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A quality-adjusted labour input series for the United Kingdom (1975–2002)

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Contents

Abstract 3

Summary 4

1 Introduction 5

2 Method 6

3 Data 9

4 Results 12

4.1 Education impact 13

4.2 Age impact 14

4.3 Gender impact 15

4.4 Separating the effects of wages and hours 16

4.5 Comparing with other results in the literature 17

5 Industry-level results 18

6 Robustness of results 19

6.1 Expanding the number of education and age groups 20

6.2 Occupation 21

6.3 Full-time workers 21

6.4 Private sector workers 21

6.5 Actual hours worked 22

6.6 Matching of worker types between the GHS and LFS surveys 22

7 Applications of research 22

8 Conclusion 26

Appendix 28

References 38

Abstract

In this paper, annual indices of labour input adjusted for the education, age and gender distributions of the UK workforce are presented for the period 1975-2002. These measures show that improvement in labour quality, as proxied by education, age and gender, has added on average 0.67 percentage points per year to the growth rate in total labour input. Changes in the education distribution more than account for the improvement in labour quality, adding 0.68 percentage points per annum. Changes in the age distribution have made a much smaller contribution, adding only 0.11 percentage points to the growth rate. The rise in female participation has had a small negative effect of 0.08 percentage points, as women have had a preference for part-time work, which tends to be paid less per hour than full-time jobs. Using this evidence, the key finding of this paper is that a large proportion of growth that is usually attributed to TFP (total factor productivity) growth can be accounted for by an improvement in the quality of labour input. This result has no implications for the measurement of UK GDP growth from 1975-2002, but it does help to identify more accurately the sources of that growth.

Key words: Labour input, total factor productivity.

JEL classification: D2, J21, J24, J31.

Summary

Government policy, demographic shifts and social change have radically altered the structure of the UK labour force. For example, since the 1970s, the workforce on average has become older, better educated, and more balanced between the genders. This paper examines these changes in the labour market from 1975 to 2002, and their implications for labour quality.

Economists are interested in evaluating factor inputs (such as capital and labour) because they are measures of an economy's productive potential. The standard measure of labour is to aggregate the number of hours worked by each person in the economy. Yet this method does not take into account the fact that some people are more productive than others. By adjusting standard measures of an economy's total hours worked with a labour quality index, we can derive a truer measure of the contribution of labour to production.

An overall shift in the structure of the workforce can change the aggregate skill (quality) level in an economy. Measuring 'skill' is difficult, since it is a loose term that in part reflects the characteristics of a worker and is not directly observable. To compound matters, individuals are different, and, to a certain extent, their skill levels are subjective. For example, it could be argued that a younger workforce is likely to be more innovative and dynamic than an older one. Conversely, an older workforce, with greater work experience, might be more productive. In order to capture skill levels, it is necessary to find proxies. This paper uses information on wage differentials between worker groups as a measure of skill.

Data from the Labour Force Survey and the General Household Survey are used to construct the quality-adjusted labour input series over the period 1975-2002. The total hours worked by particular groups of workers are weighted by their respective wage bill shares. Our benchmark series takes into account gender, five age groups and four education levels.

We find that the quality of the UK workforce has increased since 1975. Adjusting for labour quality adds 0.67 percentage points per annum to the growth rate of labour input from 1975-2002. This increase can be attributed to changes in the educational distribution. Meanwhile, the workforce, in general, has become older, reflecting the temporary increase in the birth rate after the Second World War. This has had a positive effect on measured labour quality, particularly after 1990.

Adjusting labour input for quality changes has some interesting economic implications. The final section of the paper explores these issues. Its key finding is that a large proportion of what is usually considered to be TFP (total factor productivity) growth can be attributed to an improvement in the quality of the labour input. This result has no implications for the measurement of UK growth from 1975-2002, but it does help us to identify more accurately the sources of that growth.

1 Introduction

The drivers of output growth are of great interest to policymakers, business leaders and academics alike. For example, O'Mahony and de Boer (2002) suggest that in terms of total factor productivity (TFP), the United Kingdom has been lagging behind other countries in recent years. Understanding the determinants of output growth is of great importance, since individual components have different implications for the inflationary outlook for monetary policy. This paper focuses on the measurement of labour input in production in the UK economy and its implications for measured total factor productivity.

The number of workers in an economy is the simplest measure of labour input, but it treats all workers equally, regardless of whether they work part-time or full-time. An alternative measure is the number of hours worked in an economy. This method recognises the fact that hours worked differ from person to person. However, hours of work are not homogenous: their quality depends on the characteristics of the individual and the job. Therefore, any change in the composition of the labour force may affect the degree of heterogeneity, or quality, of hours worked and so the volume of 'effective' hours. This means that any measure of labour input which does not take into account both changes in the actual number of hours for a given level of quality and changes in the quality of hours worked, may mismeasure the labour input in the economy.

This issue, of adjusting factor inputs for quality, is well known and documented in the existing literature, but is very often ignored, due to the difficulty in obtaining the required disaggregated data. Ho and Jorgenson (1999) report annual indices of quality-adjusted labour input for the US civilian workforce during the period 1948-95, and, since 1993, the US Bureau of Labour Statistics have reported official series on quality-adjusted labour input going back to 1948 (see BLS (1993)). There have not been many similar studies for the United Kingdom, due to the lack of long-run disaggregated wage data. O'Mahony and de Boer (2002) calculate quality-adjusted labour input series using 48 industries for the United Kingdom, Germany and the United States over the period 1950-99. But they apply the wage-bill share by educational attainment in 1993 to the whole sample period. Card and Freeman (2002) use the General Household Survey (GHS) to estimate that changes in UK labour quality have added 0.2 percentage points per year to labour input from 1974-1979 and 0.9 percentage points per year from 1980-96. The ONS has recently undertaken a project to study the viability of constructing official series for a quality-adjusted labour input for the UK economy. Lau (2002) reports the results from this work. She constructs growth rates of quality-adjusted labour input for the United Kingdom over the period 1994-2001 using data from the Labour Force Survey. It shows that educational attainment is the main contributor to labour quality, while age and gender

have very small effects. This paper goes beyond this by estimating a series back to 1975, and by assessing whether other factors play an important role in determining labour quality.

This paper builds on the Card and Freeman (2002) and ONS work, by using data from both the Labour Force Survey (LFS) and the General Household Survey (GHS) to construct the quality-adjusted labour input series over the period 1975-2002. We do this by disaggregating hours as much as possible by the characteristics of individual workers, and obtain the quality-adjusted labour input by using a Tornqvist index to aggregate the hours of each group weighted by their contribution to the total product. Assuming firms behave competitively in the labour market, the contribution of each group to the total product is equal to its wage-bill share. This aggregation procedure has the useful property that changes in the quality of hours can be attributed separately to the different individual characteristics and to combinations of them.

Data on hours worked over the period 1975-2002 were taken from the LFS. Data on wage-bill shares were derived from GHS wages and LFS employment from 1975-92, and from the LFS alone from 1993-2002. A wide variety of worker categorisations have been explored to determine which characteristics are relevant for this study. It is concluded that the main determinant of labour quality over this period is education attainment, adding 0.68 percentage points per year to the annual growth of the unadjusted labour input. The contribution of other attributes has been much smaller, ranging from the 0.11 percentage points contribution of age group to -0.08 percentage points of gender. Given this result, we have chosen as our benchmark a quality-adjusted labour input that takes into account gender, five age groups and four education levels as the relevant characteristics. Chart A.1 in the appendix shows the various contributions of the component indices to the headline measure of labour quality. It should be noted that adjusting labour input for education alone leads to a higher annual contribution than adjusting for education, age and gender (0.68 percentage points per annum compared to 0.67 percentage points per annum). However, the aim of this research is to capture quality changes in the workforce and not just to maximise the level of index.

This paper is organised as follows. In Section 2, we define the theoretical framework used to derive the labour input series. Section 3 details the data sources and explains what we mean by the labour quality of the workforce. Section 4 presents the main results for the whole economy, while Section 5 presents results disaggregated by ten industries. Section 6 reports some robustness analysis. Section 7 explores the implications of these results. Finally, Section 8 concludes.

2 Method

The quality of an hour worked depends on the characteristics of the individual and the job. This can be made explicit by expressing the volume of the quality-adjusted labour input (L) as a function of

the hours worked by all the groups of workers *(n)* with different characteristics (h_i): $L = g(h_1, h_2, ..., h_n)$. That is, hours are allowed to be heterogeneous across groups, but not within groups. We assume *g* to be a translog aggregator function homogeneous of degree one, with the following form:

$$L = g(h_1, h_2, ..., h_n) = \exp\left[a + \sum_{i=1}^{n} s_i \ln h_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} s_{ij} \ln h_i \ln h_j \right]$$

$$\text{where} \quad \sum_{i=1}^{n} s_i = 1, \quad s_{ij} = s_{ji} \quad \text{and} \quad \sum_{i=1}^{n} s_{ij} = 0.$$

It can then be shown that the growth rate of this quality-adjusted labour input *L* takes the form of a Tornqvist index (called $\Delta \ln L$ from now on):[(1)]

$$\Delta \ln L_t = \ln\left(\frac{L_t}{L_{t-1}} \right) = \sum_i \left[\frac{s_{i,t} + s_{i,t-1}}{2} \right] \ln\left(\frac{h_{i,t}}{h_{i,t-1}} \right) \qquad \textbf{(1)}$$

where s_{it} is the share of labour compensation of group *i* at time *t* and the weights in the index are given by the average shares in periods *t* and *t*-1. In this equation we have assumed that firms behave competitively in the labour and product markets and therefore pay workers their marginal revenue product. This assumption is not necessarily inconsistent with situations where labour is not supplied competitively. Marginal product will equal the wage as long as firms choose employment competitively; ie they are not monopsonists in the labour market.[(2)] If workers are not paid their marginal product, the weights in the index are still valid so long as wages across worker groups are proportional to their marginal products.

The unadjusted Tornqvist index of labour input ($\Delta \ln H$), which treats all hours worked as homogeneous, is equivalent to the growth rate of total hours worked in the economy (*H*).[(3)] The Tornqvist index, adjusted for labour quality ($\Delta \ln L$), also measures growth of hours in the economy, but takes into account the fact that the workforce is made up of different types of workers. Therefore, the difference between the adjusted and the unadjusted Tornqvist index measures the impact that changes in the average quality of hours worked has on the growth rate of labour input.

$$\Delta \ln Q_t = \Delta \ln L_t - \Delta \ln H_t$$

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(1) This aggregation procedure is consistent with the methodology generally used in the literature to measure productivity. Jorgenson (1995) shows that the only requirement is a production function that is homothetically separable. A necessary condition for this is that the production function is separable in all its inputs and these inputs are homogeneous in their components (as is our case).

