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# GROWTH IN EURO AREA LABOR QUALITY

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Composition of the euro area workforce evolves over time and in response to changing labor market conditions. We construct an estimate of growth in euro area labor quality over the period 1983–2005 and show that labor quality has grown on average by 0.47 percent year-on-year. Labor quality growth was significantly higher in the early 1990s than in the 1980s. This strong increase was driven mainly by an increase in the share of those with tertiary education and workers in prime age. Growth in labor quality moderated again toward the end of the 1990s, possibly reflecting the impact of robust employment growth resulting in the entry of workers with lower human capital. The contribution of labor quality to labor productivity has increased over time, accounting for up to one fourth of euro area labor productivity growth. The results point to a lower contribution of total factor productivity to euro area growth.

## 1. Introduction

The composition of the euro area workforce in terms of the personal characteristics of persons employed, such as average educational attainment and labor market experience, evolves over time and in response to changing labor 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 labor productivity. However, standard unadjusted measures of labor input ignore changes in human capital—changes in average labor quality—leading to an underestimation of the contribution of the labor input to economic growth. Best practice in the area of productivity measurement suggests that changes in labor quality should be taken into account by using a quality-adjusted number of hours actually worked as a measure of labor input (OECD, 2001).

A sustained decline in euro area labor productivity growth since the 1980s highlights the need for understanding how euro area labor quality growth has evolved. Existing analysis of the causes of the decline in labor productivity growth

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suggest that lower productivity growth is due to both a decline in capital deepening and lower total factor productivity (TFP) growth over this time period (see Gomez-Salvador *et al.*, 2006). At the same time, robust euro area employment growth in the late 1990s 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 toward workers with lower human capital. However, we are not aware of attempts to quantify the growth in euro area labor quality and its contribution to the decline in labor productivity growth. Estimates for some euro area countries suggest that excluding changes in labor quality indeed results in a significant underestimation of the contribution of labor input to productivity growth (Jorgenson, 2005). 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.[1]

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 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).

In this paper we present first evidence of changes in labor 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 labor input in the euro area covering the period 1983–2005, using a methodology that is similar to that used by the U.S. Bureau of Labor Statistics (BLS, 1993). Measuring labor quality for the euro area requires combining information from different sources, such as microdata from the European Community Household Panel (ECHP) and the European Labor Force Survey (LFS). In addition to our benchmark calculation, we explore the robustness of our results by constructing alternative indices based on other possible methods, as well as taking advantage of available microdata to estimate the contribution of changes in labor quality over the late 1990s using a direct regression based approach suggested in Aaronson and Sullivan (2001). We also construct partial labor quality indices to show what changes in the composition of the euro area workforce have driven changes in overall labor quality. Finally, we use the series to illustrate the impact of changes in labor quality on labor productivity growth using a standard growth accounting framework.

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

The results suggest that euro area labor quality has increased continuously since the early 1980s, growing on average by 0.47 percent year-on-year. As a result, improvements in human capital have on average accounted for up to one fourth of euro area labor productivity growth. As regards changes over time, labor quality growth was significantly higher in the early 1990s than in the 1980s. The strong increase in the early 1990s 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 labor quality moderated again toward the end of the 1990s, possibly reflecting the impact of robust employment growth resulting in the entry of marginal workers with lower human capital. Accounting for positive labor quality growth lowers existing estimates of total factor productivity growth.

The rest of this paper is organized as follows. In Section 2 we survey the existing literature on calculating measures of labor 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 labor input in the euro area. In Section 4, we show our main results and analyze their robustness. We also describe changes in returns to human capital characteristics and the composition of the euro area labor force that steer changes in labor quality growth. In Section 5 we use the newly-constructed index to estimate the contribution of changes in labor quality to the labor productivity growth over this time period. Finally, we conclude in Section 6 with a summary and conclusions for economic policies.

## 2. Related Literature

Jorgenson *et al.* (1987) and Ho and Jorgenson (1999) contain a description of the standard methods used to account for labor quality and include benchmark estimates of labor quality for the U.S. Ho and Jorgenson construct a quality-adjusted measure of labor input based on a cross-classification of hours worked into a number of cells by observed worker characteristics (sex, age, education and self-employment status). They then compute changes in the aggregate labor 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 labor quality as the difference between growth in this aggregate labor input and growth in a raw measure of hours worked. Using this approach they find that in 1948–95 labor quality grew on average by 0.6 percent per year in the U.S. Ho and Jorgenson also find that the rise in average level of educational attainment is the main driver of the increase in quality, whereas changes in the age structure of the work force, such as the entry of a large inexperienced cohort (the "baby boomers") into the labor force, also explains changes in labor quality growth over time in labor quality growth.

