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Measurement of labor quality growth caused by unobservable characteristics

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Abstract

The standard economy-wide indices of labor quality (or human capital) largely ignore the role of unobservable worker characteristics. In this paper, we develop a methodology for identifying the contributions of both observable and unobservable worker characteristics in the presence of the incidental parameter problem. Based on data for Switzerland over the period 1991-2006, we find that a large part of growth in labor quality is caused by shifts in the distribution of unobservable worker characteristics. The overall index differs little from the standard indices, but contributions to growth attributed to education and age are corrected downwards.

JEL Classification: J24, J31
Key words: human capital, labor quality

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1 Introduction

Macroeconomists have long been interested in economy-wide indices of labor quality (or human capital). The usual context is growth accounting; that is, the decomposition of output growth into the contributions of labor, capital and multi-factor productivity. Measures of labor input typically are derived from hours of workers with different education, age, gender characteristics, with wage rates serving as weights to account for differences in marginal products. The index of labor quality then is the ratio between the indices of labor input and hours worked. This standard approach is described in Jorgenson, Gollop, and Fraumeni (1987) and Bureau of Labor Statistics (1993).[1]

Although the observable characteristics (education, age, gender) explain only a small proportion of the total variation in wages, the unobservable characteristics get little attention in the standard approach to calculating indices of labor quality. A notable exception is Abowd, Lengerman and McKinney (2002) who calculate the distribution of unobserved characteristics for the period 1992 to 1997 in U.S. data. They succeed in explaining a very large portion of the total variation in wages and attribute substantial variation to individual and employer heterogeneity.

In this paper, we add to this literature by examining the contribution of shifts in the unobserved characteristics of workers to the index of labor quality in Switzerland. The data set covers the years 1991 to 2006. Because the panel is highly unbalanced, the incidental parameter problem (Neymann and Scott, 1948) prevents us from estimating the individual heterogeneity consistently. Consistent estimates can be obtained, however, for the average individual effect of a worker group. Based on these results, we calculate an index of labor quality that accounts for shifts in the distribution of observed and unobserved characteristics. We examine whether the standard indices of labor quality are robust to these extensions. Moreover, we compute the first-order partial indices proposed by Jorgenson et al. (1987) and examine whether the standard indices identify the sources of growth in labor quality correctly.

The paper is organized as follows. Section 2 presents the methodology. The data are described in Section 3. Sections 4 and 5 present the results and examine robustness issues. Section 6 concludes.

[1] More recent studies are Aaronson and Sullivan (2001) for the U.S.; Schwerdt and Turunen (2007) for the euro area; Bell, Burriel-Llombart, and Jones (2005) for the U.K.; and Bolli and Zurlinden (2008) for Switzerland.

2 Methodology

This section first develops the methodology for calculating the index of labor quality, where shifts in the distribution of unobserved characteristics are taken into account. We then describe how the contribution of these shifts to growth in labor quality can be identified.

2.1 Calculating the index of labor quality

The methodology for calculating the index of labor quality is based on the assumption that the relative productivity of individual workers is reflected in their relative wage rates. Following the Bureau of Labor Statistics (1993), the calculation can be separated into two steps. First, earnings equations à la Mincer (1974) are estimated, and predicted wages are calculated for each individual based on these estimates. Second, individual labor qualities are aggregated based on the methodology proposed by Jorgenson et al. (1987).