(2) See Ho and Jorgenson (1999) and BLS (1993) for a more detailed discussion of this issue.

(3) Since in this case there is only one group, comprising all workers in the economy, the wage-bill share is equal to 1. Therefore, the index collapses to the growth rate of hours.

According to equation **(1)**, the quality-adjusted index will grow by more than the unadjusted one when the groups with larger wages experience greater growth in hours ($H_{i,t}$). Therefore, in order to understand which groups are driving the changes in the quality-adjusted index and why certain employee characteristics are contributing more than others, one has to look separately at the components of the wage-bill share ($s_{i,t}$). The wage bill of group *i* ($W_{i,t}$) can be expressed as the average wage per hour of group *i* ($w^h_{i,t}$) multiplied by the total number of hours worked by group *i* ($H_{i,t}$). Similarly, the total wage bill (W_t) can be expressed as the national average wage per hour (w^h_t) multiplied by the total number of hours worked (H_t).

$$s_{i,t} = \frac{W_{i,t}}{\sum_i W_{i,t}} = \frac{w^h_{i,t} H_{i,t}}{\sum_i w^h_{i,t} H_{i,t}} = \left(\frac{w^h_{i,t}}{w^h_t}\right) \cdot \left(\frac{H_{i,t}}{H_t}\right) \qquad \textbf{(2)}$$

The wage-bill share of group *i* will be large either because its wage per hour (marginal product) is significantly greater than the national average, or because its share of total hours is large, or both. So the quality-adjusted index will grow by more than the unadjusted index if the most productive groups of the economy experience greater growth in hours, provided that they represent a non-negligible share of total hours worked.

A useful feature of the Tornqvist index is that it allows the calculation of the separate contribution to the growth of the quality-adjusted labour input of each of the characteristics considered. This is called a (first order) partial index of characteristic *i*. For example, for education this partial index would be equal to equation **(1)** but with the indicator *i* referring to workers with education level *i* and therefore summing over all other characteristics. This partial index of education ($\Delta \ln L_E$) captures substitution between the different education groups, but ignores substitution among other characteristics, such as gender or age group. The contribution of education to the quality-adjusted labour input will then be equal to:

$$\Delta \ln Q^E_t = \Delta \ln L^E_t - \Delta \ln H_t$$

There are as many partial indices as categories considered in calculating the labour input. Similarly, a second-order index is a partial index involving two characteristics, say education and gender, ($\Delta \ln L^{E,G}$) and is equal to equation **(1)** with *i* counting over the education and gender categories only. The second-order contribution of education and gender is calculated as:

$$\Delta \ln Q^{E,G}_t = \Delta \ln L^{E,G}_t - \Delta \ln H_t - \Delta \ln Q^E_t - \Delta \ln Q^G_t$$

This index reflects the impact of changes in the composition of hours worked by education and gender on the growth of labour quality, excluding the first-order effects of these characteristics.

The total quality-adjusted labour index can also be obtained as the sum of all the first-order partial indices, plus all the second (and higher) order partial indices. However, in most cases, the first-order partial indices will account for most of the variation in the total index.

3 Data

In order to determine the data required to calculate the index, we first have to decide which worker characteristics are relevant. One could argue that each individual in the UK labour force has some distinctive characteristic that cannot be ignored in measuring labour quality. However, this is obviously impossible to implement.[4] Instead, we will have to choose the dimensions we consider to be the most significant, that take into account the restrictions imposed by the data available.

Measuring the 'skill level' (quality) of an individual is difficult since it is a characteristic that cannot be directly observed and is embodied in a variety of different forms. For example, the overall skill level of a worker may include (but is not restricted to) on-the-job training, work experience and general management ability. Therefore, in order to capture the overall quality level of a worker (or a group of workers) it is necessary to find directly observable proxies that embody it. Educational attainment is often seen as a good indicator (OECD (1994)).[5] Similarly, worker occupation might reflect skill levels if formal qualifications are a requirement for the job. The length of work experience (which may be imperfectly proxied by age) may be positively correlated with human capital because people improve their skills by working. However, a younger workforce with a lower average work experience, might be more innovative and hence more productive.[6]

In this paper, we have followed the previous literature in considering the following characteristics: education, gender and age. Nevertheless, we have checked the robustness of our results to other dimensions, such as the industrial sector and worker occupation, as well as to different levels of aggregation of the characteristics considered. We have also extended the analysis to exclude public sector and part-time workers.

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[4] This would require a panel data set of all individuals covering the entire sample period.
[5] Detractors of this view would argue that the accumulation of educational qualifications is increasingly used for signalling purposes and has no inherent value in production. Both theories imply that education and wages are positively related, so assessing which approach is more valid is difficult. There is plenty of empirical evidence to support the human capital theory. For example Ho and Jorgenson (1999) cite Kroch and Sjoblom (1994) who use two measures of education in modelling wages; years of schooling and rank in the educational distribution. The latter is used as a proxy for unobserved ability under the signalling hypothesis. They find that the relative education levels are rarely significant and conclude that signalling effects from education are weak relative to its productivity enhancing potential.
[6] A more detailed discussion of using proxies for skill levels is provided in Barnes and Kennard (2002).

Table A: Classification of labour force[7]

Gender	Male, female.
Age group	16-24, 25-34, 35-44, 45-54, 55-64 (-59 for female).
Education	Other qualifications, GCSE or equivalent, A Level or equivalent, degree or equivalent.

From equation **(1)**, we need data on wages earned and hours worked disaggregated by age, gender and educational attainment.

Three sources of data fulfil our requirements, though each has its limitations: the New Earnings Survey (NES), the Labour Force Survey (LFS), and the General Household Survey (GHS).

The NES has the advantage of providing a large sample size (1% of the working-age population) going back to 1975. But it does not have information on educational attainment, which is generally regarded as one of the main determinants of the quality of labour input. Worker occupation could be used as a proxy for education. However, when we studied this possibility using LFS data over the period 1993 to 2002, we found that occupation failed to capture about 50% of the rise in labour quality (see robustness section below).

For our purposes, the LFS is the best of the three surveys. It has information on all the relevant characteristics and has an annual sample large enough[8] to be representative at the population level. Moreover, it includes grossing factors to convert sample estimates into population estimates. Its main limitations are that it only contains wage information from 1992 Q4, and no educational classification exists before 1979. Finally, its periodicity has changed over time: the survey was conducted on a biannual basis from 1975 to 1983, annually from 1984 to 1991 and quarterly from 1992.

The GHS has information on all the relevant characteristics and goes back to the late 1970s, but it has a small sample size.[9] The biggest limitation is that this survey does not have grossing factors, which means that we cannot convert sample means into population means. The results are therefore dependent on the sample frame of the survey. For example, according to the GHS, usual hours worked have fallen by approximately 30% over the period 1974-96, while according to the LFS they

[7] See Table A.1 in the appendix for a more detailed classification of all the characteristics used. In addition, Table A.2 in the appendix contains a detailed list of the qualifications included in each category of the education classification.
[8] The LFS sampled approximately 130,000 people of working age from 1975-83, 95,000 from 1984-91 and 85,000 from 1992 Q1 to 2001 Q1.
[9] The GHS survey size steadily declined from 18,000 in 1975 to 13,000 in 1996.

have increased.[10] The GHS survey was discontinued in 1996, though it was resurrected as a biannual survey from 1998.

Thus, it is not possible to construct a data series going back to 1975 using a single data source. Therefore, we use data on hours worked from the LFS together with data on wages from the GHS for the period 1975-92 and from the LFS for the period 1993-2002.

The wage is defined as gross weekly earnings of employees and those in government schemes. The wage-bill share over the period 1975-92 is calculated as the average wage from the GHS by worker type, multiplied by the corresponding total employment from the LFS to create a total wage bill by worker type. This is then divided by the sum of all the wage bills of all worker types to create a wage-bill share. An alternative method of constructing wage data over this period would be to take the wage-bill shares directly from the GHS. Both methods lead to similar results over the period 1980-2002. The problem with the latter method, however, is that we found that it led to counter-intuitive results for the late 1970s. In particular, the adjusted index fell below the unadjusted index due to negative contributions of second and third-order indices. While it is possible this represents economic factors (for example, trade unions may have squeezed the wage distribution in favour of the least productive workers), it is more likely to be caused by errors in the data. For this reason, we use the first approach. Finally, over the period 1993-2002, LFS wage data from the spring quarter are used.

We defined hours worked as total weekly usual hours[11] worked by all workers. Usual hours tend to be less volatile than actual hours but have a similar information content.[12] Over the whole sample periods, hours worked were obtained from the LFS.[13] When the LFS became quarterly (from 1992), the spring quarter was used. From 1975 to 1983, hours data were interpolated to create a complete time series due to the biannual nature of the LFS. Finally, between 1975 and 1978, the LFS contains no data on educational attainment. It was therefore necessary to apply GHS shares of hours by education levels within each age and gender group to LFS hours by age and gender for this period only.

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[10] It could be argued that this issue is irrelevant since we are interested in the difference between adjusted and unadjusted labour input (rather than the actual levels). However, the contributions to labour quality are affected by the absence of population weights in the GHS.

[11] The LFS only collected usual hours data from 1979. Actual hours data was used for pre-1979 analysis. LFS hours data appear less reliable in the 1970s and less weight should be attached to the results in this period.

[12] See Shortall (2002) for a more detailed discussion.

[13] An alternative way of calculating hours would be to take average hours worked from the GHS and weight them by total number of heads employed in the LFS. Both methods lead to qualitatively similar results.

4 Results

The quality-adjusted labour index series we have derived are shown in Chart 1 and Table B (column 2). The labour input index adjusted by education, gender and age has grown faster than the unadjusted labour index (or total hours worked) since 1975, though the effect has been particularly marked from 1981 onwards. This reflects the impact of important changes in labour composition (or quality of hours worked) over the period, which have raised annual growth of labour input by 0.67 percentage points (pp) on average (from 1981-2002 the contribution to labour input was 0.82pp per annum). That is, the standard, unadjusted labour input, by not taking into account the impact of changes in labour composition, has underestimated the level of labour input by 20% over the period 1975-2002.