Alternative estimates for the U.S. using different methodologies are provided by the BLS (1993) and Aaronson and Sullivan (2001). The BLS method differs from Ho and Jorgenson 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 labor input. Compared to 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.[2]

Aaronson and Sullivan (2001) extend the regression approach taken by the BLS further to calculate the labor 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. Estimates of labor quality growth for the U.S. differ somewhat between these three studies. In particular, BLS (1993) finds a lower average growth rate of labor quality since the late 1940s in the U.S. than those presented in Ho and Jorgenson (1999). However, since the 1980s the results in the three studies are similar.[3]

Evidence for countries other than the U.S. is less extensive, and in particular no estimate exists for the euro area as a whole.[4] Jorgenson (2005) provides evidence of labor 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 labor quality growth in the euro area has been positive between 1980 and 2001, ranging from approximately 0.45 percent annual growth in Germany to 0.86 percent in France (Jorgenson, 2005). For the euro area as a whole this suggests that labor quality grew on average by approximately 0.57 percent per year.[5] The results also suggest that growth in labor quality was strongest in the period 1989–95, mainly due to robust improvement in labor quality in France. Furthermore, growth in labor quality declined somewhat in all three countries in 1995–2001. While the contribution of labor quality to labor productivity growth is smaller than the contribution of the other two components of labor 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 labor

[2]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).

[3]Changes in labor quality growth also figure prominently in the recent discussion of the increase in U.S. labor productivity growth in the late 1990s. In particular, Jorgenson *et al.* (2005) find that the increase in the employment of college-educated workers contributed significantly to the increase in U.S. 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 U.S. 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 1990s. See also Aulin-Ahmavaara (2004) for a discussion of alternative approaches to accounting for human capital in the context of the System of National Accounts.

[4]Labor quality growth estimates for several European countries from the EU-KLEMS project have become available during the submission process of our paper, in March 2007. EU-KLEMS results for the market economy suggest somewhat stronger labor quality growth in the euro area than our estimates for the whole economy (see www.euklems.net for more detail).

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

quality growth was always positive and accounted for just below one fifth of the growth in labor productivity (Jorgenson, 2005).

Further evidence is available for some euro area countries. In particular, Melka and Nayman (2004) estimate labor 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 labor quality for France, the Netherlands and Germany. While the estimates in O'Mahony and van Ark (2003) are based on relatively limited data sources, they provide additional insight in the sectoral diversity in labor quality growth. Their findings suggest that labor quality growth has been larger in sectors that produce information and communication technology (ICT). In addition, the slowdown in labor quality growth in 1995–2000 appears to have been most relevant in non-ICT sectors.[6]

## 3. Measuring Euro Area Labor Quality

We follow the BLS approach to estimating changes in labor quality in the euro area. Our measure of quality adjusted labor input is constructed as follows. First, using available microdata for individual workers (see below), we estimate cross-sectional wage equations separately for each country and for males and females:

$$\log W_i = \alpha + \sum_{e=1}^{2} \mathrm{EDU}_i^e \beta_e + \sum_{a=1}^{5} \mathrm{AGE}_i^a \gamma_a + Z_i \eta + \varepsilon_i \tag{1}$$

where the subscript $i$ refers to the individual. These equations are estimated using weighted OLS, using sample weights provided with the microdata.

The dependent variable $W_i$ is the individual gross nominal hourly wage in PPP units. The use of gross nominal hourly wages is motivated by the use of the labor quality estimate primarily as an input to productivity analysis within a growth accounting framework (see OECD, 2001). The PPP conversion is needed to translate nominal wages that are reported in national currencies to comparable units across countries. Following Jorgenson (1995) and Jorgenson and Nishimizu (1978), the bilateral wage PPP between country $j$ and Germany is used.[7]

The right hand side variables include dummy variables for two education categories EDU (with secondary education as the omitted category), five age categories AGE (with those between 34 and 45 as the omitted category) and a number of control variables $Z$ (dummy variables for part-time employment status and for sector). Note that altogether this combination of classifications results in $36 \times 12$ worker–country groups.

The main source of detailed information on wages and characteristics of individual workers in euro area countries is the European Community Household Panel (ECHP). The ECHP 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.

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

[7]Jorgenson and Nishimizu (1978) argue that wage PPPs are needed to convert labor inputs into comparable units across countries. For alternative results that use PPPs based on price levels provided by the ECHP, see Schwerdt and Turunen (2006).

Wages in the ECHP are reported by survey participants as net earnings (including bonuses) in the previous month in national currency.[8] From this information gross wages are constructed using the gross/net ratio provided by the survey. We divide the monthly wage by monthly hours worked to derive a measure of nominal gross hourly wages for each individual.

