Quality–adjusted labour input: new estimates for 1993 to 2008

Alex Turvey
HM Revenue & Customs (formerly Office for National Statistics)

Peter Goodridge
Imperial College London

Mark Franklin
Office for National Statistics

Summary

Quality–adjusted labour input (QALI) is a measure of labour input which takes account of the quality of the workforce as well as volume of hours worked. It provides a more complete picture of the input of labour to the production process than traditional measures, which focus only on the quantity of labour input, and is therefore more suitable for assessing productivity performance. Along with the volume index of capital services, QALI is a key input to multi–factor productivity and growth accounting analyses (see Long and Franklin 2010 for the latest estimates).

This article presents new estimates of QALI for 1993 to 2008, which are the result of significant development work since the previous release (Goodridge 2009). This includes a change to the compositional categories used in the quality–adjustment process, an expansion in industrial detail, and the presentation of a longer time series. This work also fed into the growth accounting dataset used in the NESTA Innovation Index, a joint ONS/Imperial College project to identify the contribution of innovation to economic growth (NESTA 2009).

Introduction

Standard labour productivity measures express growth in output with respect to the volume of labour input, either in terms of employment, jobs or hours worked. The implicit assumption underlying this approach is that labour is homogeneous, as it does not take into account the composition, or quality, of the workforce.

'As a result an hour worked by a highly experienced surgeon and an hour worked by a newly hired teenager at a fast food restaurant are treated as equal amounts of labour'. OECD (2001)

However, labour is far from homogeneous, and the 'value' of an hour worked, or marginal productivity, varies significantly between workers. The quality–adjusted labour input (QALI) series attempts to address this, providing a measure which explicitly recognises the heterogeneity of labour by weighting the volume of hours worked according to the pay shares associated with certain characteristics – qualifications, age, gender and industry – which may be indicative of a worker's quality.

QALI is therefore a conceptually stronger method for use in productivity and growth accounting analyses, and is a useful tool for assessing the evolution of human capital over time. It is used alongside experimental estimates of capital services (Wallis, Long and Turvey, 2010) to produce multi–factor productivity (MFP) estimates (Long and Franklin, 2010).

This article presents new estimates of QALI for 1993 to 2008. Data are presented for the whole economy, the market sector and for 10 industries.

Methodology

To perform the quality adjustment, hours worked are differentiated into *n* types of worker (h_1 to h_n) determined by their characteristics: age, educational attainment, industry and gender. The reasons for using these particular characteristics are explained in **Box 1**. The hours worked by these different worker types contribute to total labour input *L* through a function *g*.

$$L = g(h_1, h_2, ..., h_n)$$

Economic theory states that in competitive markets with constant returns to scale, labour will be hired until its marginal cost (wage) equals its marginal revenue product, or marginal productivity. Therefore, when measuring labour input, using income data as a weight takes into account the relative productivity (or 'quality') of workers as well as the quantity of hours worked. The assumption that workers are paid their marginal product will hold true even if firms do not behave competitively in the labour market, and is only violated in the case of monopsony, where a firm has a degree of monopoly power in the purchase of labour.

Following the OECD (2001) recommended methodology, the growth in quality–adjusted hours is represented as a Tornqvist index:

$$\frac{\Delta L(t)}{L(t)} = \sum_i \left[\frac{w_i(t) + w_i(t-1)}{2} \right] \frac{\Delta h_i(t)}{h_i(t)}$$

where $w_i(t)$ is the share of total labour income paid to group *i* in period *t*, the weight used is the average of $w_i(t)$ and $w_i(t-1)$, and the income shares sum to one. The use of data from the current and previous period to weight the index is a feature of Tornqvist indices, making them more current, or representative, measures (Bell *et al* 2005). A more detailed discussion of index numbers can be found in Goodridge (2007).

Box 1 Labour characteristics

The choice of labour characteristics involves a trade–off between parsimony and data availability, and the objective of capturing significant developments in labour inputs to production. None of the following characteristics represent labour quality in and of themselves, but only as dimensions of the income–share weights.

Age

Age is included as a proxy for work experience. Although imperfect, as it takes no account of periods of unemployment or inactivity, the assumption is that older workers tend be more productive due to their greater experience, and therefore receive greater compensation for their labour. Alternatively, it has been suggested that younger workers may be more dynamic and innovative than their older counterparts (Bell *et al* 2005). However, if this is true in some cases, then provided labour markets are competitive, these workers will be paid their marginal product and growth in hours will be weighted accordingly.

Gender

Gender is chosen because of the persistent pay differential that exists between males and females, even after holding other factors constant. Although not a driver of quality change itself, it may represent hidden characteristics such as an increased tendency to take career breaks or to fulfil part–time posts that are not as well paid. Therefore, this complements, or improves, the use of age as a proxy for work experience, as well as helping to explain the pay differential. However, if the pay differential instead reflects discrimination, then the assumption that workers are paid their marginal product is violated, resulting in hours growth being weighted incorrectly and the quality adjustment carrying a downward bias. This is a weakness of the model.

Education

This is measured as the highest qualification attained and used as a proxy for skills. Qualifications either act as a signal of ability to employers or they provide the knowledge for specific job requirements. This characteristic is the primary driver of the index. Due to the increasing prevalence of higher degrees and their growing association with higher pay, they are included as a stand–alone category.

Industry

Although primarily included for the observation of industry trends and the use of QALI in industry–level MFP, this category also helps capture inherent differences in skill and productivity that exist between industries. The industry categories chosen are broad partly because industry is self–reported in the LFS, leading to inaccuracy of response, and also because of small sample sizes for some sectors.

Data source

The Labour Force Survey (LFS) is a continuous household survey that covers approximately 53,000 households every quarter. It provides data on the volume of hours worked, and contains series for educational attainment, industry, gender and age, plus pay data, which are used to carry out the quality adjustment. Although the LFS became quarterly in 1992, questions about the respondent's income were not asked until 1993, so the QALI series begins in the first quarter of 1993.

Scaling

To improve consistency with the National Accounts and ONS headline productivity measures, various components of QALI are scaled to ONS aggregates. Specifically:

- gross weekly pay is scaled to National Accounts 'Compensation of Employees' (CoE)
- actual hours worked are scaled to productivity hours[1]
- total jobs are scaled to productivity jobs

The first adjustment improves the consistency of the LFS–based data with National Accounts income measures. While the LFS only provides information on wages and salaries, CoE also includes bonuses and income–in–kind and, as such, is a more complete indicator of total remuneration. Additionally, as with other household surveys, LFS microdata include proxy responses, missing responses and inaccurate data. Respondents have particular difficulty recalling their pre–tax income or bonuses accurately; scaling the data helps overcome these issues. Scaling LFS jobs and hours data to the headline productivity jobs and hours series, which use superior business survey–based industry breakdowns, improves the accuracy of industry–level QALI estimates.

Data issues

Approximately 30 per cent of responses in the LFS dataset are proxy responses, given on someone else's behalf. In order to check that this does not cause bias in the estimation of QALI, the quality–adjustment of hours was carried out on personal responses only, and the relationship between adjusted and unadjusted hours remained the same. It was therefore decided to leave proxy responses in the data, since excluding them would create additional problems, such as a reduced sample size and grossing to population totals.

The inclusion of the self–employed poses an issue, as wages for the self–employed are not recorded in the LFS, or any other survey. This is because self–employed people remunerate themselves for a combination of labour and entrepreneurial effort, without distinguishing between the two. In producing QALI, the wages of employees with similar characteristics are used as an approximation for the labour income of the self–employed. This is likely to be an over–estimate (Turvey 2009), but the method used is the most appropriate for such a detailed dataset.

To measure labour's true input to production as accurately as possible, no restrictions have been placed on outliers such as workers that report very high or low responses on hours worked or income. Data on actual hours rather than usual hours are used because, conceptually, it is the former that needs to be measured if we want to measure the actual input of labour to production.