Chart 1: Quality-adjusted labour input

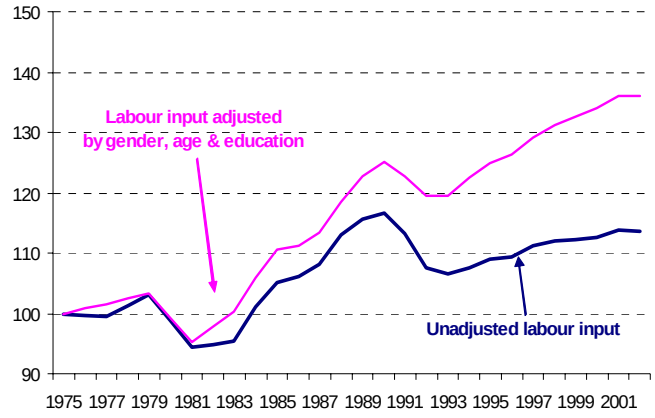
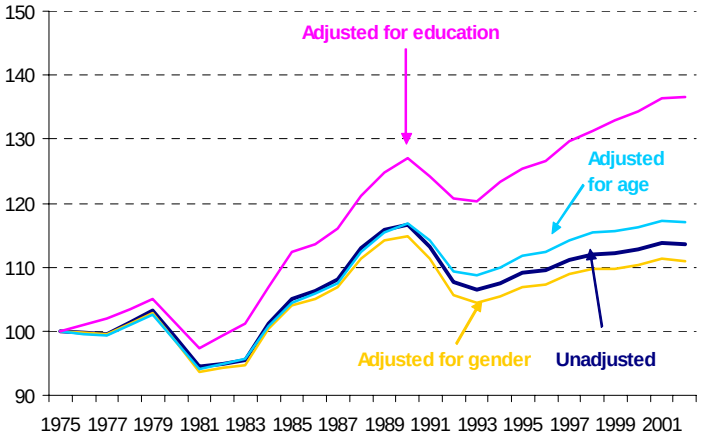


Chart 2: Partial indices by education, age group and gender



Both the unadjusted and adjusted labour input series appear to follow the economic cycle. Each declined in absolute terms during the late 1970s and early 1990s, and rose in the 1980s and mid-1990s. The biggest contribution (the difference between the adjusted and unadjusted series) of labour quality occurred during economic downturns. This is consistent with firms recruiting heavily during a boom, and then shedding their least productive workers in an economic downturn.

The separate contributions of education, age and gender to the quality-adjusted labour input series can be calculated using the partial labour indices defined in Section 2, and shown in Chart 2 and Table B (columns 3-6). Changes in the educational composition of the workforce have had the greatest impact on the quality-adjusted labour input index, contributing 0.68pp of the 0.67pp annual average growth of the index (102% of the total contribution of labour quality). Changes in the age structure of the workforce have had a much smaller impact, contributing only 0.11pp (16% of the total contribution) on average per year in the period 1975-2002. This effect has been concentrated in

the period after 1990, contributing 0.23pp (25% of labour quality) between 1990 and 2002. Finally, changes in male and female shares of employment have had a small negative effect on labour quality throughout the period.

Table B: Quality-adjusted labour indices

	Unadjusted	Quality adjusted education, age & gender	FIRST-ORDER CONTRIBUTION Education	Age	Gender
Level of index					
1975	100.0	100.0	100.0	100.0	100.0
1980	98.9	99.3	101.2	98.3	98.2
1985	105.1	110.6	112.3	104.5	104.1
1990	116.7	125.1	127.1	116.8	114.9
1995	109.1	125.0	125.4	111.8	106.9
2002	113.6	136.1	136.5	117.0	111.0
Average annual contribution					
1975-2002		0.67	0.68	0.11	-0.08
1980-1990		0.66	0.63	0.06	-0.09
1990-2002		0.92	0.82	0.23	-0.06

4.1 Education impact

Educational attainment has had such a great impact on labour quality because the strongest growth in hours[(14)] (from 12.8% of total hours worked in 1975 to 43.2% in 2002) has been concentrated in the most highly paid groups, those with qualifications above GCSE (see Table C).[(15)] This has been further strengthened by the fact that the group with the lowest marginal product (as measured by wage per hour), those with 'other or no' qualifications, experienced a reduction in the number of hours worked over the period (from 61.1% of total hours worked in 1975 to 22.9% in 2002). The growth in the total hours worked by the most productive workers can partly be attributed to the rapid increase in the supply of people holding such qualifications. This is enhanced by a decline in average hours being concentrated in the lower paid educational groups. There has been a clear shift in the education distribution towards more educated workers over time. However, it is difficult to distinguish whether this was initially supply or demand driven. If it were completely supply driven, in a competitive labour market one would expect to see the relative wage of skilled people fall. However, the wage differential of the most productive groups relative to the least productive has not narrowed over the period.

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(14) The growth (fall) in total hours of qualified (unqualified) workers has been completely driven by the rise (fall) in employment, since the average number of hours worked has fallen continuously over the period, following its secular trend. For a more detailed analysis on average hours, see Shortall (2002).

(15) This result is even stronger if one considers a more disaggregated education classification (eight levels), since workers with degree or more are the most productive and have had the largest growth in hours (employment) over the sample. This is discussed further in the next section.

This can be seen in the wage data (Table C). Workers holding degrees relative to people with 'other or no qualifications' earned approximately 80% more in terms of hourly pay, both in 1975 and 2002. This suggests that, despite a large increase in supply of more educated workers, demand had also increased to the extent that relative wages have not fallen over the period.[16]

Table C: Components of the quality-adjusted labour index by education level

	Degree	A Level	O Level	Other qualificatons
Total hours				
Share in 1975	9.1	3.7	26.0	61.1
Share in 2002	29.9	13.3	33.9	22.9
Average annual growth rate 1975-2002	**4.5**	**4.9**	**1.0**	**-3.6**
Wage share				
Share in 1975	15.1	4.8	26.1	54.0
Share in 2002	41.5	13.7	28.6	16.2
Average annual growth rate 1975-2002	**3.8**	**4.0**	**0.3**	**-4.4**
Wage per hour (ratio to 'other quals')				
Level in 1975	1.8	1.5	1.1	1.0
Level in 2002	1.8	1.3	1.1	1.0
Average annual growth rate 1975-2002	**-0.1**	**-0.7**	**0.0**	**0.0**

4.2 Age impact

The change in the age composition of the workforce has also contributed to labour quality, particularly after 1990. There was a sharp fall in the hours share of 16-24 year olds, from 19.5% in 1990 to 12.3% in 2002 (see Table A.3 in appendix). This group of workers is the least productive in terms of hourly wages (35-44 year olds earned 70% more in 2002). This decline was coupled with an increase in the total hours share of older workers (the share of 35-60/65 year olds increased from 54.1% in 1990 to 62.3% in 2002). These workers also have higher average wages because they are more experienced, and hence more productive. Furthermore, the wages of the most productive age group (35-44 year olds) relative to the least productive group rose from 1.6 to 1.7 between 1990 and 2002. However, these positive contributions were partly offset by the fact that 25-34 year olds, who worked 26.4% of total hours in 1990, did not increase their hours worked during this period. Before 1990, the change in the age distribution was not enough to significantly increase the quality-adjusted input. The share of hours worked by 16-24 year olds remained constant from 1975-90. Meanwhile, the share of hours worked and the share of the wage bill of the most productive groups either fell slightly (45-60/65 year olds) or rose slightly (25-45 year olds), thus partially offsetting each other.

[16] This issue is covered in more detail in Section 4.4.

Two factors can explain why adjusting labour quality for age has had these effects. First, the period of rapid population growth after the Second World War has led to an increasingly older workforce. This in turn implies a more experienced workforce, which is on average more productive. Second, more people are remaining in education rather than joining the labour market after school. This has reduced the pool of young workers in the economy and so contributed to the fall in the hours share of 16-24 year olds from 1990 to 2002. Finally, it should be noted that, although changes in the age distribution have been important, the effect is small compared to the educational composition of the workforce, which explains most of the growth in the quality-adjusted index.

4.3 Gender impact

Adjusting labour input for gender composition marginally reduced the growth of labour quality in the period 1975-2002. It is important to note, however, that this result simply reflects the relative wage of men and women in the labour force. Throughout this period, there has been an increase in participation of women in the labour market, from 37.1% in 1975 to 45.6% in 2002 (Table A.4 in appendix). However, their wage-bill share only grew from 21.3% to 35.8% over the same period. This is because they worked fewer hours than men (31.2 hours per week compared with 42.0 for men in 2002), and because, their hourly pay was lower (men earned approximately 20% more per hour than women). There are several possible reasons for this. First, it could be due to women working more in part-time jobs that tend to be worse paid than equivalent full-time positions. But after restricting the sample to those working in full-time jobs, adjusting for gender still had a negative effect on labour quality, albeit slightly smaller.[(17)] Therefore, part-time work cannot fully explain the gender impact.

A reason why women might earn less than men may be that as they tend to transition in and out of the labour market more frequently than men, they do not build up as much human capital, which is then reflected in their wage. This cannot, however, be tested using the LFS, as data on lifetime employment does not exist.

An alternative explanation for why women earn less than men is that, on average, they are less well educated. This was true in 1975: the proportion of women holding degrees, A Levels and O Levels was less than men (Table A.12 in appendix). But by 2002, women were more educated than men (29% of women held degrees compared with 27% for men; 15% of women held A Levels compared with 13% for men). However, comparing the average wage of men and women with similar

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[(17)] From 1975-2002, adjusting for gender contributed –0.08pp to labour quality. Restricting the sample to full-time workers and adjusting for gender accounted for –0.06pp of the contribution of labour quality (see Table A.11 in appendix). From 1991-2002, the negative contribution of adjusting for gender for all workers was – 0.06pp for all workers compared with –0.04pp for full-time workers.

educational qualifications shows that in 2002, men with degrees or equivalent were paid 25% more per hour than women with degrees (Table A.7 in appendix). In fact, men were paid more per hour than women across all educational classifications.

The Tornqvist index that is used to derive labour quality assumes that workers are paid their marginal product and makes no allowance for any discrimination that may exist in the market. In the case of gender, this evidence suggests that this assumption does not hold, and this is a weakness of the model. The observed differences in pay levels may arise because women are unable, due to their personal circumstances, to take up higher paid jobs, or because of explicit pay discrimination (which does not reflect their inherent productivity). To account accurately for the quality effects of growth in participation of women in the labour market, we should include the first effect but adjust for the latter. Unfortunately, it is virtually impossible to separate these effects in our data. Finally, it should be noted that the overall impact on labour quality after adjusting for gender is small compared with the education and age effects.