We assume that the data generating process for the natural logarithm of the real hourly wage rate q is given by

$$\ln q_{i,t} = X_{i,t}\beta + \alpha_i + \delta_t + \varepsilon_{i,t}, \tag{1}$$

where i refers to the individual and t refers to time, $X_{i,t}$ is a vector consisting of dummy variables for worker characteristics and a constant, α_i denotes the unobservable individual effect, and δ_t denotes the unobservable time effect.[2] Given the large number of individuals, estimating (1) would cause an enormous loss in degrees of freedom and would aggravate multicollinearity problems among the regressors (Baltagi, 2001). Therefore, we use the "within" estimator:

$$\ln q_{i,t} - \overline{\ln q}_i = (X_{i,t} - \overline{X}_i)'\beta + (\delta_t - \overline{\delta}) + (\varepsilon_{i,t}, -\overline{\varepsilon}_i), \tag{2}$$

where $\overline{\ln q}_i = \frac{1}{T_i}\sum_t \ln q_{i,t}$ denotes the average labor quality of individual i. The averages $\overline{X}_i$, $\overline{\delta}$ and $\overline{\varepsilon}_i$ are defined analogously. Since the data set is an unbalanced panel, the number of observations per individual, T_i, is varying. The "within" estimator produces consistent estimates regardless of potential correlation between explanatory variables and unobserved individual effects.[3]

[2] For a discussion of the empirical evidence on Mincer's human capital earnings function, see Card (1999).

[3] The Hausman test rejects the null hypothesis that the individual effects are uncorrelated with the other explanatory variables in the model. This holds for all ten panel equations described in the text.

The worker characteristics considered in this paper are education, gender and age, where the latter is used as a proxy of work experience. We estimate (2) separately for the two genders. This is standard in the literature because the pattern of earnings differs between men and women (see Aaronson and Sullivan 2001, Bureau of Labor Statistics 1993, and Schwerdt and Turunen 2007). Likewise, we estimate (2) separately for each education class since education attainment does not change after age 25 for most individuals. With gender and education characteristics dealt with in this way, we have a total of ten panel equations (2), where $X_{i,t}$ consists of a constant and dummy variables for groups of age.

Given the estimated parameters $\widehat{\beta}$ and $\widehat{\delta}_t$, the individual intercepts $\widehat{\alpha}_i$ can be recovered according to:

$$\widehat{\alpha}_i = \overline{\ln q_i} - \overline{X}_i \widehat{\beta} - \overline{\widehat{\delta}}. \tag{3}$$

But since the number of observations per individual, T_i, is small in our data set, the parameter estimates are inconsistent. This is the incidental parameter problem discussed by Neymann and Scott (1948).[4] While the estimates are not consistent, they are unbiased, however, implying that $E[\widehat{\alpha}_i] = \alpha_i$ (Hsiao, 2003). Consequently, we have

$$\widehat{\alpha}_i = \alpha_i + \mu_i, \tag{4}$$

where μ_i is independently distributed with mean zero. Furthermore, given that the number of observations per worker group j can be assumed to approach infinity, it is possible to obtain a consistent and unbiased estimate of the group-specific intercept:

$$\begin{aligned} \lim_{N_{j,t}\to\infty} \overline{\alpha}_{j,t} &= \lim_{N_{j,t}\to\infty} \frac{1}{N_{j,t}} \sum_{\substack{i=1 \\ i\epsilon j}}^{N_t} \alpha_i \\ &= \lim_{N_{j,t}\to\infty} \frac{1}{N_{j,t}} \sum_{\substack{i=1 \\ i\epsilon j}}^{N_t} \widehat{\alpha}_i - \lim_{N_{j,t}\to\infty} \frac{1}{N_{j,t}} \sum_{\substack{i=1 \\ i\epsilon j}}^{N_t} \mu_i = \lim_{N_{j,t}\to\infty} \widehat{\overline{\alpha}}_{j,t}. \end{aligned} \tag{5}$$

Since $\lim\limits_{N_{j,t}\to\infty} \frac{1}{N_{j,t}} \sum_{\substack{i=1 \\ i\epsilon j}}^{N_t} \mu_i = 0$, it is possible to calculate predicted wage rates as

$$\widehat{q}_{j,t} = \exp(\widehat{\overline{\alpha}}_{j,t} + X_{j,t}\widehat{\beta} + \widehat{\delta}_t). \tag{6}$$

Next, the predicted wages are used to weight the hours worked. The aggregation follows Jorgenson et al. (1987). Assuming a standard translog