Changes since previous release

Due to constraints imposed by the sample size of the LFS, when performing the quality adjustment there is an inevitable trade–off between the different categories. In particular, a judgement needs to be made whether to prioritise the main compositional categories (education, age and gender) or focus on the industrial breakdown. The approach historically taken for QALI has been to prioritise the compositional breakdown, especially education, which has been found to be the main driver of the index in work by the ONS and the Bank of England (Bell *et al* 2005). In the previous QALI article (Goodridge 2009), the quality adjustment was carried out using eight education levels and six age groups; this meant results could only be produced for six broad industry groupings.

The adjustment groups used for this article do not represent a radical departure from previous work; education remains the principal driver of QALI, and so is still covered in detail. But after consultation with users and development of the series for its use in the Innovation Index (NESTA, 2009), greater emphasis has been placed on the industrial breakdown. Results are now available for 10 industries, to allow for more detailed industry–level multi–factor productivity (MFP) estimates. This has come at the expense of some compositional detail, with education and age being reduced to six and three groups, respectively. The compositional and industrial breakdowns used for the current and previous QALI estimates are summarised in **Table 1**.

In the case of education, merging the groups NVQ2, NVQ1 and 'other qualifications' is intended to reduce what is possibly an unnecessary level of detail, as there is little discernible difference in earnings amongst workers in these groups. The loss of detail on age is potentially more significant, as there is a greater pay differential observed across age ranges, especially between workers aged 16–19 and 20–29. However, this was judged a necessary sacrifice to increase the industrial coverage. The advantage of the new compositional breakdown is that it aligns QALI more closely with the 'Labour Services' series in the EU KLEMS database (see **Box 2**) and that produced by the Bank of England (Bell *et al* 2005). This development work also fed into the growth accounting dataset used in the NESTA Innovation Index, a joint ONS/Imperial College project to identify the contribution of innovation to economic growth (NESTA, 2009).

The other significant development for this release is the extension of the QALI time series. In the previous article (Goodridge 2009), results were only produced as far back as 1997, due to breaks in the LFS qualification variable. Since then, work has been undertaken to overcome this problem, linking together responses pre– and post–1997 to create a consistent data series for the education category. QALI is now produced as far back as 1993, which is the date from which questions about a respondent's income were first included in the LFS.

Table 1 Current and previous adjustment categories

Previous breakdown (Goodridge 2009)				
Education	**Age**	**Gender**	**Industry**	**Industry description**
Higher degree	16-19	Male	ABCE	Agriculture, hunting and forestry; fishing; mining and quarrying; utilities
NVQ5 (excluding higher degree)	20-29	Female	D	Manufacturing
NVQ4	30-39		F	Construction
NVQ3	40-49		GHI	Wholesale and retail trade; hotels and restaurants; transport, storage and communications
NVQ2	50-59		JK	Financial intermediation; real estate, renting and business activities
NVQ1	60+		LMNOPQ	Public administration and defence; education; health and social work; other social and personal services
Other qualifications				
No qualifications				
New breakdown				
Education	**Age**	**Gender**	**Industry**	**Industry description**
Higher degree	16-29	Male	ABCE	Agriculture, hunting and forestry; fishing; mining and quarrying; utilities
NVQ5 (excluding higher degree)	30-49	Female	D	Manufacturing
NVQ4	50+		F	Construction
NVQ3			G	Wholesale and retail trade
NVQ2, NVQ1 & other qualifications			H	Hotels and restaurants
No qualifications			I	Transport, storage and communications
			J	Financial intermediation
			K	Real estate, renting and business activities
			LMN	Public administration and defence; education; health and social work
			OPQ	Other social and personal services

Source: Goodridge (2009)

Box 2 The EU KLEMS project

The EU KLEMS project is an initiative to develop a database of comparable series relating to output, factor and intermediate inputs, and productivity growth for member states of the EU, plus the USA and Japan. The name is derived as an acronym of the inputs to production – capital (K), labour, energy, materials and services – to which growth in output is apportioned in the estimation of MFP. First released in 2007, the database contains a wide range of growth accounting series as far back as 1970, in current and constant prices and at a detailed level of industry.

The release of the research database marked the completion of the initial phase of the project. In the next phase, responsibility for maintaining the database is to be passed to Eurostat, with National Statistical Institutes such as ONS providing data updates. In advance of this, ONS recently completed a report (Dunn, Goodridge and Turvey, 2010) for Eurostat assessing the sources and methods used by the EU KLEMS consortium in the compilation of the original UK dataset, and transmitted a limited set of new and updated series.

One of the key recommendations of the report was to align the methodologies used to produce ONS QALI and its EU KLEMS equivalent, known as 'Labour Services'. The quality adjustment for Labour Services is currently based on 5 educational categories and 3 age ranges which match the new QALI breakdown, apart from the joint treatment of first and higher degrees. This is an area where the report advocates the EU KLEMS measure adopt the approach taken by QALI, as the high and rapidly increasing share in total compensation of workers with higher degrees relative to those with first degrees justifies the separate treatment of workers with a postgraduate degree.

The other area in which there is a continued divergence between the new QALI and current Labour Services series is the industry breakdown. Labour Services is produced for 15 industries, whereas QALI has been expanded only as far as 10 industries. This is due to the need for QALI to scale to industry-level productivity jobs and hours series, to improve the quality of estimates by making use of superior business survey-based aggregates, which partially overcome the inherent weakness in respondents reporting their own industry on the LFS. These headline productivity series are not available for all 15 industries used by EU KLEMS[2].

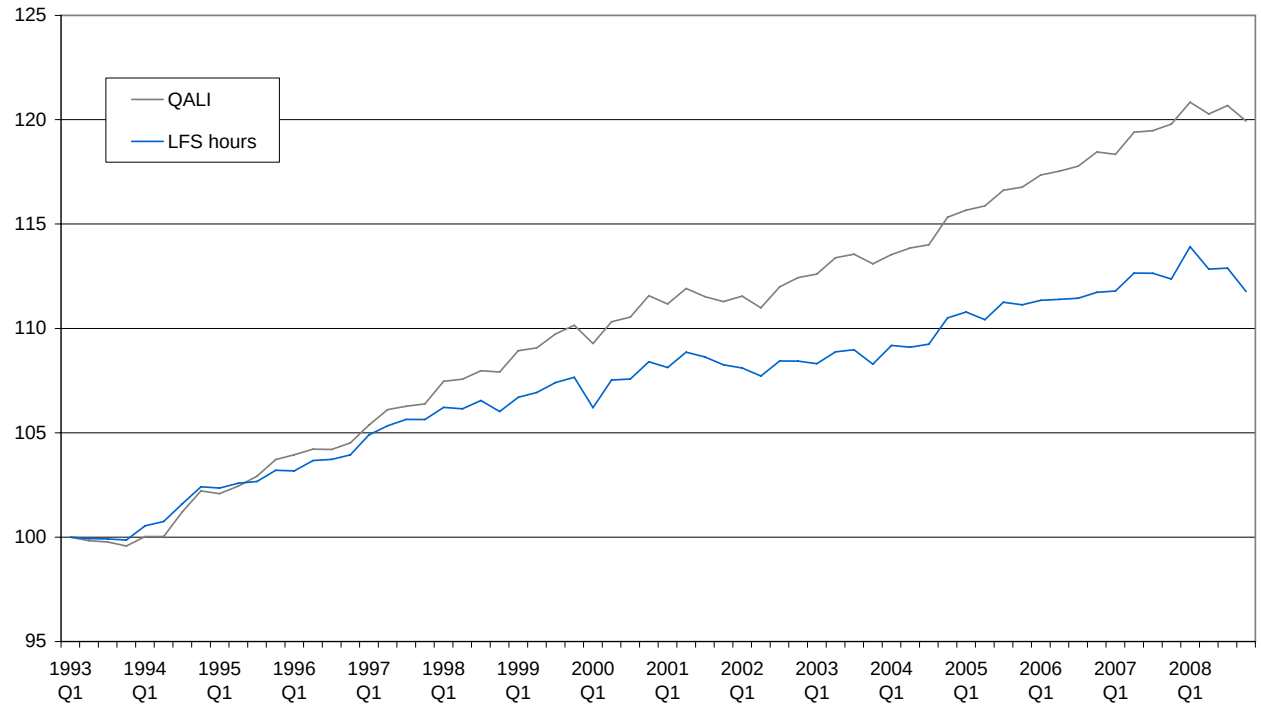
Previous QALI data produced by the Bank of England (Bell *et al* 2005) and the EU KLEMS consortium (2007a, 2007b) have shown that it is possible to extend the series back further (as far as 1970 in the case of EU KLEMS) using data from the General Household Survey. However, the data quality is considerably lower prior to 1993, and figures can only be produced on an annual basis, so only the 'headline' quarterly series is presented here. But an extended QALI series, to be used for research purposes, has been supplied to Eurostat by ONS for inclusion in the next release of the EU KLEMS database.