4.4 Separating the effects of wages and hours

It is possible to decompose the effects of relative wages and hours growth to the contribution of labour quality. Keeping wages fixed at a predetermined level (eg 1975), one can assess the contribution of hours growth by group to the growth of the labour quality index.

Table D: Separating the effects of wages and hours growth in the labour quality index

	Adjusted for			
	Education, age & gender	Education	Age	Gender
Labour Quality Average annual contribution				
1975-2002	**0.67**	**0.68**	**0.11**	**-0.08**
Constant wages (1975 levels) Average annual contribution				
1975-2002	**0.83**	**0.84**	**0.10**	**-0.12**

The growth in labour quality can mainly be explained by hours growth rather than changes in relative wages across worker groups. But without an explicit model of segmented labour markets or skill-biased technical change it is very difficult to say anything about why this has been the case. In a standard competitive labour market framework, one would expect that if the relative supply of

skilled workers has increased, but the relative wages have remained constant, the relative demand of skilled workers must have also risen. When labour is adjusted for education, age and gender, and wages are fixed at 1975 levels, the index grows faster than the normal labour quality index (0.83pp compared to 0.67pp per annum from 1975-2002). This indicates that wage dispersion between groups has moved in favour of the least productive groups, that is, it has fallen in relative terms over time. Analysing the first-order indices separately reveals that wage dispersion has fallen slightly between educational groups, but increased slightly between age groups. Adjusting labour input for gender has a negative effect on labour input (-0.08pp from 1975-2002) and falls to -0.12pp per annum when wages are fixed at 1975 levels. This is because faster employment growth occurred among women than men.[18] Therefore, keeping wage differentials at 1975 levels has the effect of reducing the contribution further, since wage dispersion between men and women has fallen over time.[19]

4.5 Comparing with other results in the literature

Table E: Comparisons with previous work on labour quality in the United Kingdom

	Average annual growth rates (percentage points)		
	Pre-1979/80	Post-1979/80 - 1996	1994-2001
Card and Freeman (2002)	0.23	0.87	N/A
Lau (2002)	N/A	N/A	0.9
Bell, Burriel-Llombart and Jones (2005)	0.08	0.87	0.8

Table E shows how the results in our paper compare with previous work. The time periods reported above come from the results of Card and Freeman (2002) and Lau (2002). All the estimates appear consistent with each other. Card and Freeman (2002) used the GHS from 1974-96 while we can only report results from 1975-96. The small differences in the growth rates primarily reflect the differences between the GHS and LFS surveys. Lau (2002) uses the LFS to estimate the labour quality contribution from 1994-2001. The small differences with our results are because her estimate adjusts for education and age, while we in addition, adjust for gender.[20]

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[18] The total hours growth of men is less than the unadjusted (whole-economy hours growth) index and so has a negative effect on the contribution of gender. Therefore, holding wages at 1975 levels (when wage dispersion was highest) accentuates this negative contribution.

[19] If there is explicit pay discrimination increasing female participation will bias-down the index. However, declining pay discrimination will offset this.

[20] There are a variety of reasons that can cause small differences in the numbers. For example, the choice of education and age groups can affect the index. Another reason is that the LFS is periodically regrossed to reflect new population estimates.

5 Industry-level results

Although it would be interesting to consider the impact of changes in the industrial composition of the workforce on labour quality when combined with education, gender and age, this is not possible given the small sample size. Nevertheless, the analysis of the separate effect of industrial composition on aggregate labour quality will help shed some light on its importance. It is only possible to construct consistent industry-level data back to 1981. Chart 3 shows that using data disaggregated by ten industries adds 0.07pp to the growth of hours, while using data disaggregated by four industries has an insignificant effect of labour quality. Using data disaggregated by 48 industries over the period 1987-2002[(21)] adds a further 0.06pp to the 0.12pp per annum contribution of ten industries (see Chart 4). The level of disaggregation seems to have an impact on measured labour quality, especially from the early 1990s onwards. This is due to the fact that changes in composition within services and manufacturing have had the largest impact on labour quality and this cannot be captured by the more aggregated classification. In particular, changes in industrial composition occurred within manufacturing and energy/construction sectors and were not picked up by the more aggregated industrial classification. In addition, within *services*, the sector with the most productive groups, *financial services*, grew most from 1990-2002, while in *distribution* (one of the least productive groups), total hours fell. Although the industrial composition has some effect on labour quality, this can only be captured using a very disaggregated industrial classification. This is not feasible with our data.

Chart 3: Robustness of industrial classification

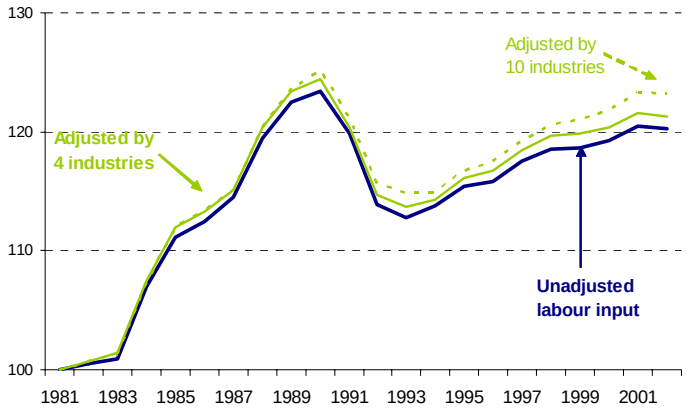
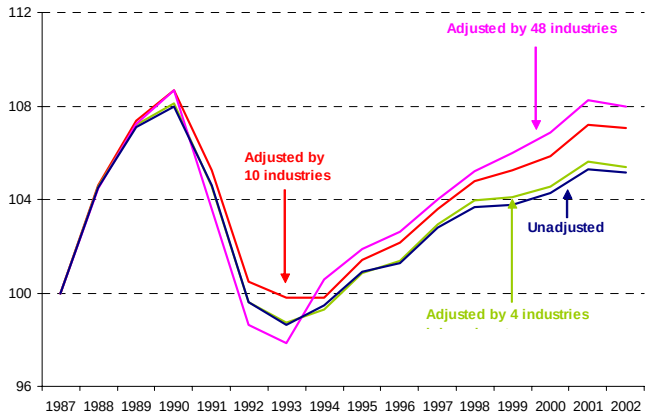


Chart 4: Robustness of industrial classification



[(21)] We cannot construct these series consistently for the whole sample period because the change in the industrial classification has important effects at such a disaggregated level. This change was implemented in the LFS in 1993.

Given the results in the previous paragraph, and the limitations imposed by the sample size, we have calculated labour input series separately by ten industries adjusted by four education levels. The resulting indices are reported in Tables A.8-A.10 and Chart A.7 in the appendix. They show that, although the growth in the unadjusted labour input has been quite different across industries, the contribution of labour quality (above hours growth) has been similar. From 1981-2002, the annual average contribution of labour quality has ranged between 0.26pp for the *agriculture* sector to 0.80pp for the *mineral extraction* sector (while annual hours growth has ranged between -3.3% for the energy sector to 4.5% for the *banking* sector). In the largest industrial sector, *other services*, labour quality contributed 0.59pp to the growth rate of hours, while in the second largest, *distribution*, it contributed 0.49 percentage points.[(22)] These relatively small differences are not surprising, since the industrial composition had a small effect on the aggregate quality-adjusted labour input series.

These results have interesting implications for more disaggregated studies since they suggest that the contribution of labour quality is largely independent of the industrial breakdown used. If, for example, one wanted to study labour productivity separately for 48 industries, using quality-adjusted labour input series calculated separately for each of the 48 industries, this would be almost equivalent to using quality-adjusted labour series calculated separately for ten industries.

Finally, these results are also in line with the results of the related literature on skill-biased technical change. This literature has shown (see Katz and Autor (1999) for a survey) that most of the recent change in labour quality across developed economies has been due to common skill-biased technical change across the economy and it has, therefore, occurred within rather than between industries.

6 Robustness of results

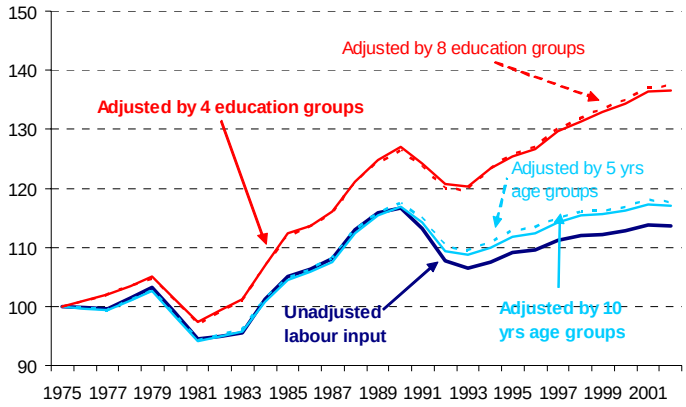
In this section we examine the robustness of the reported results to changes in the level of aggregation and/or definitions of the classifications used. The reason for looking at the data at a more disaggregated level is that changes in wage shares and hours growth may be occurring within groups that may be hidden from the index at a more aggregated level. Finally, we also study the quality of the matching in the data of worker types between the GHS and LFS surveys.

[(22)] The contribution of the two largest sectors, *other services* and *distribution* was 0.57pp and 0.65pp respectively from 1990-2002.

6.1 Expanding the number of education and age groups

We considered expanding education into 8 groups and age into 10 five-year groups.[23] In addition, we have checked whether considering only full-time workers or private sector workers changes any of the results. Finally, we have also assessed the sensitivity of the result to the definition of hours used.

Chart 5: Robustness of age and education classifications



Using eight levels of education raises the average annual growth rate of the quality-adjusted labour input by 0.03pp per annum above the growth rate using four education levels (see Chart 5). This is because this classification separately identifies workers with a degree or above[24] (see table A.2 in the appendix). This group contains the most productive workers (earning twice as much as those with no qualifications in 2002) and has had the second highest growth in total hours over the sample.