[4]For a recent review of the incidental parameter problem, see Lancaster (2000).

aggregator function, the growth rate of the quality-adjusted labor input can be calculated as

$$\triangle \ln L_t = \ln \frac{L_t}{L_{t-1}} = \sum_j \left(\frac{s_{j,t} + s_{j,t-1}}{2} \ln \frac{h_{j,t}}{h_{j,t-1}} \right), \tag{7}$$

where $h_{j,t}$ denotes the number of total hours worked by group j, and $s_{j,t}$ is the share of labor compensation of group j in time t. Finally, the growth rate of labor quality is computed as

$$\triangle \ln Q_t = \triangle \ln L_t - \triangle \ln H_t, \tag{8}$$

where H_t are total hours worked in the economy.

2.2 Identifying the contribution of shifts in the distribution of unobserved characteristics

To examine the effect of shifts in the distribution of unobservable characteristics, we can recalculate the index of labor quality based on predicted wage rates which do not include the contribution from the average of the unobserved characteristics, $\widehat{\overline{\alpha}}_j$:

$$\widehat{q}_{j,t} = exp(X_{j,t}\widehat{\beta} + \widehat{\delta}_t). \tag{9}$$

The modified index is calculated based on (2) and (7) to (9). In what follows, this index is labeled *identification index* while the index derived in Section 2.1 is labeled *benchmark index*. The difference between the benchmark index and the identification index provides a measure of the contribution of shifts in the distribution of unobserved characteristics to the index of labor quality.[5]

Based on the same framework, we can decompose the index of labor quality into the partial indices for education, age and gender (and their combinations). As described by Jorgenson et al. (1987), the first-order partial indices capture the substitution between the categories of one characteristic. The indices are calculated like the total index, except that the worker groups j are formed by only one characteristic, instead of three.

Notice that the partial indices for education, age and gender will be biased, if they are calculated based on the model with (6), instead of (9). This reflects the fact that the contribution of shifts in the distribution of

[5]The wages in (9) do not include unobserved characteristics. They are neither accounted for explicitly as in the benchmark methodology, nor are they included implicitly since the coefficients obtained from (2) are unbiased.

unobserved characteristics is captured by the partial indices of the three observable characteristics in this case. The partial indices will be more affected the stronger the correlation between the observed and unobserved characteristics.

3 Data

The data are taken from the *Swiss Labor Force Survey* and the *Work Volume Statistic*:

- The Swiss Labour Force Survey (SLFS) is a household survey conducted every year between April and June since 1991. The survey is representative for the permanent resident population aged 15 and older. It is based on a sampling of 33,000 households (16,000 before 2001) where each randomly selected household is interviewed over the phone five years in a row (for more information, see Swiss Federal Statistical Office, 2007a).

- The Work Volume Statistic (WV) is compiled from the SLFS and other sources. Data are annual and available since 1991. The WV provides more accurate data on effective working hours than the SLFS because absences due to reduced work schedules, strikes or lock-outs are taken into account (for more information, see Swiss Federal Statistical Office, 2007b).

The Swiss Federal Statistical Office (SFSO) kindly provided us the micro data from these two statistics. We can combine the data precisely such that individuals are perfectly matched between the two datasets.

Real wage rates are computed by deflating nominal hourly wages with the consumer price index. Nominal wage rates, in turn, are computed by dividing nominal earnings by hours worked. Observations of real hourly wage rates above 100 CHF are excluded from the sample because they seem to be more prone to measurement errors. Missing values are replaced by the average value of the group.

In the benchmark calculations of labor quality, three worker characteristics are considered: education, age and gender. There are five categories of education ("minimal school level", "apprentice and vocational school", "university entrance certificate", "higher vocational training", "university degree"), five age groups ("15-24", "25-39", "40-54", "55-64", "65 and more") and the two genders ("male", "female"). For some calculations, the number of categories is expanded (see Section 5).