Results

Figure 1 compares an index of whole economy QALI with a series of unadjusted hours worked from the LFS, which is used in the production of headline labour productivity series. The difference between the two represents the quality adjustment, known as 'labour composition'. As can be seen, QALI has been growing faster than LFS hours throughout almost the entire period, reflecting a consistent positive contribution from labour composition. This divergence has continued even as both series declined in 2008, with the greater fall in LFS hours – and commensurate increase in labour composition – suggesting lower–skilled workers suffered proportionately more than those with high skills as the economy entered recession.

Figure 1 QALI and hours: whole economy

Indices (1993 Q1 = 100)



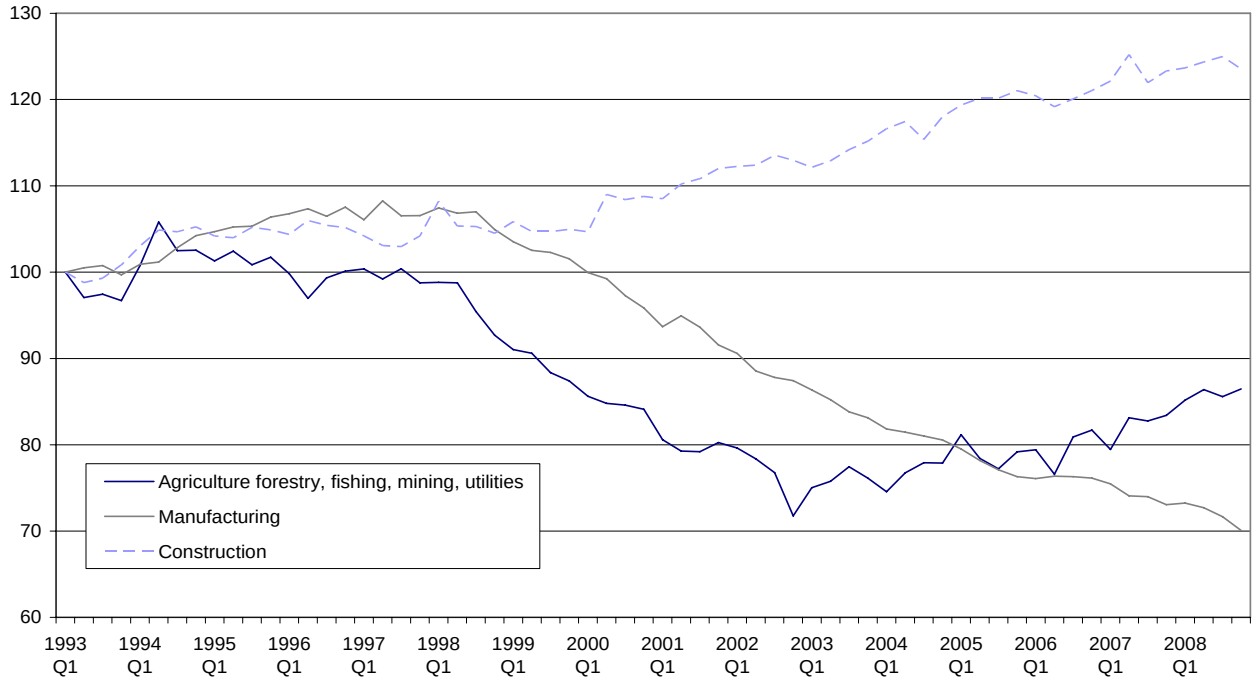
Source: LFS and authors' calculations

Figures 2, **3**, **4** and **5** show results for the 10 industries outlined in Table 1. In each case, QALI is broken down into its constituent parts, namely hours (part (a) of each Figure) and labour composition (part (b) of each Figure) , representing the quantity and quality dimensions respectively.

Amongst the production industries[3] (Figures 2a and 2b), construction has experienced the fastest growth in hours but the slowest growth in labour composition. This may reflect limited scope to substitute towards higher skilled workers in the construction sector. In the manufacturing sector, by contrast, labour input in terms of hours has fallen dramatically since 1998, while labour composition has shown strong and consistent growth, accounting for around nine percentage points over the period.

Figure 2a **Production industries: hours**

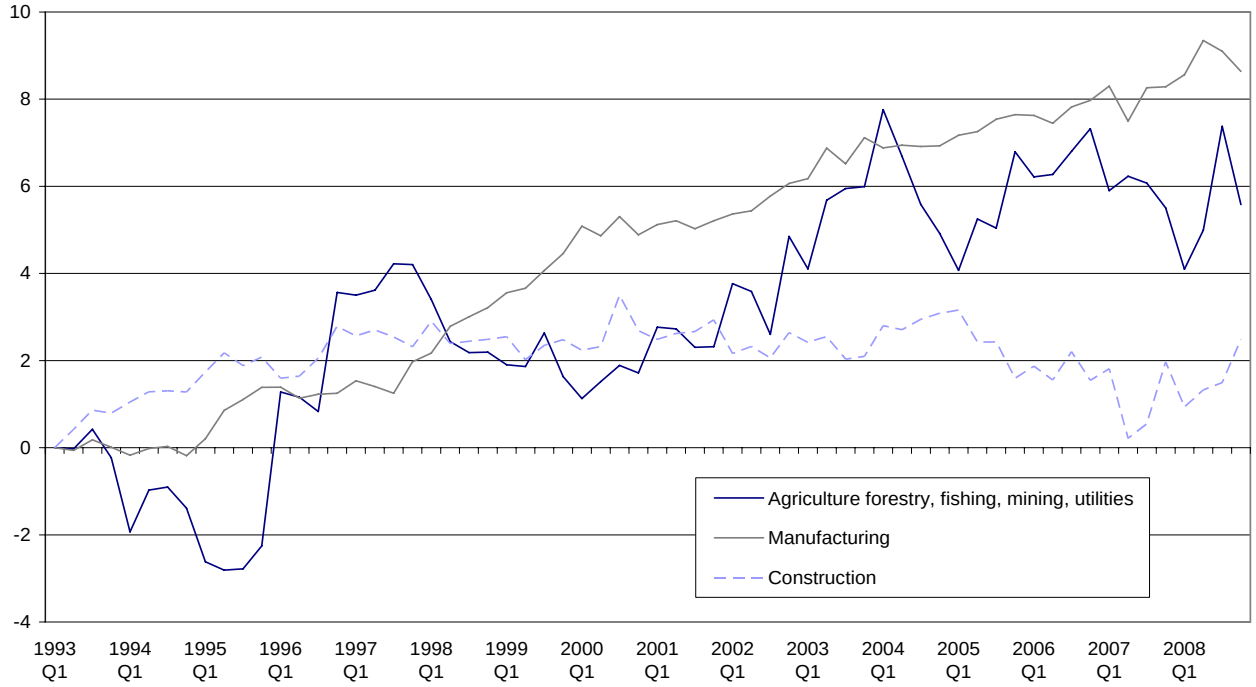
Indices (1993 Q1=100)



Source: LFS and authors' calculations

Figure 2b **Production industries: labour composition**

Index points



Source: LFS and authors' calculations

QALI in hotels and restaurants grew by almost 50 per cent between the first quarter of 1993 and the fourth quarter of 2008 (Figures 3a and 3b). Around two–thirds of this increase reflects increased hours and around one–third reflects labour composition. However, the improvement in labour composition is a relatively recent phenomenon. For most of the time up to late 2005 the quality adjustment was in fact negative, indicating a weakening skill profile in the industry relative to the base period.

