes in the composition of the work force. In particular, studies of real wage cyclicality have pointed to the importance of compositional changes in explaining the apparent acyclicality of real wages (Kydland and Prescott, 1993 and Solon et al., 1994). Results of this adjustment show that positive growth in labour quality results in lower growth in the quality adjusted real wages. However, in line with the evidence of cyclical compositional changes for the whole sample period, the results do not show a significant impact on cyclicality of euro area real wages. Lower growth rates of real wages adjusted for labour quality in recession periods in the early 1990s and the early 2000s suggest that compositional changes do play a role.

prime age. Towards the end of the 1990s growth in labour quality moderated, possibly reflecting the impact of continued robust growth in employment and the entry of marginal workers with lower human capital. Most recently, labour quality growth increased in 2003 and 2004, suggesting that the recent slow growth period may have been characterised by some "up-skilling".

Further, 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 results show that the main drivers of changes in observed labour quality are tertiary education and labour market experience. 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, to avoid over-education, both education and training should be geared towards the needs of the job market. In this respect, changing demographics are likely to also 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. At the same time, the results of the accounting exercise point 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.

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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	*1984-2001*
Germany	0.13	0.44	0.15	0.33	0.26	*0.24*
France	1.25	1.35	0.63	0.48	0.94	*1.03*
Italy	0.32	0.35	0.69	0.54	0.47	*0.44*
Jorgenson (2004):						
Germany	0.58	0.62	0.46	na.	na.	*0.52*
France	0.65	1.44	1.09	na.	na.	*0.86*
Italy	0.32	0.65	0.71	na.	na.	*0.51*

Source: authors' calculation and Jorgenson (2004).

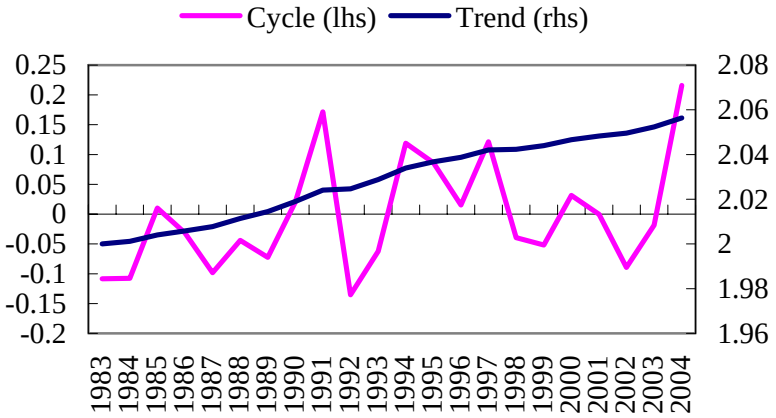
Table 5. Growth total factor productivity *(average annual growth rates)*

	Unadjusted	Adjusted
1984	3.29	3.09
1985	1.56	1.09
1986	1.12	0.84
1987	0.99	0.67
1988	1.64	1.07
1989	1.81	1.31
1990	0.90	0.20
1991	1.14	0.34
1992	1.19	1.10
1993	0.90	0.22
1994	2.37	1.55
1995	1.54	1.10
1996	0.46	0.16
1997	1.24	0.74
1998	0.02	-0.02
1999	1.59	1.34
2000	1.31	0.91
2001	-0.22	-0.48
2002	0.23	0.04
2003	-0.07	-0.49
2004	0.47	-0.15

Source: authors' calculation.