4 Results

Based on equations (2), (3) and (6) to (8), and the data described in Section 3, we can calculate the labor quality index which accounts for changes in the distributions of observed characteristics (education, age, gender) and unobserved characteristics. Figure 1 shows this index ("Benchmark") from 1991 to 2006. The index grows by 7.1% over these 15 years, which corresponds to an average growth rate of 0.46% per year. Splitting up the sample reveals that growth is highest in the early 1990s, slows down in the second half of the decade, and speeds up again after the year 2000. The average growth rates for the sub-samples are 0.62% between 1991 and 1995, 0.26% between 1995 and 2000 and 0.52% between 2000 and 2006. The two bumps in 1996 and 2002 coincide with revisions of the SLFS questionnaire.

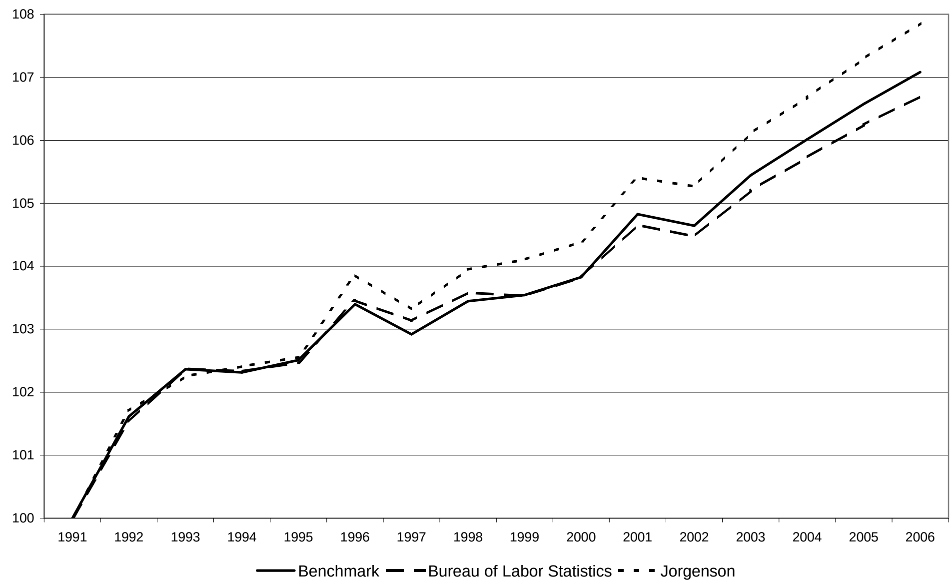

Figure 1: *Indices of labor quality for various methodologies*

Figure 1 also shows the indices calculated based on the traditional methodologies proposed by Jorgenson et al. (1987) and the Bureau of Labor Statistics (1993). Jorgenson et al. use the average real wage of a worker group as a measure for labor quality. The Bureau of Labor Statistics estimates Mincerian wage equations where, in contrast to (1), the presence of unobserved individual heterogeneity is not accounted for (i.e. $\alpha_i = \alpha$).

Comparing these standard indices to our benchmark index reveals three points. First, the adjustment for shifts in unobserved characteristics affects growth in labor quality. The benchmark index grows more rapidly than the index based on the method by the Bureau of Labor Statistics, and less rapidly than the index based on the method by Jorgenson et al. (1987). Second, the correction is more pronounced in the case of the method by Jorgenson et al. than in that of the method by the Bureau of Labor Statistics. Third, the size of the corrections is moderate overall, suggesting that the standard indices are quite robust to the adjustment for shifts in the distribution of unobserved heterogeneity.