Labour composition grew more consistently in industries G and I (wholesale and retail trade and transport, storage and communications), with the former exhibiting the larger increase in both quality and quantity of labour input.

The results for industries J and K (financial intermediation and business services) are particularly striking (Figures 4a and 4b). Relative to the first quarter of 1993, QALI has grown faster in business services than any other industry; despite a recent decline, it was two–thirds higher in 2008 Q4. This principally reflects increased hours as the volume of labour supply increased to meet demand, with only a modest contribution from labour composition. Meanwhile, financial intermediation experienced the strongest growth in labour composition, around 23 percentage points, as the sector attracted many highly–skilled workers during a period of very strong growth.

Industries LMN and OPQ (public administration, education and health and other personal and social services) both exhibit strong growth in the quality and quantity of labour input between 1993 and 2008 (Figures 5a and 5b). 'Other services' experienced the second–highest growth in QALI, and its increase in labour composition was only slightly below that of financial intermediation. The industry does, however, remain small relative to the financial sector.

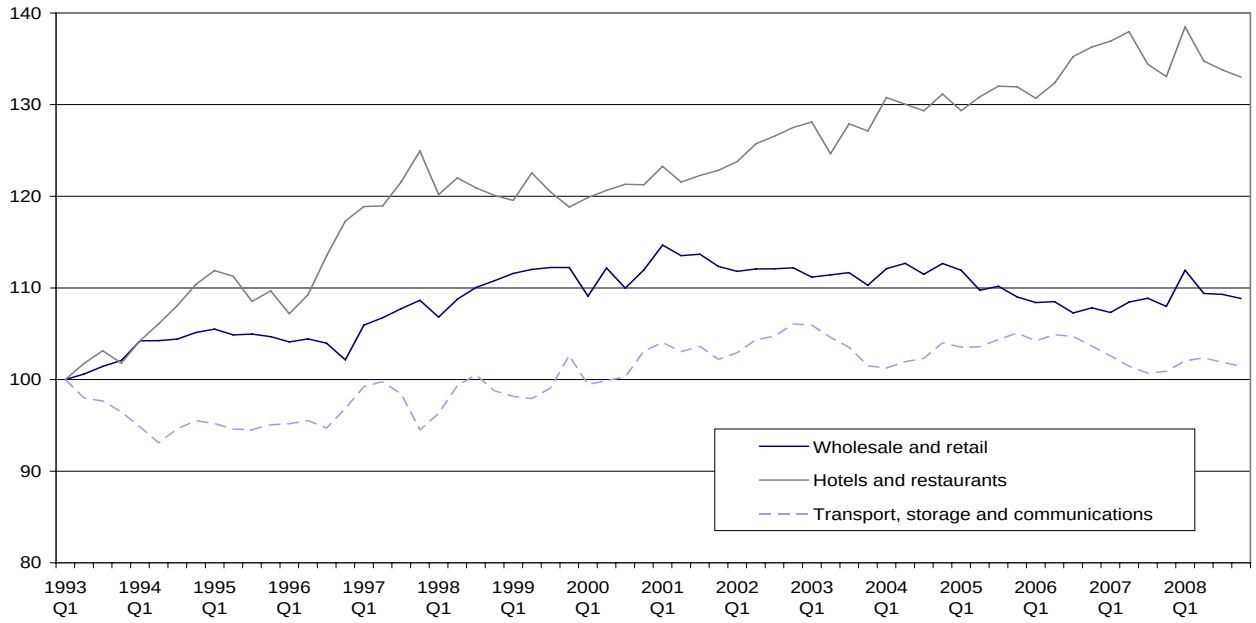
Figures 6a and **6b** present indices of hours and labour composition for the market sector. These series begin in the first quarter of 1994, the earliest date the variables used to filter out non–market sector responses can be found in the LFS. Figures 6a and 6b also include corresponding data for the whole economy, which have been rebased to 1994 Q1 for ease of comparison.

Over the whole period, movements in unadjusted hours have been similar for the market sector and whole economy, which is unsurprising given the large overlap between the two. Prior to 2001, hours grew faster in the market sector, although the two series have converged since 2003. Labour composition has grown consistently faster for the whole economy, particularly from 2004. This ties in with the strong performance shown by industry LMN (a crude approximation of the public sector), which had above–average growth in QALI and labour composition over the same period.

Figure 7 shows estimates of QALI by highest qualification. Due to space constraints, unadjusted hours and labour composition are not presented here. However, hours closely track the QALI series, as the remaining quality adjustments of age, gender and industry have only a small effect once education is separated out.

Figure 3a Wholesale and retail; hotels and restaurants; transport, storage and communications: hours

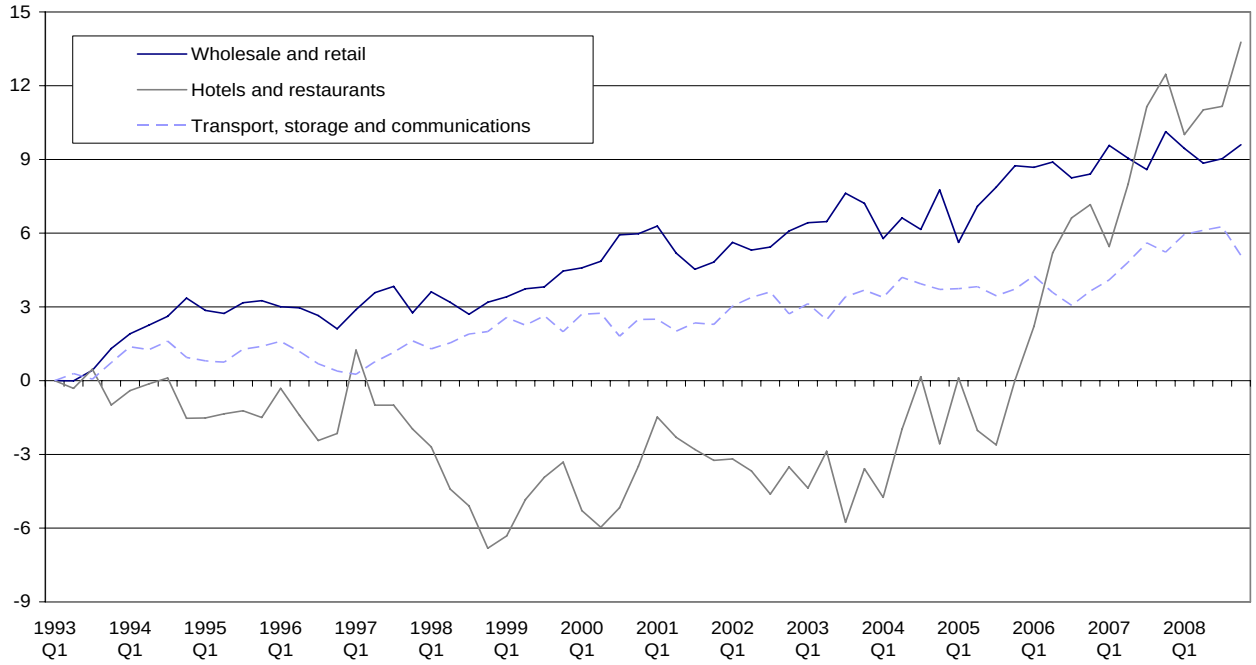
Indices (1993 Q1=100)