Re-defining the age groups using 10 five-year bands, instead of 5 ten-year bands, marginally increases the average annual growth rate of the quality-adjusted labour input by a further 0.02pp per annum (see Chart 5). This is due to the fact that within-group variation in the age composition is biased towards increases in relatively more productive groups. Finally, re-defining age groups into equally sized groups also has a negligible effect on the index.

[23] In Section 4 we used four education groups and five age groups.
[24] When education is classified into four groups, people with degrees were combined with people with high vocational qualifications (see Table A.2 in appendix).

6.2 Occupation

We assess whether occupation is a good proxy for education. If this is the case, adjusting labour quality for occupation should lead to similar results as adjusting for education. Chart A.5 demonstrates that occupation is not a good proxy for education, since it captures less than half of the contribution of education (0.19pp per annum compared with 0.69pp per annum for education from 1993-2002). This led us to discard the NES as an alternative data source since it only includes information on occupation.

So far in this paper we have used all the employed workers included in the sample for our calculations. However, there are reasons to exclude certain workers due to their characteristics: in particular, part-time workers and public sector workers.

6.3 Full-time workers

One argument supporting the exclusion of part-time workers is that they are more likely to be subject to pay discrimination (part-time employment is less regulated). If workers are not paid their marginal product, the labour quality index will be distorted. In fact, restricting attention to full-time workers only has a small effect on the contribution of labour quality to the growth of labour input, increasing it by 0.03pp per year from 1975-2002 and 0.04pp per year from 1990-2002 (see Chart A.3 and Table A.6, in the appendix). This is because it shifts down both the unadjusted and adjusted measures of labour input by almost the same proportion. The main reason for this is that total hours grew by less for full-time workers than for part-time workers over the sample period, due to both lower employment growth and a larger reduction of average hours.

6.4 Private sector workers

Many studies that try to measure total factor productivity do not consider public sector workers since it is very difficult to measure their output and hence their productivity.[(25)] However, considering only private sector workers has an negligible effect on labour quality (0.61pp per year from 1994-2002 compared to 0.62pp per year for all workers). The only consequence is to proportionally shift up the profile of both the unadjusted and adjusted labour indices (see Chart A.2 and Table A.6, in the appendix). This is because hours growth is greater for private sector workers than for public sector workers because of faster employment growth in the former. The small difference in the contributions to the labour input series is due differences in the education distribution.

[(25)] However, this is problematic since the LFS only provides a variable indicating whether an individual is employed by the public or private sector from 1993. We have tried constructing a proxy using the industrial sector and the share of public workers in each sector, but it does not seem to capture this characteristic correctly. This is because the share of public sector workers in each industrial sector varies over time.

6.5 Actual hours worked

Considering actual hours worked (instead of usual hours) has a very small effect on the contribution of labour quality to the growth of labour input, increasing it by 0.03pp per year (see Chart A.4 and Table A.6, in the appendix). This is due to the fact that usual hours have grown quicker than actual hours over the sample period, although this growth has been similar across the different worker characteristics considered. It is noticeable from Chart A.4 that the level of actual hours in 2002 is similar to the level in 1975, while usual hours have grown. This is because actual hours appear quite erratic near the beginning of the sample. From 1981 onwards, the growth rates of usual and actual hours are similar.

6.6 Matching of worker types between the GHS and LFS surveys

Finally, a key issue in this work is the accuracy with which worker types can be matched between the GHS and the LFS surveys. The LFS was seen as the benchmark survey because it is larger than the GHS and is also population weighted. Gender and age distributions are almost identical in both surveys. Educational distributions are also quite consistent (see Table A.13 in the appendix). There are some small discrepancies in the match between 'GCSE or equivalent' and 'other qualifications'. Most of these differences arise from the differential ranking of apprenticeship qualifications in the two surveys. Average weekly wages in the GHS and LFS are also consistent (see Chart A.8 in the appendix). The data is less reliable in the 1970s, especially in the years when the LFS was not published. However, measures of labour quality should be examined over a long period (average annual growth rates are reported in this paper), because annual figures tend to be volatile. Overall, we believe these differences are not big enough to alter fundamentally our results.

7 Applications of research

A standard production function, as proposed by Solow (1957) can be rearranged to show that:

$$\frac{\dot{A}_t}{A_t} = \frac{\dot{Y}_t}{Y_t} - S_t^{\,K}\frac{\dot{K}_t}{K_t} - S_t^{\,L}\frac{\dot{L}_t}{L_t} \qquad \textbf{(3)}$$

$\frac{\dot{Y}_t}{Y_t}, \frac{\dot{K}_t}{K_t}$ and $\frac{\dot{L}_t}{L_t}$ are the growth rates of output, capital and labour respectively. S_t^K and S_t^L are the income shares of capital and labour, and in a scenario of constant returns to scale, $S_t^K + S_t^L = 1$. The term $\frac{\dot{A}_t}{A_t}$ is the growth rate of the Hicks-neutral shift parameter and is a measure of the growth of output that cannot be explained by the growth in inputs. This term, commonly referred to as the Solow residual, is not directly observable and is referred to as total factor productivity growth (TFP). If factor inputs are only measured in terms of quantity, then any quality changes to these inputs will

manifest in this residual value. The effect of accounting for changes in labour quality is to reallocate some of this residual value into the growth rate of labour input. The contribution of labour input to output growth increases, while the contribution of the residual decreases.[26]

It has been shown that labour input adjusted for the education, age and gender distributions of the United Kingdom has added on average 0.67pp per year to the growth rate of unadjusted labour input. In other words, using total hours growth in the economy to measure labour has underestimated true labour input by 20% over the period 1975-2002. This evidence can be used to better explain TFP growth in the United Kingdom. The key finding in this paper is that a large proportion of what is usually considered to be TFP growth can be attributed to an increase in the quality of the labour input. This result has no implications for the measurement of UK growth from 1975-2002, but it does help us to identify more accurately the sources of growth during this period, and this may be useful in forecasting output growth and hence potential inflationary pressures.[27]

Chart 6.1 shows TFP growth using unadjusted hours against TFP growth with labour input adjusted for quality (both measures use usual hours worked).[28] Once the labour input has been adjusted for quality, TFP growth is reduced by approximately 50% over the period 1975-2002. That is, 50% of the residual value that was referred to as TFP can actually be accounted for by a more accurate measure of labour input.

Chart 6.1: TFP level using usual hours worked

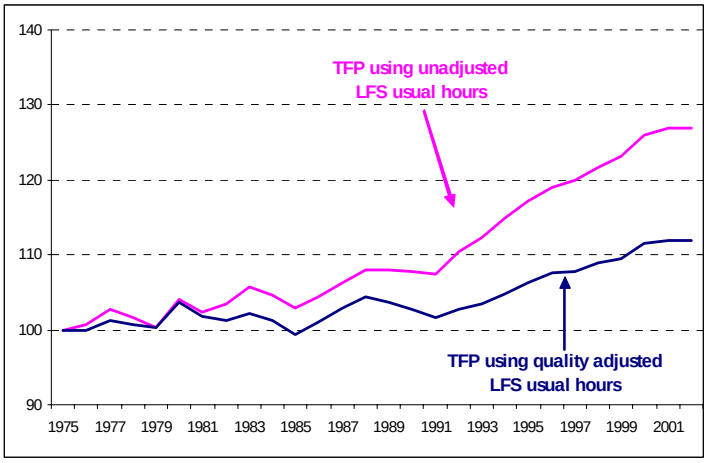
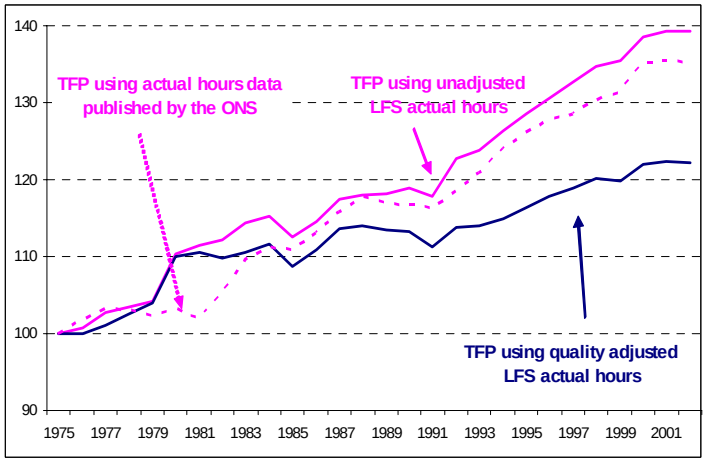


Chart 6.2: TFP level using actual hours worked



[26] The same is true if capital is adjusted to reflect changes in quality. This is beyond the scope of this paper.
[27] The microdata from the LFS has been regrossed to reflect the 2001 census, but not to all subsequent revisions.
[28] GDP at factor prices is used in this growth accounting exercise. Capital and labour shares (in the production function) are fixed at 0.3 and 0.7 respectively.

When actual hours[29] are used as a basis for its TFP calculations, a quality-adjusted measure of labour input reduces TFP by approximately 40% over the period 1975-2002 (Chart 6.2).

Charts 7.1 and 7.2 show the varying contributions of capital, labour and TFP to GDP growth over time. The former uses unadjusted usual hours while the latter uses quality-adjusted usual hours.

Chart 7.1: Contributions to GDP growth using unadjusted labour input

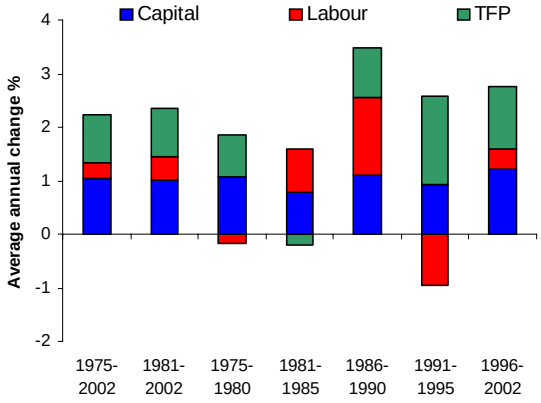
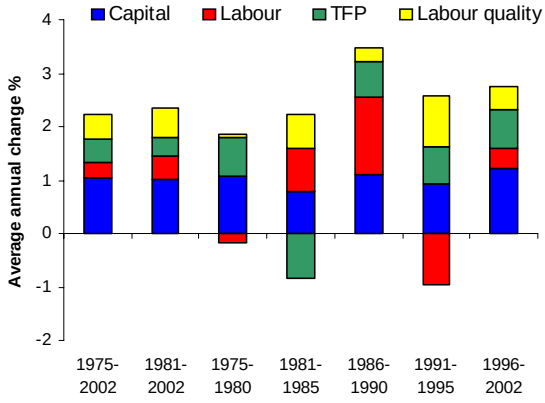


Chart 7.2: Contributions to GDP growth using quality-adjusted labour input



Improvements in labour quality were particularly important in explaining economic growth during the 1980s. During the early 1990s' recession, relatively high unemployment led to a fall in the volume of hours worked in the economy (Chart 7.1). However, on a quality-adjusted hours basis, effective hours rose fractionally as firms kept their most skilled workers. This is a good example of how adjusting for labour quality might affect a policymaker's assessment of the balance between demand and supply.