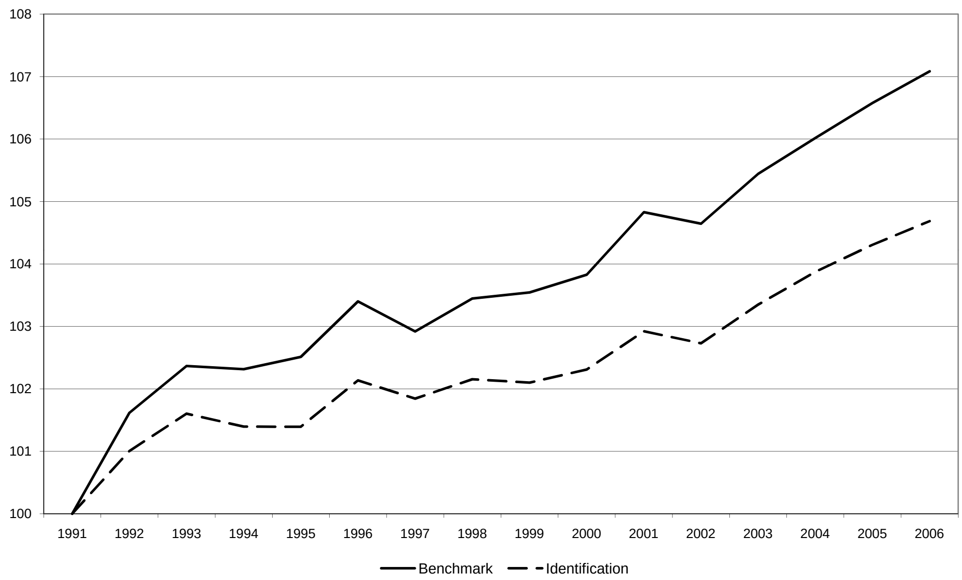

Figure 2: *Indices of labor quality for the benchmark and the identification methodology*

There are two possible explanations for the robustness of traditional labor quality indices to the adjustment for shifts in the distribution of unobserved characteristics. Either the impact of these shifts is not large, or the substitution between the worker classes considered captures the effect of these shifts reasonably well. To assess which of these two explanations is valid, we calculate the identification index described in Section 2.2. Figure 2 shows the identification index together with the benchmark index. The identification index grows by 4.7% from 1991 to 2006, corresponding to an average growth rate of 0.31% per year. The difference between the two indices displayed in Figure 2 is substantial and suggests that labor quality growth caused by shifts in the distribution of unobserved characteristics is economically significant. The results is in line with Abowd et al. (2002) who find that shifts in the distribution of unobserved characteristics were the main driver of labor quality growth in the U.S. between 1992 and 1997.

The robustness of the traditional labor quality indices can be traced back to the underlying methodologies. As described above, Jorgenson et al. use the average wage rate of a worker group as a measure of labor quality. Since these averages reflect both observed and unobserved characteristics, the resulting index of labor quality is likely to capture some of the shifts in the distribution of unobserved characteristics. The method by the Bureau of Labor Statistics, in turn, is based on estimates of Mincerian wage equations which do not allow for unobserved individual heterogeneity ($\alpha_i = \alpha$). As unobserved characteristics may be correlated with observed characteristics, the coefficients are expected to pick up some of the effects of the omitted variables. In sum, the explicit consideration of shifts in unobserved characterstics cause only minor adjustments in the overall index of labor quality because the standard methodologies account for these shifts indirectly.