The education categories in the ECHP 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).[9] While more detailed education categories are available at the country level, detailed hours data from the European Labor Force Survey (LFS, see below) are available only for these three broad education categories. Indeed, country differences in educational systems complicate complete harmonization of the measurement of educational attainment at a more detailed level. 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 (four in their case) is sufficient for measuring aggregate labor quality.

The use of education and age to proxy human capital is in line with the literature on labor quality and is informed by economic theory about the main determinants 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 recent surveys, see Ashenfelter *et al.*, 1999; Card, 1999). 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).

In addition to formal education, workers gain human capital after finishing school through increased labor market experience and on-the-job training. However, compared to education, measuring experience is significantly more complicated and the empirical literature largely relies on incomplete proxies. A common approach to measure experience is to approximate labor market experience with age minus years spent in schooling minus the school starting age. This approach is adopted in several studies of labor quality (for example, Ho and Jorgenson, 1999; Aaronson and Sullivan, 2001). An alternative approach, taken in this study, is to use age directly as a proxy for human capital gained after school. This approach allows us to match wage information from the ECHP for age groups with the LFS information on hours worked. Furthermore, different labor 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 labor market experience results in different experience–earnings profiles for men and women.

[8]Except for France and Finland where wages are reported as gross wages.
[9]A detailed description of the ISCED classification can be found in Annex 3 of OECD (2004).

Finally, employment status (such as part-time employment) and sector of activity are important additional determinants of wages that may confound the estimated returns to human capital variables.

Note that the use of wages as a measure of worker productivity is based on the underlying assumption that relative wages are equal to the relative marginal products of labor. Various characteristics of actual labor markets, such as discrimination, union bargaining, signaling 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 U.S. However, due to lack of more direct measures, wages remain the best available proxy of worker productivity.

In a second step we construct average predicted wages $\tilde{W}_{j,t}$ for each worker country group $j$ and year $t$ based on the predicted wages from equation (1). Following BLS, average values for the control variables (part-time employment and sector) for the whole sample are used when calculating predicted wages, such that their impact is excluded from the calculation of the labor quality index (BLS, 1993). We use these predicted wages 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:

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

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

$$s_{j,t} = \frac{\tilde{W}_{j,t} H_{j,t}}{\sum_{j} \tilde{W}_{j,t} H_{j,t}} \tag{3}$$

where $H$ refers to total hours worked. As an alternative robustness check, we also construct weights using the average predicted wages $\tilde{W}_j$ (over time) to construct weights that vary over time only due to differences in the composition of hours worked.

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

$$\ln\left(L_t / L_{t-1}\right) = \sum\nolimits_j \bar{s}_{j,t} \ln\left(H_{j,t} / H_{j,t-1}\right). \tag{4}$$

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

$$\Delta \ln Q = \Delta \ln L - \Delta \ln H. \tag{5}$$

We use data from the LFS as the main source to construct measures of hours worked for worker groups.[10] Eurostat collects data from national labor force

[10]The LFS data used in this paper were extracted in December 2006.

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 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 2005.[12]

In addition to the principal data sources, the ECHP and the LFS, we use additional sources of information to extend the time period covered by the labor quality index. First, while we have information on hours worked cross-classified by gender and age, prior to 1992 no information is available along the educational dimension from the LFS. For example, total hours worked by 35–44 year-old males are known, but information on what share of these hours can be attributed to each of the three educational categories is missing. 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 organization 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. Up to three cross-section data points per country are available from the LIS. As a final step, we fill in the missing data points between LIS and LFS observations by using predicted values for the respective shares stemming from weighted regressions for each worker–country group. Time trends as well as information from the complete GSOEP series are used to construct these predicted values. Overall, the imputation of hours worked for some worker–country groups before 1992 suggests that the results from this earlier period need to be interpreted with some caution.

Second, we use the GSOEP to extend the time period covered by time-varying predicted wages beyond the period available in the ECHP. To do this we estimate equation (1) for Germany and construct average predicted wages for worker groups as described in equation (2) for each year in 1983–2005. We then extrapolate the average predicted wages obtained from the ECHP for each worker–country group using the predicted values from regressions for each worker–country group that include time trends as well as equivalent predicted wages from the GSOEP series. We evaluate the robustness of this extrapolation by comparing results from the main labor quality index with an index that does not rely on additional information on wages beyond the 1994–2001 period in Section 4.

[11]Total hours usually worked were utilized for data availability reasons. Only for the post-1992 period is complete information 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.