Source: LFS and authors' calculations

Figure 3b Wholesale and retail; hotels and restaurants; transport, storage and communications: labour composition

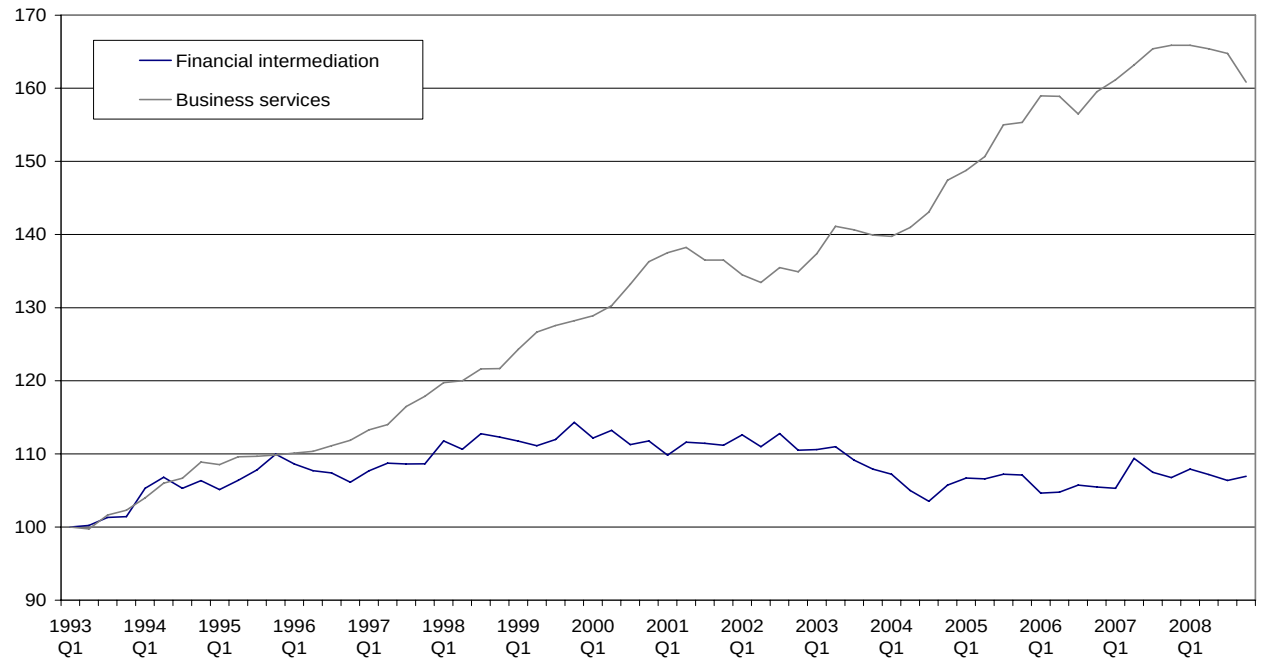
Index points



Source: LFS and authors' calculations

Figure 4a Finance and business services: hours

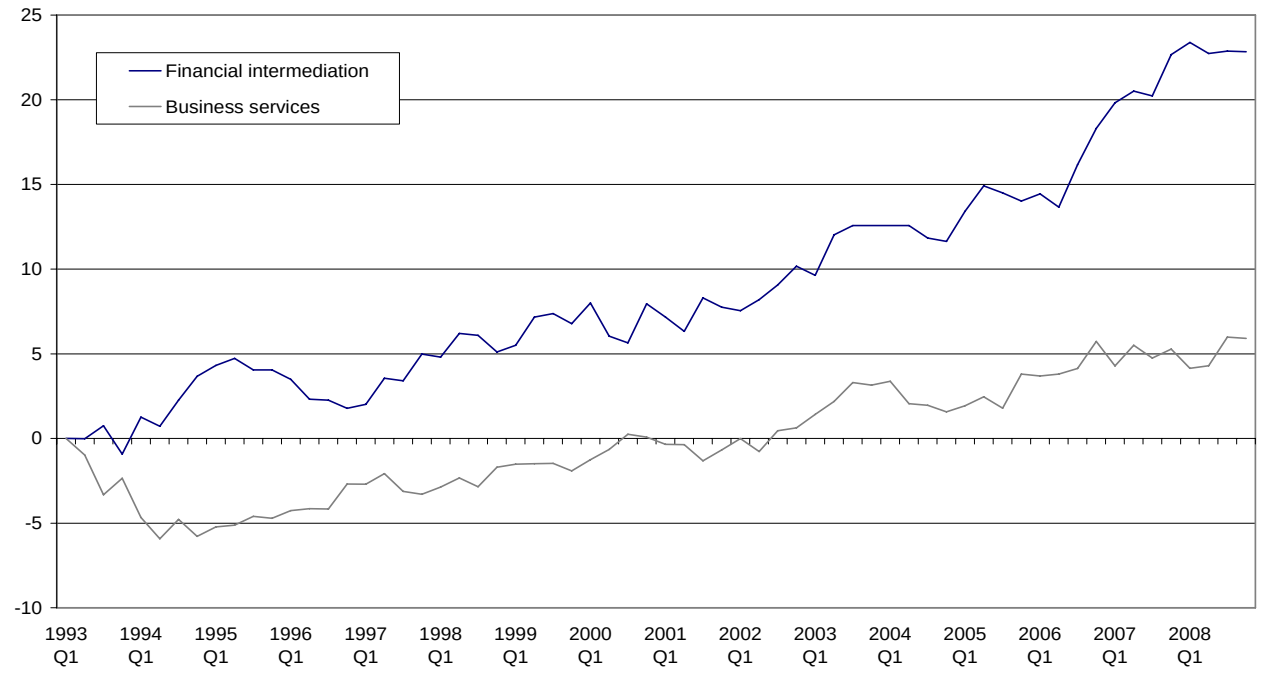
Indices (1993 Q1=100)