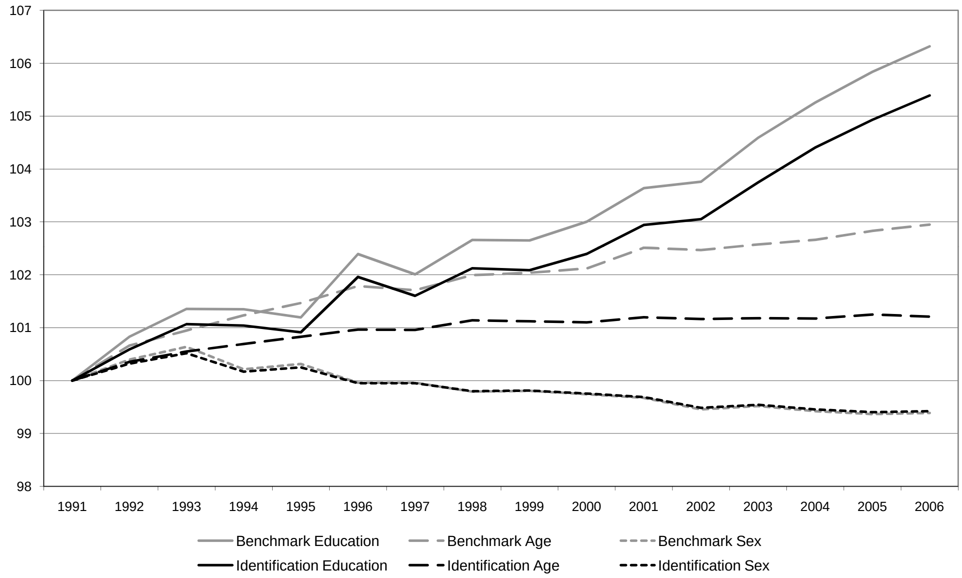

Figure 3: *Partial indices of labor quality for the benchmark and identification methodology*

The first-order partial indices of education, age and gender are depicted in Figure 3 for both the benchmark index and the identification index. In the benchmark case, we note that the partial index of education grows by 6.3% between 1991 and 2006, implying that the substitution between education classes captures 0.41pp of labor quality growth each year. The second largest contribution is captured by the substitution between age classes which adds 0.19pp per year. The substitution between men and women is negligible (-0.04pp per year).[6]

To examine the effects of shifts in the distribution of unobserved characteristics on the first-order partial indices of the observable characteristics, we can compare the decomposition of the identification index with that of the benchmark index. Figure 3 shows that the labor quality growth captured by substitution between age classes is lower if unobserved heterogeneity is held constant. The difference is 1.7pp over the full period. The partial indices for education suggest that the impact of the substitution between classes of education is overestimated to a lesser degree (0.9pp). Finally, the labor quality growth caused by the substitution between men and women is identical in both cases.

Our results imply that the age-earnings profile and, to a lesser degree, the education-earnings profile flatten when individual heterogeneity is explicitly taken into account. Examining the age-earnings profiles for the two genders and the five educational classes, we find relatively strong effects on age-earnings profiles for men and for higher educational classes. One interpretation is that age is a poor measure of labor market experience. Results by Zoghi (2007) for the United States suggest that information on actual labor market experience can improve the estimates substantially.

5 Robustness

This section examines the robustness of our benchmark results with respect to alternative assumptions. The results are presented in graphs. The benchmark series are given for comparison.

5.1 Additional worker characteristics

The benchmark index assumes that allowing for substitution between worker groups formed by education, age and gender is sufficient to capture all changes in labor quality. In order to test this assumption, we use two additional characteristics to form worker groups: the economic sector and the employment

[6]The first-order partial indices of education, age and gender do not add up to the benchmark index because the second-order and third-order effects are not considered.

status. We consider three different sectors ("primary", "secondary", "tertiary") and two forms of the employment status ("full time", "part time"). To prevent the number of worker per group from falling too low, the effects of these additional characteristics are examined separately.