Labour quality grew in the late 1990s, but slowed relative to the 1980s. Using unadjusted hours, TFP growth appears to have increased in the early 1990s relative to the late 1980s. However, when labour is quality adjusted, TFP growth actually declines steadily from the mid-1980s.[30]

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[29] Our measure of actual hours is derived from the individual microdata files of the LFS. These files do not necessarily include all the revisions in the data that happened after its release. This may explain the slight differences with the official series of actual hours published by the ONS (dashed line in the charts).

[30] This slowdown in UK TFP growth in the late 1990s relative to the early 1990s is consistent with Basu *et al* (2003). Differences in the precise numbers are due to methodology: for example Basu *et al* (2003) use a different measure of capital, make an ICT adjustment to GDP, vary the shares of capital and labour over time and only include the private sector.

Table F: Average annual TFP growth

Usual hours		
	TFP using unadjusted hours	TFP using quality-adjusted hours
1975-2002	0.9%	0.4%
1981-2002	0.9%	0.3%
1975-1980	0.8%	0.7%
1981-1985	-0.2%	-0.9%
1986-1990	0.9%	0.7%
1991-1995	1.7%	0.7%
1996-2002	1.2%	0.7%

Actual hours		
	TFP using unadjusted hours	TFP using quality-adjusted hours
1975-2002	1.2%	0.7%
1981-2002	1.1%	0.5%
1975-1980	2.0%	1.9%
1981-1985	0.4%	-0.2%
1986-1990	1.1%	0.8%
1991-1995	1.6%	0.6%
1996-2002	1.1%	0.7%

The tables above show TFP before and after labour input has been quality adjusted. The implication of these results is that a large proportion of what is usually considered to be TFP can be attributed to an increase in the quality of labour input. While it is very difficult to forecast labour input and TFP growth accurately, it is easier do so for something that we can explicitly identify (labour quality) than something that we cannot (TFP). This is important because, if quality-adjusted labour input growth has been a key driver of economic growth in the past, then predicting to what extent it will rise in the future is important in understanding future growth and hence inflationary prospects for the economy. In order to analyse the long-term effects of changes in labour quality on potential supply, it is important to take into account the counter-cyclical nature of the index. This is because it is a measure of the average quality of those in employment, not the average quality of potential labour

supply: as the labour market tightens, firms have to recruit the less productive workers, causing a reduction in average quality.

Labour quality can only grow if both the supply and demand for skilled workers increases. If the demand for skilled workers remained constant, a rise in the supply of these workers would, by itself, lead to a fall in their relative wage. This in turn would lead to a fall in their wage-bill share. However, relative wages have remained roughly constant between 1975 and 2002. Therefore, it must be the case that firms have preferred to employ skilled workers even though they are more expensive. That is, demand has shifted in their favour.[31]

From 1975 to 2002, growth of quality-adjusted labour input is largely accounted for by an increase in the overall education level of the population, coupled with an even stronger rise in the demand for skilled individuals. Looking at university and higher education enrolment rates may indicate whether the supply of skilled labour will increase at the same rate in the future. But it is much more difficult to predict the future trend in the demand for skilled labour and consequently the net effect on wages and employment.

Gender has had a small negative effect on labour quality from 1975 onwards, as more women joined the labour market. This negative effect can be mainly attributed to women being on average less educated than men over the period. However, by 2002, women in employment were as well educated as their male counterpart, which is reflected in a narrowing of the wage differential (see Table A.7). This wage differential is likely to continue to narrow in the future, especially if additional anti-discrimination measures are implemented, while more flexible work practices will enable women to combine work and family responsibilities more easily (and thus accumulate more human capital). Therefore, any further rise in female employment is unlikely to lower labour quality.

The effect of an ageing population has had a positive effect on labour input, especially from 1990 onwards. These 'baby boomers' will probably continue to have a positive effect on labour input until they retire. If these three factors continue to follow their actual trend, one would expect labour quality to keep on growing, at least in the medium term.

8 Conclusion

This paper presents annual indices of labour input adjusted for the education, age and gender distribution of the UK workforce for the period 1975-2002. These measures show that improvement

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[31] To forecast TFP, a theoretical model is required that would establish how TFP (and many other factors) affect the demand for skilled workers (eg, a model with skill-biased technological change).

in labour quality has added on average 0.67pp per year to the growth rate in total labour input. Changes in the education distribution more than account for the improvement in labour quality, adding 0.68pp per annum. Changes in the age distribution have had a much smaller contribution, adding only 0.11pp to the growth rate, while the rise in female participation has had a small negative effect of –0.08 percentage points.

These results are broadly robust to more disaggregated definitions of the characteristics as well as to the consideration of more characteristics of workers, like the industrial sector. In addition, the results remain unchanged if one considers only full-time or private sector workers. We calculated labour input series separately by ten industries adjusted by four education levels and discovered that the contribution across industries was similar. This suggests that the contribution of labour quality is fairly independent of low-level industrial breakdowns.

In a standard growth accounting framework, the residual value (TFP) is the growth in output that cannot be accounted for by the growth inputs. The effect of accounting for changes in labour quality is to reallocate some of this residual value into the growth rate of labour input. The contribution of labour input to output growth increases, while the contribution of the residual decreases. Our analysis shows that apparent TFP growth is reduced by over 50% when labour input is quality adjusted; that is, over 50% of previously unexplained growth may be attributed to increases in labour quality. The implication of this result is that a significant proportion of economic growth can be attributed to an improvement in the labour quality of the workforce.

Appendix

Chart A.1 Contributions of the components of the quality-adjusted labour index

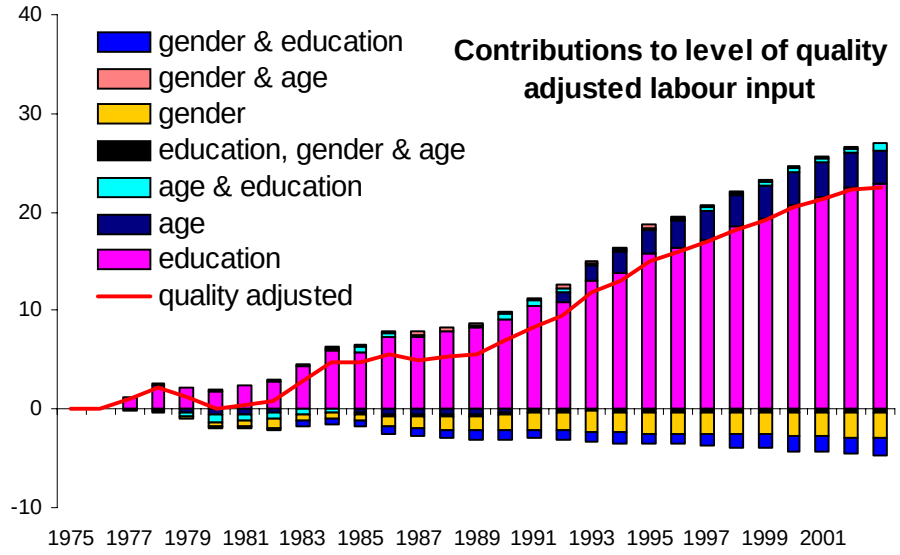


Table A.1 Labour force classification

Gender	Male, female.
10 years age groups	16-24, 25-34, 35-44, 45-54, 55-64 (-59 for female).
5 years age groups	16-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64 (male only).
4 education levels	Other qualifications, GCSE or equivalent, A Level or equivalent, degree or equivalent.
8 education levels	No qualifications or Other vocational qualifications, Other academic qualifications, Low vocational, GCSE, Mid vocational, A Level, High vocational, degree or higher.
4 industries	Agriculture, energy & construction, manufacturing, services.
10 industries (SIC92)	Agriculture, energy & water, minerals, metal goods, other manufacturing, construction, distribution, transport, banking, other services.
9 occupation levels (SOC-92)	Managers, professional, associate professional and technical, clerical, craft, personal and protective service, sales, operators, other.

Table A.2 Classification of qualifications

4 GROUPS	8 GROUPS	QUALIFICATIONS
BELOW GCSE	OTHER VOCATIONAL OR NO QUALIFICATIONS	NVQ level 1, GNVQ foundation level, SCOTVEC modules, YT/YTP certificates, RSA other, City and Guilds 'other', BTEC/SCOTVEC general certificate.
	OTHER ACADEMIC	CSE below grade 1, GCSE below grade C.
GCSE OR EQUIVALENT	LOW VOCATIONAL	NVQ level 2, GNVQ intermediate level, RSA diploma, City and Guilds Advanced and Craft level, BTEC/SCOTVEC general diploma and completed apprenticeship.
	GCSE	O Level, CSE grade 1, GCSE grade A to C.
A LEVEL OR EQUIVALENT	MID VOCATIONAL	NVQ level 3, GNVQ advanced level, RSA advanced diploma, ONC, OND, BTEC/SCOTVEC national level.
	A LEVEL	A Level, AS Level, Scottish 6th year Certificate, SCE higher level.
DEGREE LEVEL	HIGH VOCATIONAL	Nursing qualifications, NVQ level 4-5, GNVQ advanced level, RSA higher diploma, HNC, HND, BTEC/SCOTVEC higher level.
	DEGREE	Graduate and Undergraduate Degree, all teaching qualifications.