Source: LFS and authors' calculations

Figure 4b Finance and business services: labour composition

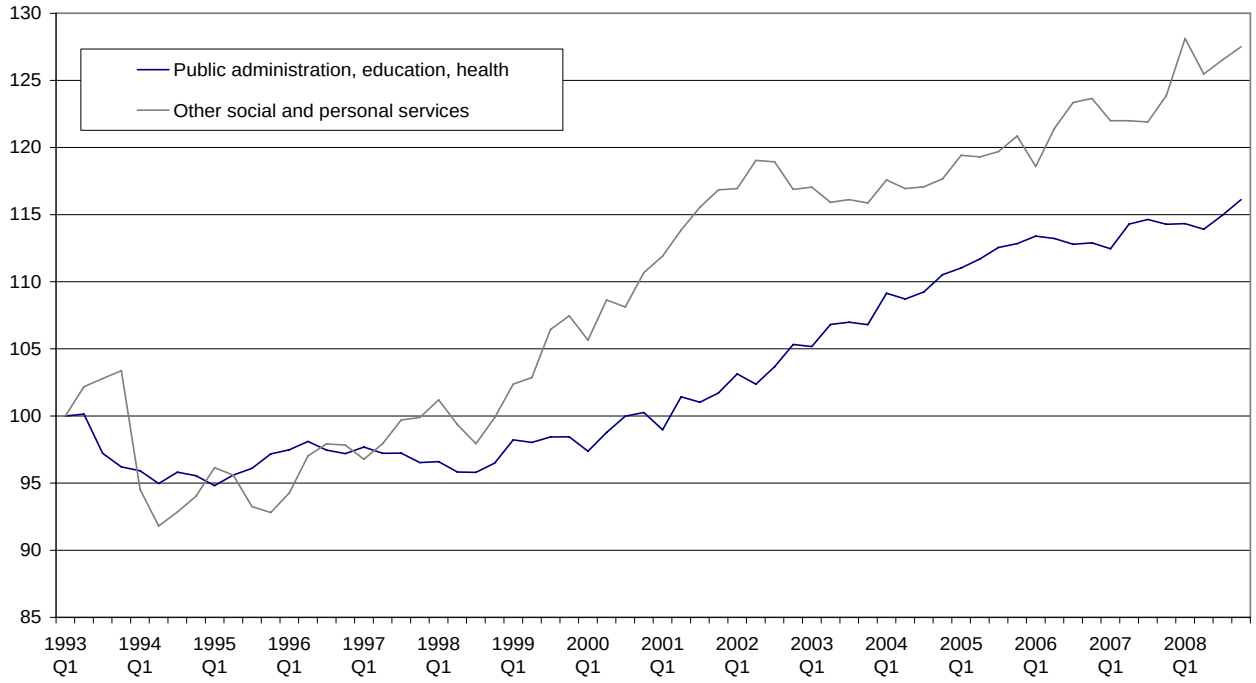
Index points



Source: LFS and authors' calculations

Figure 5a Public and other services: hours

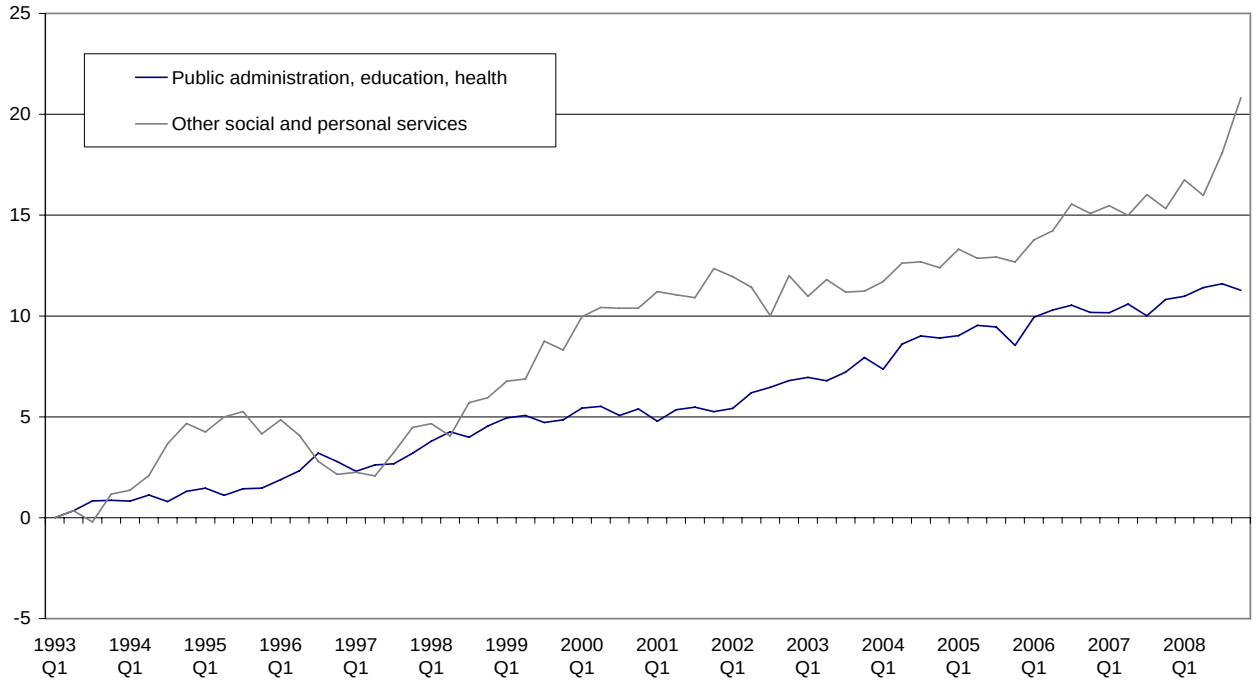
Indices (1993 Q1=100)