Figure 1. Trend/Cycle decomposition of labour quality growth

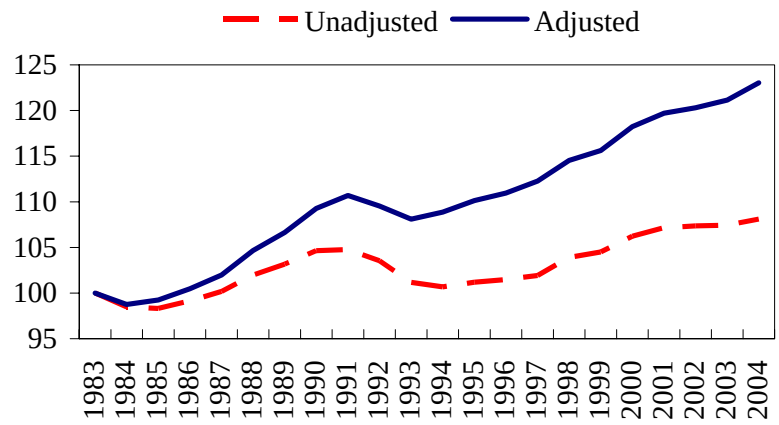
(log levels and percentage point deviations from trend)



Source: authors' calculation. The trend and cycle have been extracted using the band-pass filter (the cycle refers to the band between 2 and 8 year frequencies).

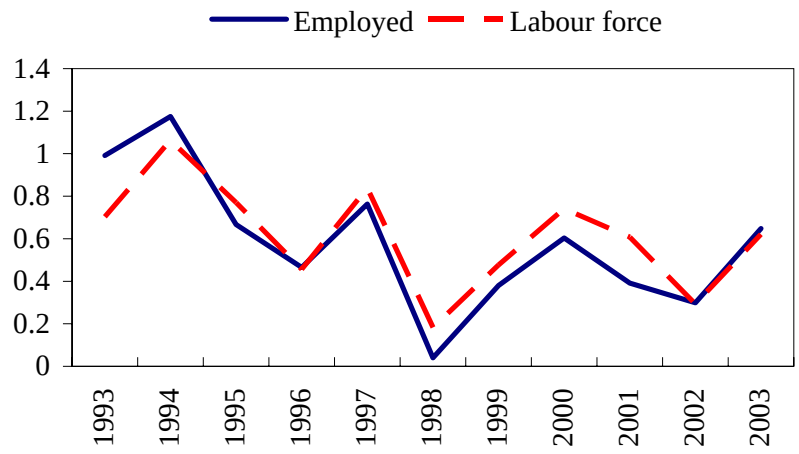
Figure 2. Labour quality adjusted labour input

(index points: 1983=100)



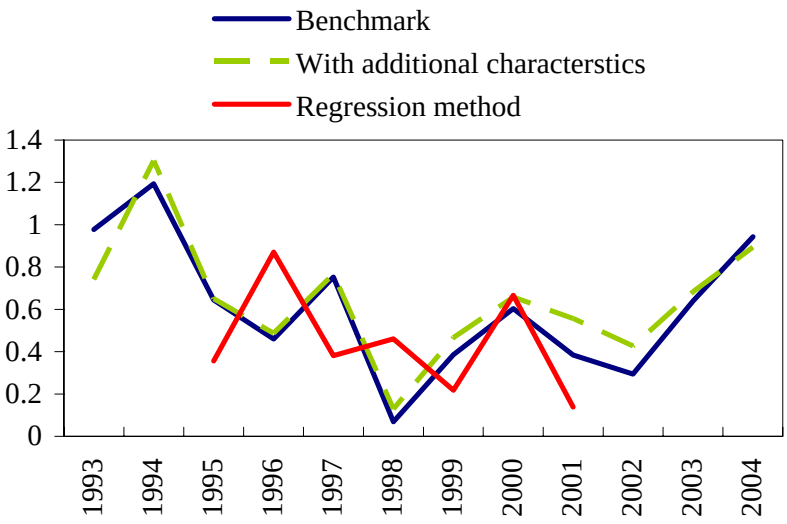
Source: authors' calculation. Unadjusted labour input refers to total hours worked from the Groningen Growth and Development Center growth accounting database.