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

TABLE 1

COMPLETE EURO AREA RESULTS (INDEX: 1983 = 100)

| | | First Order Indices | | | Second Order Indices | | | |
|---|---|---|---|---|---|---|---|---|
| | Total | 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 | 100.21 | 99.92 | 100.23 | 99.95 | 100.03 | 100.13 | 99.96 | 99.99 |
| 1985 | 100.71 | 99.88 | 100.40 | 100.19 | 100.03 | 100.22 | 99.99 | 100.00 |
| 1986 | 100.87 | 99.83 | 100.29 | 100.46 | 100.05 | 100.27 | 99.96 | 100.00 |
| 1987 | 101.12 | 99.80 | 100.33 | 100.73 | 100.05 | 100.24 | 99.97 | 100.01 |
| 1988 | 101.67 | 99.76 | 100.45 | 101.19 | 100.05 | 100.22 | 99.98 | 100.02 |
| 1989 | 102.11 | 99.73 | 100.60 | 101.57 | 100.06 | 100.17 | 99.96 | 100.01 |
| 1990 | 102.94 | 99.66 | 100.72 | 102.40 | 100.06 | 100.16 | 99.95 | 99.99 |
| 1991 | 103.72 | 99.47 | 100.97 | 103.14 | 100.03 | 100.14 | 99.96 | 100.00 |
| 1992 | 104.10 | 99.47 | 101.35 | 103.17 | 100.01 | 100.02 | 100.07 | 99.99 |
| 1993 | 104.92 | 99.45 | 101.78 | 103.67 | 99.97 | 99.95 | 100.06 | 100.00 |
| 1994 | 105.82 | 99.42 | 102.14 | 104.25 | 99.96 | 99.95 | 100.06 | 99.99 |
| 1995 | 106.39 | 99.41 | 102.39 | 104.64 | 99.93 | 99.92 | 100.06 | 99.99 |
| 1996 | 106.84 | 99.37 | 102.71 | 104.84 | 99.91 | 99.88 | 100.06 | 100.00 |
| 1997 | 107.46 | 99.37 | 102.90 | 105.30 | 99.89 | 99.86 | 100.06 | 100.00 |
| 1998 | 107.57 | 99.36 | 102.87 | 105.48 | 99.90 | 99.83 | 100.04 | 100.00 |
| 1999 | 107.86 | 99.31 | 102.84 | 105.86 | 99.90 | 99.82 | 100.04 | 100.00 |
| 2000 | 108.32 | 99.26 | 102.92 | 106.29 | 99.90 | 99.82 | 100.04 | 100.00 |
| 2001 | 108.66 | 99.22 | 103.13 | 106.48 | 99.88 | 99.81 | 100.03 | 100.01 |
| 2002 | 108.91 | 99.16 | 103.31 | 106.61 | 99.88 | 99.81 | 100.02 | 100.02 |
| 2003 | 109.51 | 99.12 | 103.60 | 106.95 | 99.87 | 99.81 | 100.02 | 100.02 |
| 2004 | 110.35 | 99.12 | 103.83 | 107.55 | 99.86 | 99.80 | 100.03 | 100.02 |
| 2005 | 110.89 | 99.12 | 104.03 | 107.86 | 99.82 | 99.82 | 100.04 | 100.03 |

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

*Source*: Authors' calculations.

## 4. RESULTS

Estimates of labor quality indicate a continuous increase in euro area labor quality in the last 20 years (see Table 1 and Figure 1). The estimated average growth rate of euro area labor quality in the 1984–2005 period is 0.47 percent year-on-year. The estimated growth rate for the euro area is lower that a simple aggregation of previous results for Germany, France and Italy presented in Jorgenson (2005) (averaging 0.57 percent in 1984–2001). This difference is likely to reflect a number of factors, including differences in underlying data, methods and country coverage. In particular, we include estimates from all euro area countries and allow changes in the composition of the euro area workforce across countries to influence growth in euro area labor quality. We also calculate the first order contributions of sex, age and education to euro area labor quality growth following the method described in Ho and Jorgenson (1999).[13] The results show that, as expected, education has been the main driving force of labor quality growth (see Table 1).

[13]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.

TABLE 2

Growth in Labor Quality: Country Estimates (average annual growth rates)

| | 1984–1989 | 1990–1994 | 1995–1999 | 2000–2005 | 1984–2005 | *1984–2001* |
|---|---|---|---|---|---|---|
| Euro area | 0.35 | 0.72 | 0.38 | 0.46 | 0.47 | *0.46* |
| Germany | 0.08 | 0.57 | 0.16 | 0.40 | 0.27 | *0.27* |
| France | 1.40 | 1.12 | 0.56 | 0.40 | 0.89 | *0.98* |
| Italy | 0.34 | 0.35 | 0.59 | 0.49 | 0.45 | *0.41* |
| *Jorgenson (2005):* | | | | | | |
| 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' calculations and Jorgenson (2005).