Table A.3 Components of the quality-adjusted labour index by 5 age groups

	16-24	25-34	35-44	45-54	65
Total hours					
Share in 1975	19.3	23.1	21.2	22.6	13.8
Share in 1990	19.5	26.4	25.0	19.5	9.6
Share in 2002	12.3	25.3	27.8	23.5	11.0
Average annual growth rate					
1975-2002	-1.6	0.3	1.0	0.1	-0.8
1990-2002	-3.8	-0.3	0.9	1.6	1.2
Wage share					
Share in 1975	13.4	24.6	23.2	24.0	14.8
Share in 1990	13.0	27.9	27.5	21.8	9.8
Share in 2002	8.7	26.5	30.3	24.6	10.0
Average annual growth rate					
1975-2002	-1.6	0.3	1.0	0.1	-1.5
1979-1990	-1.4	0.9	1.4	-0.1	-3.1
1990-2002	-3.3	-0.4	0.8	1.0	0.2
Wage per hour (ratio to 16-24 year olds)					
Level in 1975	1.0	1.5	1.5	1.5	1.5
Level in 1990	1.0	1.6	1.6	1.7	1.5
Level in 2002	1.0	1.6	1.7	1.7	1.5
Average annual growth rate					
1975-2002	0.0	0.1	0.4	0.4	0.1
Average hours					
Level in 1975	40.4	40.1	39.2	39.4	40.8
Level in 1990	36.8	40.3	39.8	39.3	38.5
Level in 2002	31.0	39.0	38.0	38.3	36.3
Average annual growth rate					
1975-2002	-1.0	-0.1	-0.1	-0.1	-0.4
Number of workers					
share in 1975	18.7	23.0	21.6	23.1	13.7
share in 1990	20.7	25.6	24.6	19.3	9.7
share in 2002	14.7	24.1	27.1	22.8	11.3
Average annual growth rate					
1975-2002	-0.9	0.2	1.0	0.0	-0.8

Table A.4 Components of the quality-adjusted labour index by gender

	Men	Women
Total hours		
Share in 1975	70.1	29.9
Share in 2002	61.7	38.3
Average annual growth rate		
1975-2002	**-0.5**	**0.9**
Wage share		
Share in 1975	78.7	21.3
Share in 2002	64.2	35.8
Average annual growth rate		
1975-2002	**-0.7**	**1.9**
Wage per hour (ratio to women)		
Level in 1975	1.6	1.0
Level in 1990	1.4	1.0
Level in 2002	1.2	1.0
Average annual growth rate		
1975-2002	**-0.8**	**0.0**
Average hours		
Level in 1975	44.7	31.9
Level in 1990	45.0	31.2
Level in 2002	42.0	31.2
Average annual growth rate		
1975-2002	**-0.2**	**-0.1**
Number of workers		
Share in 1975	62.9	37.1
Share in 1990	57.1	42.9
Share in 2002	54.4	45.6
Average annual growth rate		
1975-2002	**-0.5**	**0.8**

Table A.5 Components of the quality-adjusted labour index by ten industries

	Agriculture, forestry, fishing	Energy and water supply	Minerals, ores, metals, chemicals	Metal goods, engineering, vehicles	Other manufacturing industries
Total hours					
Share in 1981	3.2	3.7	4.5	14.0	11.9
Share in 1990	2.6	2.5	3.5	11.1	9.7
Share in 2002	1.6	1.5	2.4	8.4	6.9
Average annual growth rate					
1981-2002	**-3.4**	**-4.2**	**-2.9**	**-2.4**	**-2.6**
1981-1990	-2.3	-4.0	-2.9	-2.5	-2.3
1990-2002	-4.2	-4.4	-2.9	-2.3	-2.8
Wage share					
Share in 1981	1.9	5.1	5.1	15.1	11.2
Share in 1990	1.5	3.5	4.0	12.0	9.3
Share in 2002	0.6	2.0	3.1	9.5	6.5
Average annual growth rate					
1981-2002	**-5.5**	**-4.3**	**-2.4**	**-2.2**	**-2.5**
1981-1990	-2.6	-3.9	-2.8	-2.5	-2.0
1990-2002	-7.6	-4.6	-2.1	-2.0	-2.9
Wage per hour relative to agriculture					
Share in 1981	1.0	2.6	2.2	2.1	1.8
Share in 1990	1.0	2.5	2.0	1.9	1.7
Share in 2002	1.0	2.0	1.8	1.6	1.5
Average annual growth rate					
1981-2002		**-1.4**	**-1.0**	**-1.1**	**-0.9**
1981-1990		-0.8	-0.8	-0.9	-0.6
1990-2002		-1.9	-1.1	-1.3	-1.2

	Construction	Distribution, hotels&catering, repair	Transport and communication	Banking, financial & business service	Other services
Total hours					
Share in 1981	7.7	17.9	7.1	7.3	22.7
Share in 1990	9.2	18.5	7.1	11.4	24.4
Share in 2002	8.5	17.2	8.0	15.3	30.3
Average annual growth rate					
1981-2002	**0.4**	**-0.2**	**0.6**	**3.6**	**1.4**
1981-1990	2.0	0.4	0.0	5.0	0.8
1990-2002	-0.7	-0.6	1.0	2.5	1.8
Wage share					
Share in 1981	8.3	12.0	7.9	8.7	24.7
Share in 1990	9.3	12.8	7.1	14.0	26.4
Share in 2002	6.1	13.4	7.8	19.5	31.4
Average annual growth rate					
1981-2002	**-1.4**	**0.5**	**0.0**	**3.9**	**1.1**
1981-1990	1.3	0.8	-1.2	5.5	0.7
1990-2002	-3.4	0.4	0.9	2.8	1.5
Wage per hour relative to agriculture					
Share in 1981	2.0	1.2	2.0	2.2	2.0
Share in 1990	1.8	1.2	1.7	2.2	1.9
Share in 2002	1.6	1.2	1.5	2.0	1.6
Average annual growth rate					
1981-2002	**-1.1**	**-0.2**	**-1.4**	**-0.3**	**-1.2**
1981-1990	-1.2	-0.3	-1.7	-0.1	-0.7
1990-2002	-1.1	-0.2	-1.1	-0.4	-1.6

Table A.6 Robustness analysis

	Adjusted by gender, age, education	Adjusted by education	Adjusted by age group	Adjusted by gender
All workers				
Average annual contribution				
1975-2002	0.67	0.68	0.11	-0.08
1980-1990	0.66	0.63	0.06	-0.09
1990-2002	0.92	0.82	0.23	-0.06
Full-time workers (usual hours)				
Average annual contribution				
1975-2002	0.70	0.64	0.14	-0.06
1980-1990	0.71	0.58	0.12	-0.09
1990-2002	0.96	0.80	0.27	-0.04
All workers (actual hours)				
Average annual contribution				
1975-2002	0.70	0.69	0.10	-0.07
1980-1990	0.66	0.62	0.05	-0.09
1990-2002	0.97	0.85	0.23	-0.06
Private sector workers only (in brackets is a comparison with all workers over same period)				
Average annual contribution				
1994-2002	0.61 (0.62)	0.62 (0.59)	0.06 (0.09)	-0.03 (-0.04)