Figure 3. Growth in the quality of labour force
(annual growth rates)



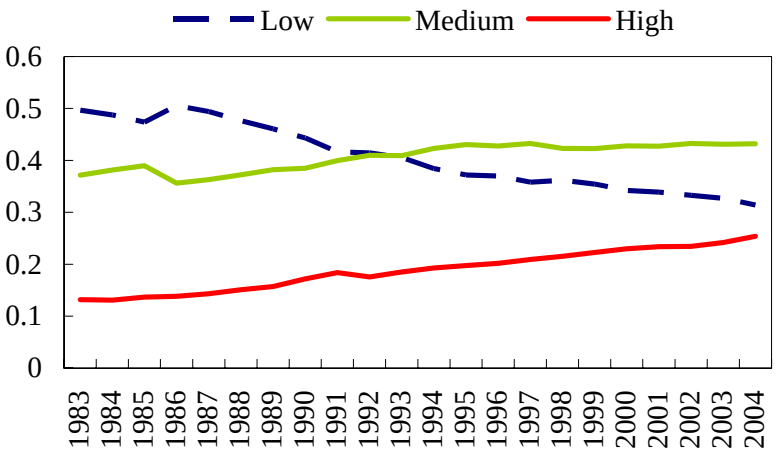
Source: authors' calculation.

Figure 4. Labour quality growth: alternative estimates
(annual growth rates)



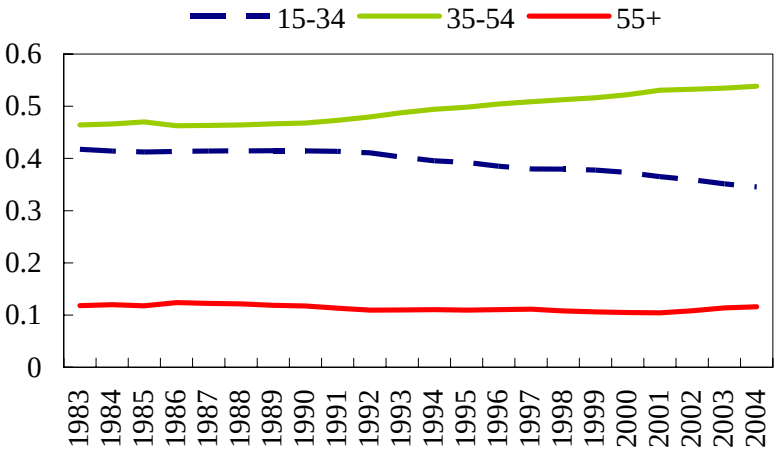
Source: authors' calculation. Benchmark refers to the main index of labour quality presented in Section 3.

Figure 5. Hours worked by educational attainment
(shares)



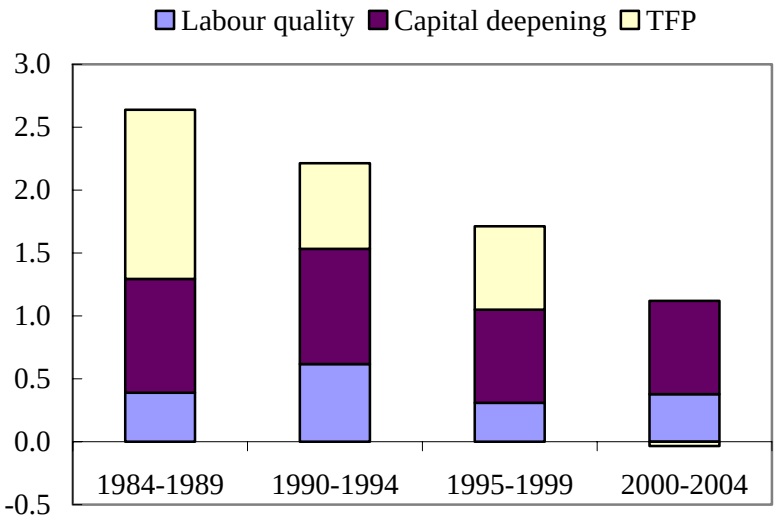
Source: authors' calculation based on the Labour Force Survey. The shift in 1985 reflects the inclusion of Portugal and Spain for which data on hours is not available before 1985. The calculation of the labour quality index takes into account changes in the country composition.

Figure 6. Hours worked by age groups
(shares)



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

Figure 7. 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.

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