A comparison with existing country results, as well as exploring the sensitivity of our results to differences in data and methods used provide a useful test of robustness of the euro area labor quality estimate. The country results for the three largest euro area countries, Germany, France and Italy for the 1984–2005 period, suggest that labor quality growth has been strongest in France and weakest in Germany (see Table 2). Both the overall average growth rates and the pattern of average growth rates over time are roughly consistent with results in Jorgenson (2005), with the exception of a somewhat lower estimated growth rate for Germany. However, our lower estimate for Germany is close to the estimated growth rate of 0.21 percent for the post-1980 period in Card and Freeman (2004). Our estimate of labor quality growth in France is also in line with the estimate by Melka and Nayman (2004) for the 1982–2001 period (0.87 percent). Both estimates show a significant decline in labor quality growth over time in France. Inklaar *et al.* (2005) also find (for the EU4, including Germany, France, the Netherlands and the UK) that the contribution of labor quality to labor productivity growth declined in the late 1990s. Overall, the comparison with existing country results supports the robustness of our estimates for the whole of the euro area.

We next explore the robustness of our results to differences in data and methods. In calculating the index shown above we have allowed for the returns to skills for different groups of workers to change over time. However, complete data on relative returns is available for the 1994–2001 period only. Before 1994 and after 2001, the relative returns are based on country specific time trends in the late 1990s period that are extrapolated based on information about changes in relative returns in Germany. We can assess the robustness of this approach in two different ways. First, we calculate an index that uses growth rates in German predicted wages only (thus excluding the impact from country specific trends in the 1990s) to extend the series backwards and forwards. Second, we construct an index of labor quality that is based on keeping the average relative returns for each country in the late 1990s period fixed throughout.

Assuming that the relative returns to individual characteristics have remained unchanged over the whole sample period may seem like a strong assumption. 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.* (1999) find that while studies for the U.S. show a significant upward shift in returns to education, studies for other countries do not find such a shift. Barth and Lucifora (2006) also find that the wage premium for those with tertiary education has been "remarkably stable" in most European countries since 1985. For Germany, the largest euro area country, this is confirmed by the evidence surveyed in Fitzenberger and Kohn (2006). These results suggest that relative wages (between groups of workers) may indeed be relatively rigid in European countries and necessary adjustments take place mainly in terms of labor market quantities. This is supported by empirical evidence on group-specific unemployment rates in Europe (see, for example, Biagi and Lucifora, 2005).

The results of the robustness tests are shown in Figure 1, together with the headline index with changing relative returns. While there are some differences in the patterns of year to year changes in the early part of the sample period, differences across methods appear small. These results suggest some caution in interpreting precise year to year movements in the early part of the sample, but overall, support the robustness of the headline estimate. The small difference between the headline estimate and the estimate that uses fixed returns suggests that changes in relative returns indeed play a small role in determining changes in labor quality. This result suggests that wage rigidities are likely to dampen relative wage adjustment in Europe.

Finally, we have explored alternative specifications of the regression equation (1). The results suggest that excluding the control variables (part-time and sector activity) results in a negligible increase in the estimate of labor quality growth. We have also applied a purely regression based approach proposed in Aaronson and Sullivan (2001) to estimate an alternative index for the time period covered by our microdata. The results point to somewhat stronger euro area labor quality growth on average in the 1995–2001 time period (0.64 percent).

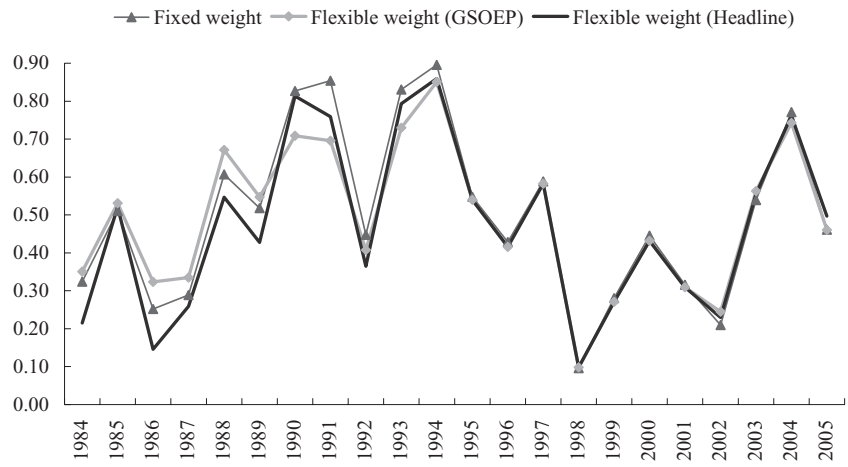


Figure 1. Growth in Euro Area Labor Quality: Alternative Indices (annual growth rates)
*Source*: Authors' calculations.