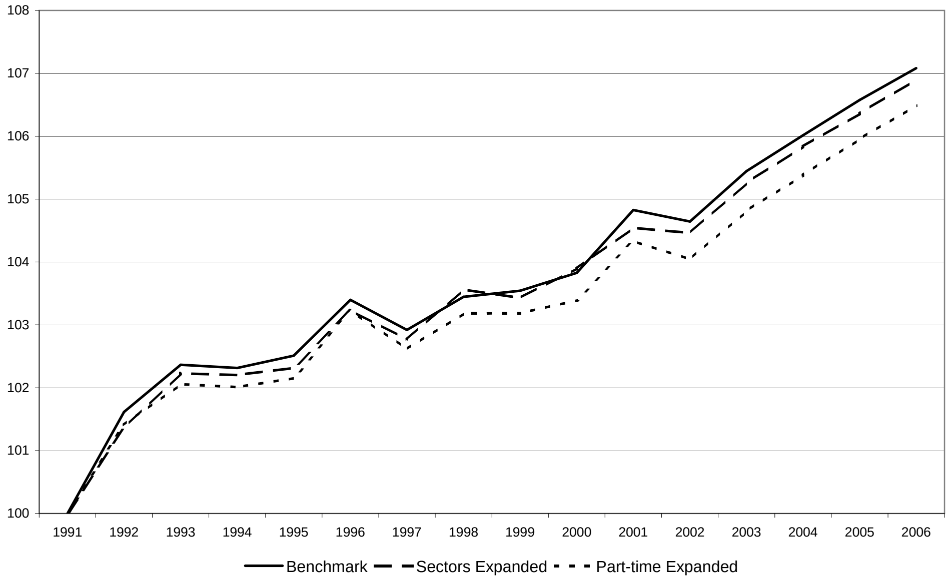

Figure 4: *Index of labor quality: set of worker characteristics expanded*

Figure 4 shows that our index is affected little by the inclusion of the additional characteristics. The average growth rates of the two alternative indices are both lower than those of the benchmark index. The differences, accumulated over 15 years, amount to merely 0.2% ("sectors expanded") and 0.6% ("part-time expanded").

It is interesting to compare these effects to those that result if the labor quality index is constructed based on the method of the Bureau of Labor Statistics (1993). The inclusion of economic sectors and employment status have qualitatively the same impact independent of the methodology. However, the size of the correction increases by a factor of 2.3 ("sectors expanded") and 1.5 ("part-time expanded") if the methodology of the Bureau of Labor Statistics is applied. This suggests that the benchmark index is more robust to the inclusion of additional variables than the index based on the method by the Bureau of Labor Statistics. The reason is that under the latter method some of the shifts in unobserved heterogeneity are captured by the additional variables. Since the benchmark methodology provides a means of quantifying the effect of shifts in observed and unobserved heterogeneity, the correction is smaller there.

5.2 Definition of the workforce

The benchmark index is calculated from data for employed persons. We have excluded self-employed, apprentices and family-workers from the sample because equating wage rates with the marginal product of labor seems questionable for these groups. The results of calculating the index of labor quality for all workers - including self-employed, apprentices and family-workers - are shown in Figure 5 ("all workers"). The difference to the benchmark index, accumulated over 15 years, amounts to no more than 0.5%.