Source: LFS and authors' calculations

Figure 5b Public and other services: labour composition

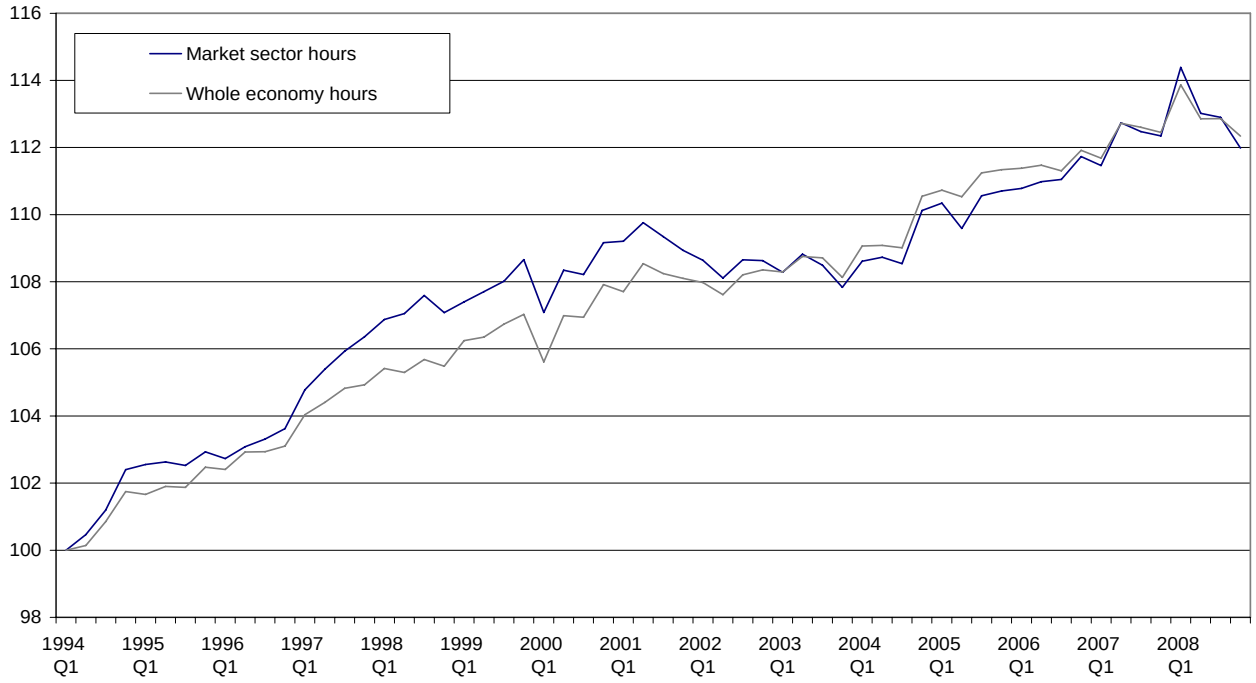
Index points



Source: LFS and authors' calculations

Figure 6a Market sector and whole economy: hours

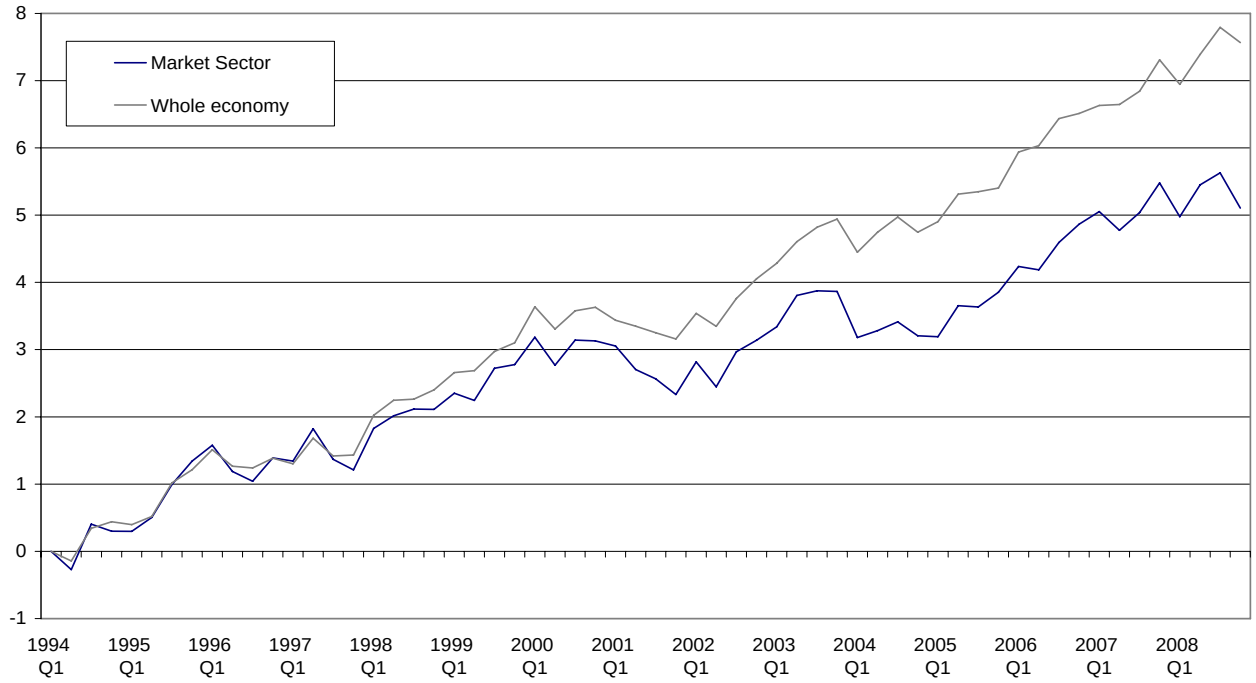
Indices (1993 Q1=100)



Source: LFS and authors' calculations

Figure 6b Market sector and whole economy: labour composition

Index points



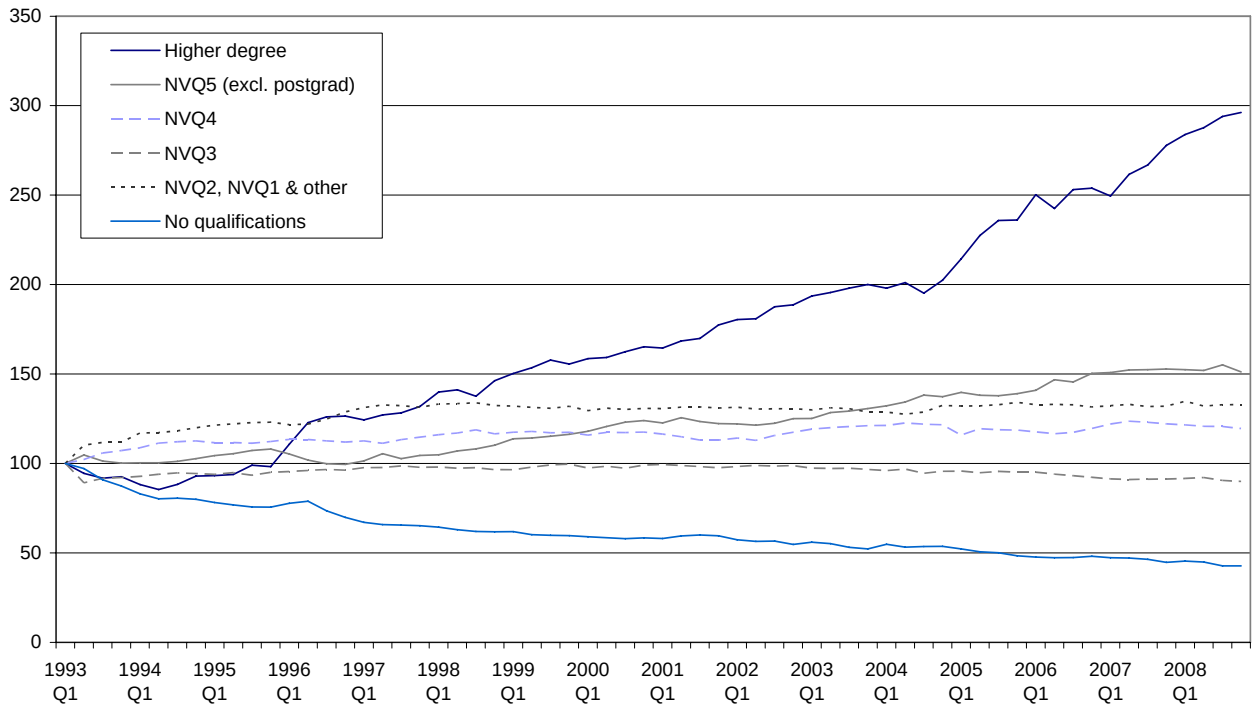
Source: LFS and authors' calculations

Growth in QALI has been most significant for the highest qualification levels, especially those with higher degrees, while the sharpest decline was in the 'no qualifications' category. The reason for these findings is the growth in qualifications attained (and corresponding fall in the share of the workforce with no qualifications), which has improved the skill profile of total hours worked over the period.

As education is the principal driver of QALI, it can thus be assumed that the trends displayed in Figure 7 are driving the whole economy and industry–level series. At the macro level, improving skills (as measured by qualifications) explain growth in labour composition, as well as QALI; and the industries which have performed strongest in this regard are those which have seen the greatest shift in labour input from low– to high–skill.

Figure 7 QALI: by highest qualification

Indices (1993 Q1=100)