Beyond the average increase in labor quality, our estimate of labor quality shows some variation in labor quality growth over time (see Figure 1 and Table 2). In broad terms the data point to three different time periods in terms of longer-term developments in euro area labor quality. The 1980s were characterized by relatively low growth in labor quality, followed by particularly strong growth in the early 1990s. Average labor quality growth appears to have moderated again somewhat toward the end of the 1990s and during the recent slow growth period, before picking up again from 2003 onwards.

Variation over time may be associated with the business cycle or structural changes. Previous empirical evidence suggests that labor 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 labor force (Solon *et al.*, 1994; Aaronson and Sullivan, 2001). 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 labor market.

Figure 2 shows a decomposition of the overall index and the first order indices for education and age into a trend and cyclical component using a standard Baxter–King bandpass filter. The results suggest some moderation in the trend increase in labor quality growth in the second half of the 1990s, mainly related to the contribution of age to the overall index. In addition, the cyclical components show fluctuations that are consistent with the euro area business cycle. Correlations of the cyclical measure of labor quality with a corresponding measure of real GDP show only a weak, lagged negative association between the two. However, recent developments, such as the significant increase in labor quality growth in the early 1990s and the subsequent decline in the course of the 1990s—a period of particularly strong employment growth—are consistent with the interpretation of countercyclical quality growth. However, this period was also characterized by labor 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 labor quality has increased significantly, suggesting that the recent slow growth period may have been characterized by some "up-skilling," in terms of contributions of both age and education.

Focusing on factors that determine the trend increase in labor quality growth, the contribution of education to labor 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 have been characterized 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.

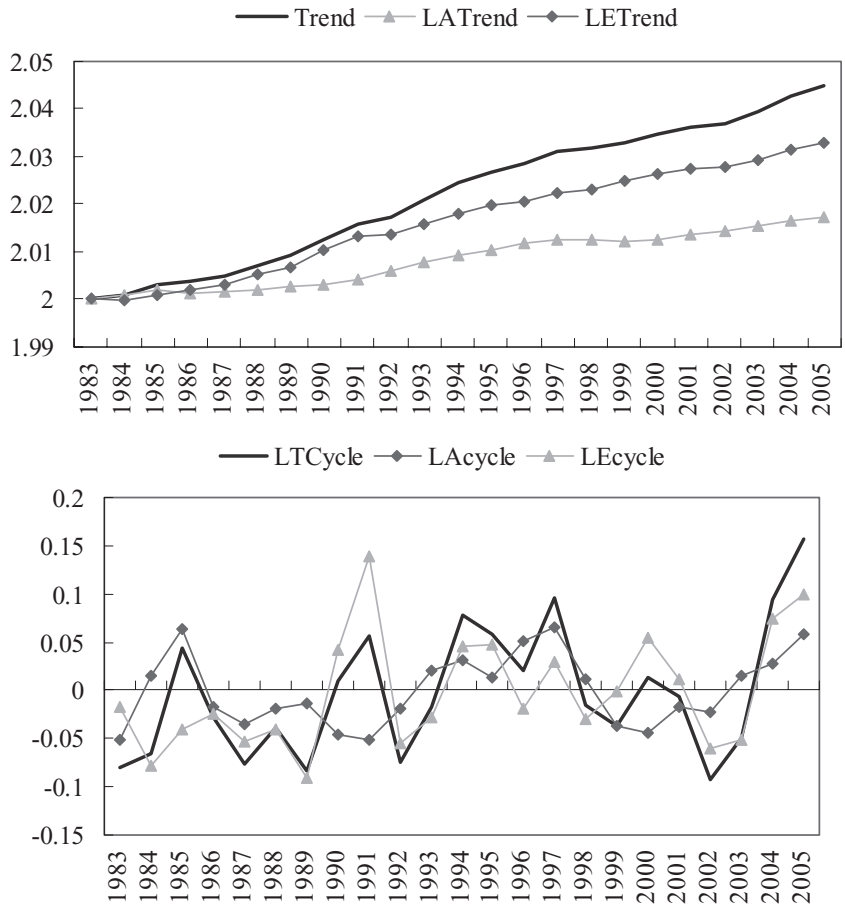


Figure 2. Trend/Cycle Decomposition of Labor Quality Growth (log levels and percentage point deviations from trend)

*Source*: Authors' calculations. The trend and cycle have been extracted using the Baxter–King band-pass filter (the cycle refers to the band between 2 and 8 year frequencies).