Chart A.2 Private sector workers vs. all workers

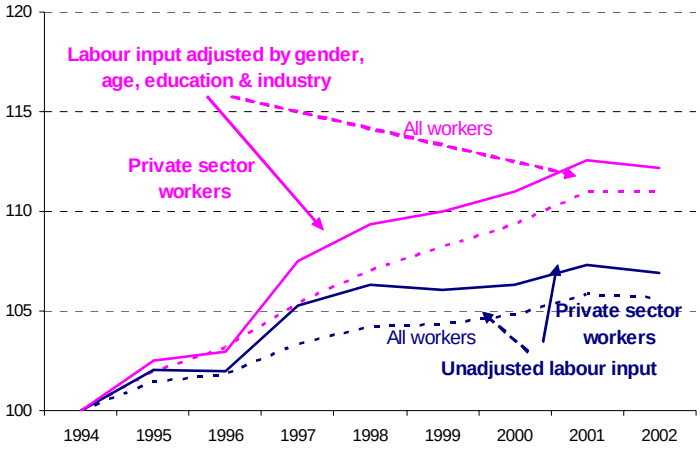


Chart A.3 Full-time workers vs. all workers

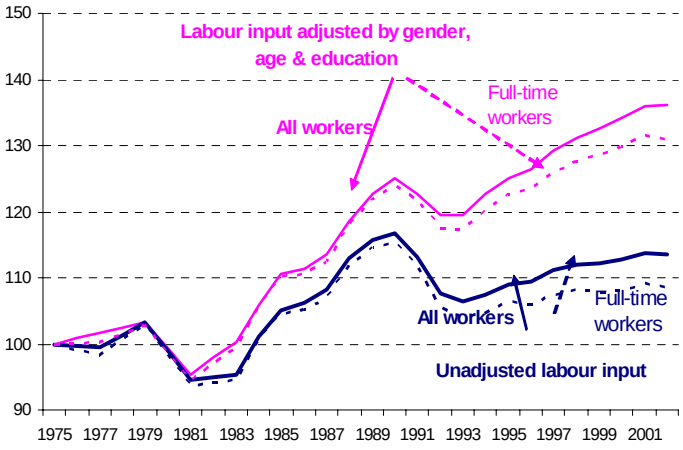


Chart A.4 Usual vs. actual hours

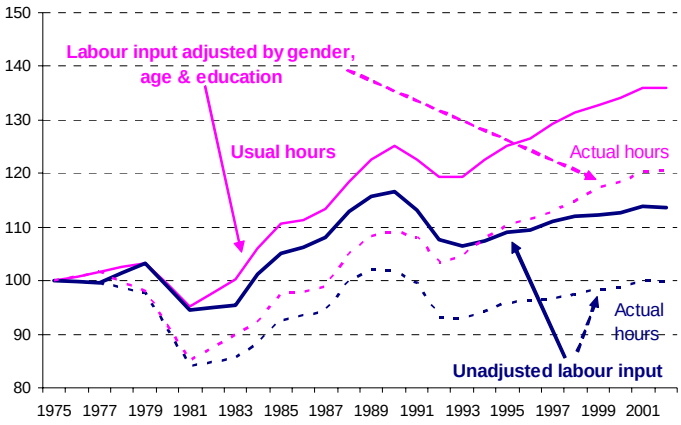


Chart A.5 Education-based skills vs. occupation based skills

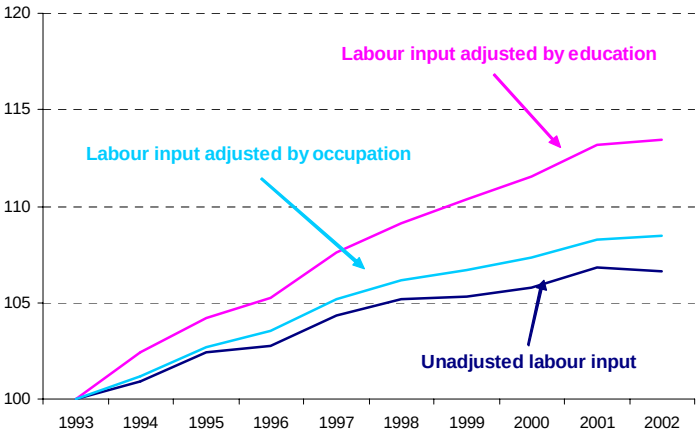
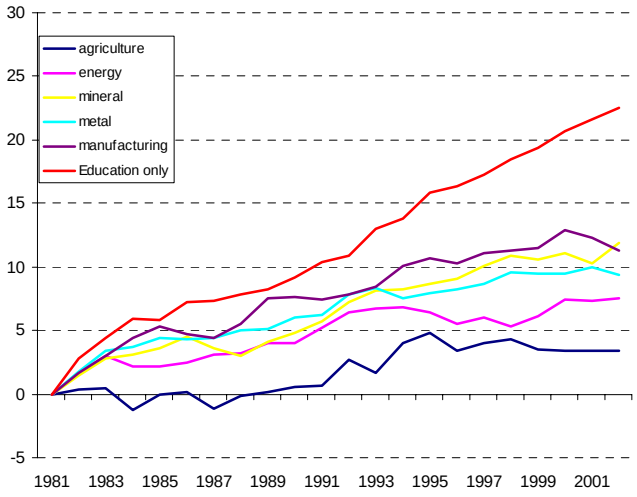


Table A.7 Ratio of male to female average wage by educational attainment

	Degree	A Level	O Level	Other qualifications
1975	1.37	1.30	1.45	1.62
1980	1.34	1.53	1.60	1.59
1985	1.31	1.34	1.33	1.53
1990	1.30	1.33	1.38	1.45
1995	1.24	1.38	1.33	1.28
2002	1.25	1.28	1.27	1.27

Chart A.7 Contribution of education to the industry-level quality-adjusted labour input



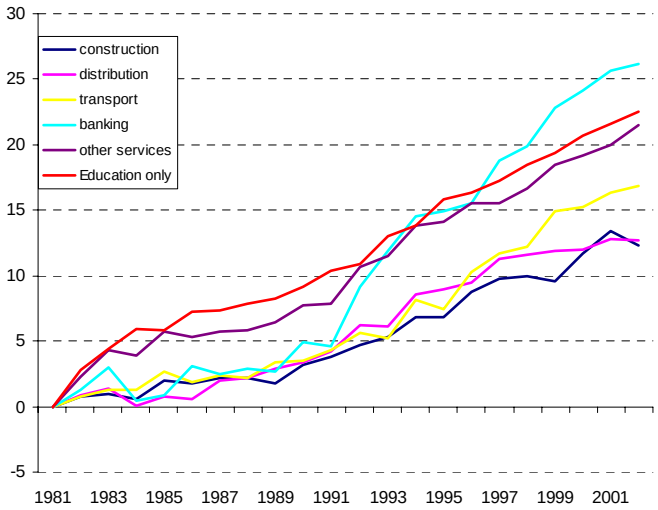


Table A.8 Industry-level labour indices adjusted for four education levels

	Agriculture	Energy	Minerals	Metal goods	Other manufacturing	Construction	Distribution	Transport	Banking	Other services
1981	100	100	100	100	100	100	100	100	100	100
1985	101	96	93	100	110	124	118	111	141	126
1990	102	90	100	105	109	152	133	128	199	141
1995	91	58	85	88	97	132	128	129	218	157
2002	63	57	77	82	82	145	130	153	280	183
average growth 1981-2002	**-2.20**	**-2.67**	**-1.23**	**-0.94**	**-0.96**	**1.80**	**1.24**	**2.05**	**5.02**	**2.92**
average growth 1981-1990	**0.20**	**-1.14**	**0.05**	**0.52**	**0.97**	**4.79**	**3.19**	**2.74**	**7.93**	**3.91**
average growth 1990-2002	**-4.88**	**-3.86**	**-2.17**	**-1.66**	**-2.05**	**0.49**	**-0.06**	**1.74**	**3.31**	**2.40**

Table A.9 Industry-level labour indices unadjusted

	Agriculture	Energy	Minerals	Metal goods	Other manufacturing	Construction	Distribution	Transport	Banking	Other services
1981	100	100	100	100	100	100	100	100	100	100
1985	101	94	89	95	105	122	117	108	140	120
1990	101	86	96	99	101	149	129	124	194	133
1995	86	51	77	80	86	125	119	121	203	143
2002	59	49	65	73	70	133	117	136	254	162
average growth 1981-2002	**-2.46**	**-3.34**	**-2.02**	**-1.51**	**-1.66**	**1.38**	**0.75**	**1.48**	**4.53**	**2.31**
average annual 1981-1990	**0.14**	**-1.64**	**-0.50**	**-0.14**	**0.16**	**4.55**	**2.89**	**2.43**	**7.62**	**3.26**
average growth 1990-2002	**-5.30**	**-4.57**	**-3.13**	**-2.15**	**-2.70**	**-0.06**	**-0.69**	**0.98**	**2.61**	**1.77**

Table A.10 Contribution of education to the annual average growth rate of the industry-level adjusted labour input

	Agriculture	Energy	Minerals	Metal goods	Other manufacturing	Construction	Distribution	Transport	Banking	Other services
1981										
1985	1.07	0.13	0.63	0.68	0.56	1.09	0.60	1.33	0.19	1.21
1990	0.38	-0.22	0.68	0.85	0.43	0.89	0.39	0.10	1.05	0.87
1995	0.79	-0.17	0.31	0.18	0.68	0.08	0.31	-0.85	-0.02	0.07
2002	0.14	-0.19	2.23	0.13	-0.69	-0.80	-0.06	0.33	0.11	0.58
average contribution 1981-2002	**0.26**	**0.68**	**0.80**	**0.58**	**0.71**	**0.42**	**0.49**	**0.55**	**0.47**	**0.59**
average contribution 1981-1990	**0.06**	**0.50**	**0.54**	**0.66**	**0.81**	**0.23**	**0.28**	**0.30**	**0.28**	**0.63**
average contribution 1990-2002	**0.42**	**0.82**	**0.99**	**0.51**	**0.63**	**0.56**	**0.65**	**0.74**	**0.61**	**0.57**

Table A.11 Labour quality-adjusted by gender for all workers and full-time workers

				FULL TIME ONLY		
	Unadjusted	Quality adjusted education, age & gender	Adjusted for gender	Unadjusted	Quality adjusted education, age & gender	Adjusted for gender
Level of index						
1975	100.0	100.0	100.0	100.0	100.0	100.0
1980	98.9	99.3	98.2	98.3	98.6	98.0
1985	105.1	110.6	104.1	104.4	110.1	103.7
1990	116.7	125.1	114.9	115.4	124.1	114.0
1995	109.1	125.0	106.9	106.4	122.7	104.8
2002	113.6	136.1	111.0	108.5	131.1	106.7
Average annual contribution						
1975-2002		0.67	-0.08		0.70	-0.06
1980-1990		0.66	-0.09		0.71	-0.09
1990-2002		0.92	-0.06		0.96	-0.04

Table A.12 Educational distribution by gender

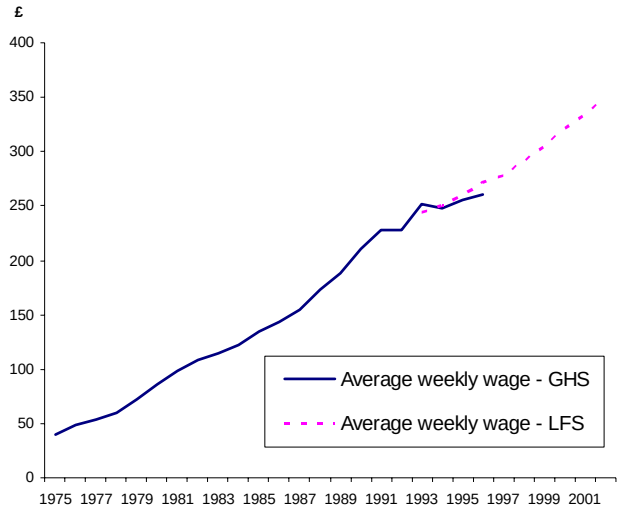
Educational distribution of workforce by gender								
	Degree		A Level		O Level		Other qualifications	
	Female	Male	Female	Male	Female	Male	Female	Male
1975	9%	10%	2%	4%	25%	27%	65%	59%
1980	12%	12%	5%	6%	19%	19%	63%	62%
1985	15%	16%	8%	9%	28%	36%	50%	40%
1990	16%	17%	10%	10%	32%	39%	42%	34%
1995	23%	24%	10%	10%	33%	39%	34%	28%
2002	29%	27%	15%	13%	32%	36%	24%	23%

Table A.13 Comparison of educational distribution in the GHS and LFS

	Educational distribution							
	General Household Survey (GHS)				Labour Force Survey (LFS)			
	Degree	A Level	O Level	Other quals	Degree	A Level	O Level	Other quals
1975	9	4	26	61	9	4	26	61
1976	9	4	27	60	10	4	27	59
1977	11	5	28	56	11	5	28	56
1978	12	5	29	55	12	5	23	60
1979	11	5	28	55	12	6	19	64
1980	12	5	29	53	12	6	19	62
1981	12	6	30	52	13	6	20	61
1982	14	6	30	50	14	7	23	56
1983	14	6	32	48	16	7	27	50
1984	15	7	31	46	15	7	32	46
1985	17	9	30	44	15	8	33	44
1986	17	10	32	42	16	8	29	47
1987	17	9	33	42	16	8	31	45
1988	17	9	31	43	16	9	31	45
1989	17	9	32	41	16	9	35	40
1990	18	10	32	40	17	10	36	37
1991	18	10	33	39	17	11	37	36
1992	19	10	35	36	20	10	37	33
1993	20	11	34	35	22	9	34	35
1994	19	12	34	35	23	10	36	31
1995	21	11	33	35	23	10	36	31
1996	21	12	33	35	24	10	36	30

Data from the LFS was interpolated when the survey was conducted on a biannual survey (see Section 3).

Chart A.8 Weekly wages in the GHS and LFS



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