Source: LFS and authors' calculations

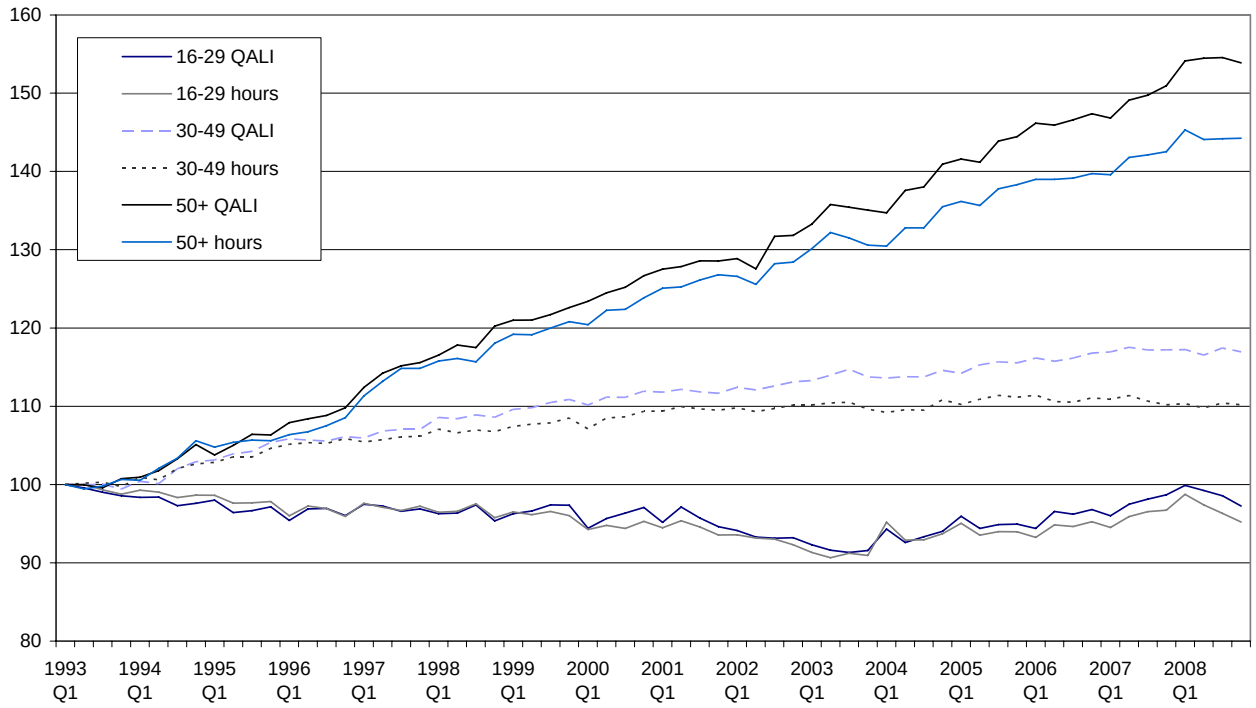
Figure 8 presents indices of QALI and unadjusted hours by age group. A striking result is observed for the over 50 group, amongst whom QALI increased by half over the period. The volume of hours worked in this age range also increased strongly, possibly reflecting increased labour–force participation amongst over–50s.

The quality and quantity of labour input increased steadily for workers aged 30–49, but declined for those aged between 16 and 29. The result for younger workers may be caused by a propensity for young people to spend longer in full–time education before entering the labour force, although this is not obviously supported by increasing labour composition. It is notable also that, in the first three quarters of the recession which began in 2008 Q2, declining labour input can be clearly

observed for 16 to 29 year–olds but not for the other groups, suggesting the early phase of the downturn had a disproportionately large effect on the young. This is consistent with the idea of firms hoarding their more skilled/experienced workers and shedding the least experienced, with the latter having a lower marginal product.

Figure 8 QALI: by age group

Indices (1993 Q1=100)



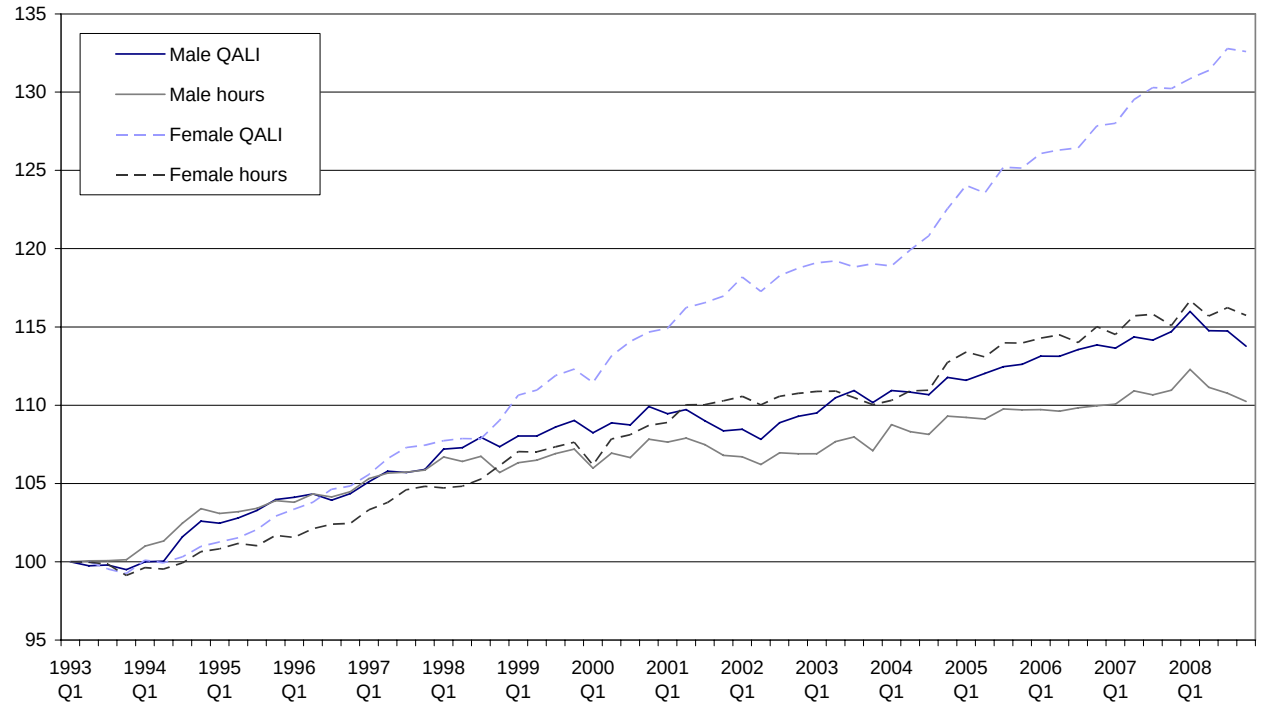
Source: LFS and authors' calculations

Lastly, **Figure 9** compares estimates of QALI and unadjusted hours for males and females. While growth in the volume of hours worked was slightly higher for females, a far bigger differential is observed for QALI, and thus labour composition. This is most likely being driven by rapidly improving educational attainment for female participants in the labour market relative to male participants.

It is also possible that it picks up some effects of equal pay legislation mandating a convergence between male and female compensation. To the extent that it shows the existence (but weakening) of discrimination in the labour market, it is demonstrating the weakness of using pay as a proxy for marginal productivity.

Figure 9 **QALI: by sex**

Indices (1993 Q1=100)



Source: LFS and authors' calculations

Conclusion

This article has presented new estimates of quality–adjusted labour input, resulting from significant development work since the previous release. The adjustment categories have been changed to achieve greater consistency with the EU KLEMS 'Labour Services' measure, and permit the production of a more detailed industry breakdown, with results now available for 10 industries. The time series has been extended back to 1993, and now incorporates a full economic cycle.

Making explicit adjustment for the quality of the workforce has the effect of increasing estimated labour input to the production process. The magnitude of the quality adjustment, or labour composition, has been increasing over time. The observed impact tends to be greatest in service industries, with financial intermediation exhibiting the largest increase in labour composition, while growth in QALI itself was highest in business services.

Within adjustment groups, the trend has been towards growth in hours worked by those with undergraduate and postgraduate qualifications at the expense of workers with little or no qualification, and those over 50 compared to the young. Lastly, growth in both QALI and labour composition has been far stronger for women than for men over the period studied.

Notes

1. Productivity hours and jobs are series used in the calculation of headline ONS labour productivity measures published in quarterly Statistical Bulletins. They provide the best measures of labour input for productivity purposes as they are produced using more reliable industry breakdowns, from both short-term and annual business surveys, which are constrained to LFS aggregates.

2. Further detail on EU KLEMS methodology, and research data produced on a KLEMS growth accounting basis, can be found at www.euklems.com

3. Strictly speaking, the production industries are only C, D and E (mining and quarrying; manufacturing; and electricity, gas and water generation). The indices for A to F are presented together for convenience.

Further information

Links to articles and data for experimental quality–adjusted labour input are available at www.statistics.gov.uk/statbase/product.asp?vlnk=14206

Links to articles and data for experimental multi–factor productivity are available at www.statistics.gov.uk/statbase/product.asp?vlnk=14901

Acknowledgements

The authors wish to thank Richard Jones and Katy Long for their help in producing this article.

Contact

elmr@ons.gov.uk

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