The contribution of age to the index of labor 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) (see Figure 4). While acting as proxy for labor market experience, the contribution of age to labor 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. In particular, the shares of those in prime age, i.e. between 35 and 54 years of age, have been steadily increasing since the early 1990s, 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 labor market experience over this time

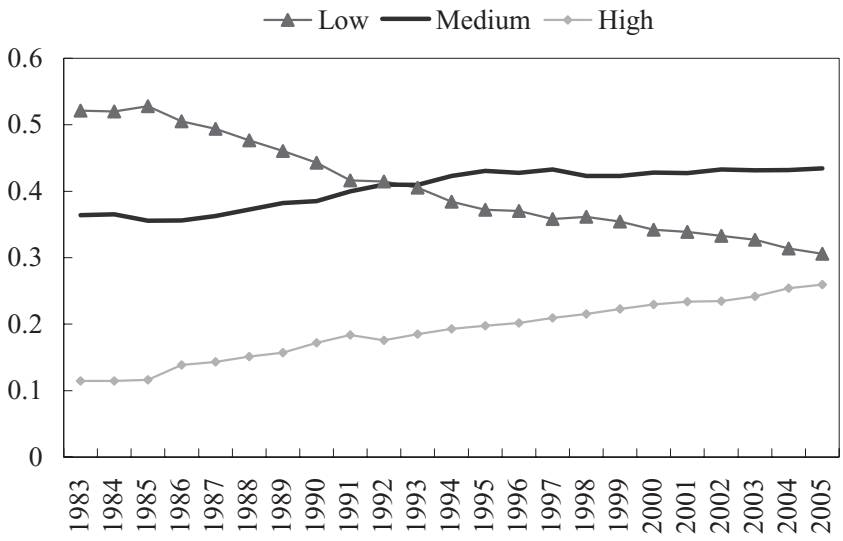


Figure 3. Hours Worked by Educational Attainment (shares)
*Source*: Authors' calculations based on the Labor Force Survey.

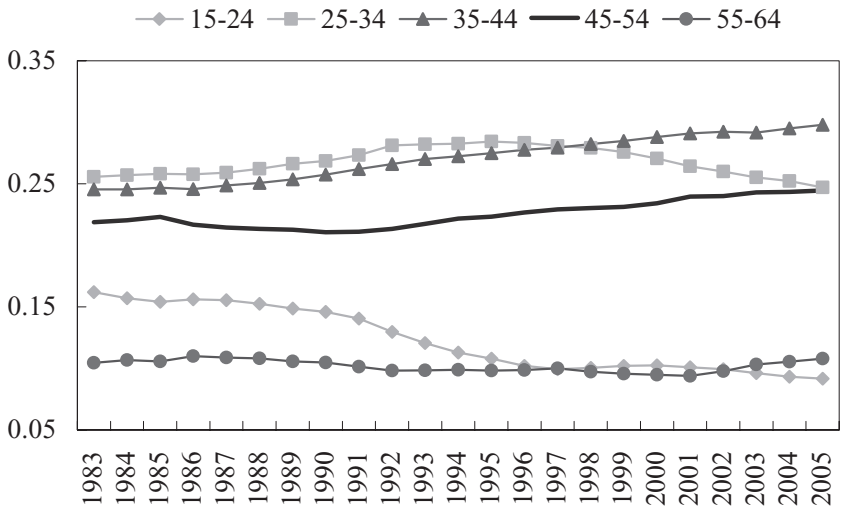


Figure 4. Hours Worked by Age Groups (shares)
*Source*: Authors' calculations based on the Labor Force Survey.

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 labor quality index has been quantitatively negligible. The small 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 labor input in a standard growth accounting framework provides further insight into recent developments in euro area labor productivity growth.[14] In particular, euro area labor productivity growth, measured by real GDP per hour worked, declined from an average annual growth of above 2 percent before the mid-1990s to just above 1 percent since 1996. Within a growth accounting framework, growth in labor productivity defined as real output per hour worked can be decomposed into three components: capital deepening (i.e. growth in the gross capital stock per hour worked), growth in labor quality and TFP growth.[15] Due to lack of data on labor quality for the euro area, previous exercises have estimated TFP growth as a residual item including the contribution of labor quality growth (Vijselaar and Albers, 2004; Sakellaris and Vijselaar, 2005). With positive growth in labor quality, this omission results in larger estimates of TFP growth and a possible misinterpretation of the determinants of the sustained decline in labor productivity growth.

The results of the decomposition of labor productivity, i.e. separating out the impact of labor quality growth from TFP growth point to a significant and increasing role for changes in labor quality in explaining labor productivity growth in the past 20 years (see Figure 5). While in the early 1980s the contribution of labor quality growth accounted for only 10 percent of productivity growth, this share has increased to 26 percent in the early 2000s. However, as discussed above, lower labor quality growth in the second half of the 1990s appears to have also contributed somewhat to the decline in labor productivity growth over the same time period.