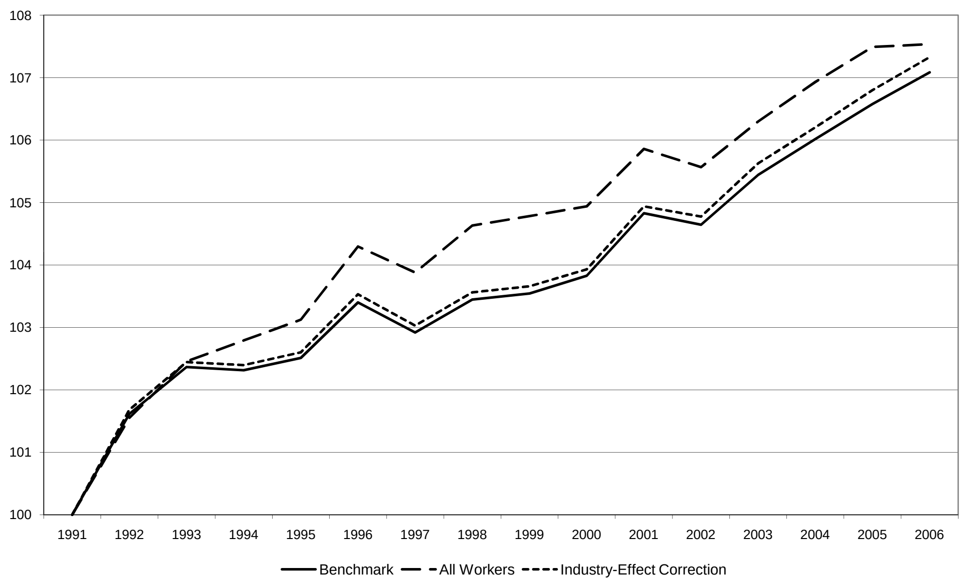

Figure 5: *Index of labor quality: definition of workforce expanded and correction of industry-effects*

5.3 Industry-specific effects

The main caveat to the results presented so far stems from missing information about firm characteristics. The unobserved individual effects reflect the residual non-time varying component of individual wages. While, in principle, they are likely to reflect individual specific factors related to human capital, such as individual ability, in practise, they reflect any other factor that is not time-varying and is specific to the individual observation. In a sample of workers that stay in the same firm, for example, the unobserved individual effect coincides fully with the unobserved firm effect. Abowd et al. (2002) emphasize the role of firm-specific heterogeneity as a source of differences in productivity and wages. Thus, it can be argued that equation (1) should be estimated including a firm-specific intercept.

Our data set does not provide information on firm heterogeneity. Therefore, we focus on industry-specific rather than firm-specific heterogeneity, acknowledging that this attempt is very incomplete since within-sector heterogeneity may also be large. We estimate (1) with twelve industry dummy variables added to the equation. The index of labor quality then is calculated based on the assumption that these dummies capture productivity differences unrelated to labor quality. From Figure 5 ("industry-effect correction"), we can see that the difference to the benchmark index is small, implying that the correction for industry-specific effects does not have a substantial impact on our index. This is in line with findings by Keane (1993) and Abowd et al. (1999). Both of these studies suggest that most of the industry wage differences are caused by individual heterogeneity.

6 Conclusions

In this paper, we have presented a methodology that enables us to calculate the growth of labor quality if shifts in the distribution of unobserved characteristics are accounted for. We draw three main findings from our analysis:

First, labor quality in Switzerland grew by 0.46% per year on average between 1991 and 2006. This is similar to the growth rates obtained by applying the standard methodologies proposed by Jorgenson et al. (1987) and the Bureau of Labor Statistics (1993). Thus our result is comforting for authors that have used the standard methodologies to measure labor quality growth. Standard methods appear to provide an accurate picture about the role of labor input as a whole in determining productivity growth.

Second, the method seems to matter for identifying the relative importance of observed characteristics for growth in labor quality. We find that a large part of labor quality growth can be attributed to shifts in the distribution of unobserved characteristics. This implies that the contributions attributed to the observed characteristics are substantially smaller if unobserved characteristics are accounted for. In particular, accounting for unobserved individual effects lowers the age contribution and, to a lesser extent, the education contribution, whereas the gender contribution is largely unchanged. As previous studies have shown that population ageing over the next few decades will put downward pressure on labor quality growth (see e.g. Aaronson and Sullivan, 2001, and Schwerdt and Turunen, 2005), the results in this paper suggest that this effect may have been overstated.

Third, our results suggest that other methodological choices are more important for the overall index than the inclusion of unobserved effects. Specifically, we find that the benchmark index is very close to the index calculated using the methodology proposed by the Bureau of Labor Statistics, whereas the largest difference is between the benchmark index and the index based on average wage rates proposed by Jorgenson et al. (1987). This result is consistent with findings by Zoghi (2007), who argues that average wage rates may differ between groups for more reasons than just differences in the defined characteristics.

Appendix

Table 1: *Number of observations used for the estimation of Mincerian equations*

	Male	Female
Minimal School Level	16,145	20,840
Apprentice and Vocational School	54,844	57,240
University Entrance Certificate	6,596	10,876
University Degree	20,955	9,177
Higher Vocational School	15,249	9,674

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