Adjusting for labor quality results in significantly lower estimates of euro area TFP growth than previously estimated (see Table 3). As TFP growth is estimated as a residual, these estimates should be interpreted with some caution. For example, the current growth accounting exercise relies on capital stock estimates for the euro area that do not take into account possible changes in the quality of capital. With this caveat in mind, the results suggest that while TFP growth has been on average slower in the 1990s compared to the 1980s, a significant slowdown in TFP growth took place during the recent period of slow growth in the euro area. The slowdown in TFP growth suggests a possible decline in the contribution of

[14]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 labor productivity (real GDP per hour worked), and growth in labor utilization (total hours worked). Labor productivity growth can be further decomposed into capital deepening, growth in labor quality and growth in TFP. For a more detailed description and an application of the growth accounting framework to euro area data, see Gomez-Salvador *et al.* (2006).

[15]The contributions of capital deepening and labor quality are weighted by the relevant factor shares.

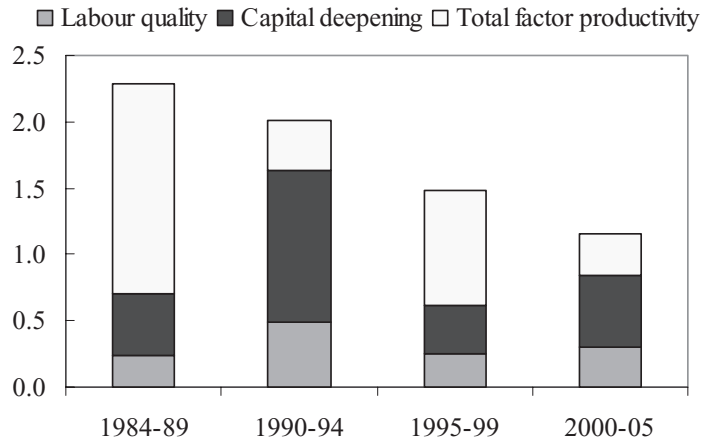


Figure 5. Decomposition of Labor Productivity Growth (contributions)

*Source*: Authors' calculations. Data on real GDP and total hours worked are based on the Total Economy Database (September 2006) from the Groningen Growth and Development Centre. Data on (gross) capital stock are based on published ECB estimates (see *ECB Monthly Bulletin*, May 2006 for a description).

TABLE 3

Growth in Adjusted and Unadjusted Total Factor Productivity (average annual growth rates)

| | Unadjusted | Adjusted |
|---|---|---|
| 1984 | 2.27 | 2.13 |
| 1985 | 1.40 | 1.08 |
| 1986 | 1.37 | 1.27 |
| 1987 | 1.32 | 1.16 |
| 1988 | 2.19 | 1.85 |
| 1989 | 2.20 | 1.94 |
| 1990 | 1.21 | 0.70 |
| 1991 | –0.01 | –0.48 |
| 1992 | 1.15 | 0.93 |
| 1993 | –0.22 | –0.71 |
| 1994 | 1.99 | 1.47 |
| 1995 | 1.38 | 1.05 |
| 1996 | 0.50 | 0.25 |
| 1997 | 1.60 | 1.25 |
| 1998 | 0.91 | 0.85 |
| 1999 | 1.09 | 0.93 |
| 2000 | 2.22 | 1.97 |
| 2001 | 0.40 | 0.22 |
| 2002 | 0.26 | 0.12 |
| 2003 | –0.15 | –0.47 |
| 2004 | 0.62 | 0.18 |
| 2005 | 0.10 | –0.18 |

*Source*: Authors' calculations.

technological progress to growth in the euro area.[16] 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 toward an increased use of labor inputs relative to capital in production triggered by wage moderation and labor market reforms.

## 6. Conclusions

We have presented the first evidence of changes in labor quality in the euro area by constructing a quality-adjusted index of labor input in the euro area covering the period 1983–2005. The index is constructed by combining data on wages and individual characteristics from microdata 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 labor 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 labor quality in 1984–2005 was 0.47 percent year-on-year, suggesting that up to one fourth of euro area labor productivity growth during this time period was due to improvements in human capital. A strong increase in labor 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 prime age. Toward the end of the 1990s growth in labor quality moderated, possibly reflecting the impact of continued robust growth in employment and the entry of marginal workers with lower human capital. Most recently, labor quality growth increased from 2003 onwards, suggesting that the recent slow growth period may have been characterized by some cyclical "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 labor quality in explaining labor productivity growth. Accounting for positive labor quality growth lowers estimates of total factor productivity growth in the euro area.

The results show that the main drivers of changes in observed labor quality are higher education and labor market experience. While it is important to recognize 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 toward 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 toward the needs of the job market. In this respect, changing demographics are likely to also have a strong impact on growth in labor quality in the future. While ageing of the working age population (until prime-age) generally increases average labor quality

[16]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 characterized by frictions such as imperfect competition (for a discussion, see Basu and Fernald, 2002).

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 labor 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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