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THE DECLINE IN UNSKILLED EMPLOYMENT IN UK MANUFACTURING

Jonathan Haskel
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THE DECLINE IN UNSKILLED
EMPLOYMENT IN UK MANUFACTURING*

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The decline in unskilled employment in UK manufacturing
Jonathan Haskel

Changes in UK employment and non-employment over the 1980s have occurred in three main dimensions: gender, skill and type of work. Firstly, gender. Between 1978 and 1992, male employment fell by 1.2 million (from 14.6m to 13.3m). But female employment rose by 1.6 million (from 9.5m to 11.1m). Second, skill. The fall in male employment has been predominantly among the unskilled. In 1977, 88% of the male population who had no qualifications were employed; for those with a degree the figure was 96%. By 1992 only 67% of those males with no qualifications were employed; the employment rate for males with a degree had fallen to 90%. Third, type of work. The rise in female employment has been mainly among part-timers. Of the 1.6m rise in total female employment between 1978 and 1992, 1.3m more women had part-time jobs.

This paper focuses on the changes in skilled employment. The main innovation of the paper is the construction and analysis of a new data set. We have constructed data on the industry skill mix using detailed data on individual occupations (we are prevented from using the individual data by anonymity restrictions). This is in contrast to most of the literature that uses data on non-manual employment as a proxy for skill. The difficulty with this approach is that manuals are skilled and non-manuals unskilled. Wood (1994) estimates that 45% of OECD manual workers are skilled (have above basic education and experience) and 38% of non-manual workers are unskilled. Measuring skills in terms of education and experience sits better in the context of the debate about the extent of education and training, where programs
are usually designed to raise skills rather than turn individuals into non-manual workers. We have then matched this information with other data sources on trade, computers, product and labour market information.

Using these data, we seek to (i) document and (ii) explain the rise in skilled relative to unskilled employment in UK manufacturing over the 1980s. In particular we investigate the two main hypotheses that have been proposed to explain the fall in demand for the unskilled.

The first centres on trade, see e.g. Wood (1994). The argument here is that developing countries, who have a predominantly unskilled labour force, specialise in unskilled-intensive goods. As trade increases, the demand for unskilled workers in developed countries falls and the industry mix becomes more skill-intensive.

The second hypothesis centres on technology, see e.g. Berman et al (1994). Here it is suggested that technological change has increased the demand for skilled labour relative to unskilled over the 1980s. One version of this view is that many firms have adopted computer technology which requires comparatively skilled labour for its operation (Kreuger, 1993).

However our data also allow us to examine two further hypotheses which have not been examined in the literature. First, the decline in unionisation in the UK over the 1980s might have contributed to the growth in skilled employment. It might be argued for example that unions defend the jobs of the unskilled and so a fall in union power might lower unskilled employment. Second, as we document below, there has been an increase in the sub-contracting of services by manufacturing over the 1980s. So for example it might be that a cleaner in a manufacturing firm, previously employed by the firm and hence in manufacturing, is now employed in the service sector. If contracting has predominantly affected unskilled labour this might contribute to the fall in unskilled employment in
Our major finding is that technology seems to be of more importance with trade playing a minor role. The paper offers two pieces of evidence in support of this view.

First, one way of stating the trade argument is that trade is more likely to have impacted on the unskilled-intensive sectors. Therefore part of the rise in the overall proportion of skilled labour would be explained by a "batting average" effect; the removal of the low skilled sectors leaves only the high skilled industries and this raises the average.

The paper reports a formal analysis of this hypothesis. We decompose the total change in the skilled employment share into the contribution of changes in employment between sectors of different skill-intensity, and changes in the proportion skilled workers within sectors. We find only a negligible contribution from the first "batting average" effect. Rather, all industries have experienced increases in the share of skilled and non-manual workers.

Second, we undertake direct statistical calculations of the effect of trade and computers on relative skilled demand within industries. Such calculations indicate a significant contribution of the introduction of computers to increases in the skill/unskilled employment ratio, but no significant effect of trade. Our results suggest that between 1981 and 1989 computers raised the skill/unskilled employment ratio by around 1.5% (the ratio rose by 4.4% over this period). This effect turns out to be robust to the use of alternative statistical techniques and the inclusion of other variables. It is also consistent with evidence from case studies and other econometric work.
The decline in unskilled employment in UK manufacturing

Jonathan Haskel

1. Introduction.

Evidence from a number of different countries suggests that the 1980s saw a fall in unskilled employment relative to skilled employment. This has been documented in the OECD (Berman and Machin, 1994, Wood, 1994) and in for example Australia (Borland and Foo, 1994), France (Suesens and Dreze, 1994), the UK, (Beau and Pissarides, 1991, Machin, 1994), and the US, (Berman, Bound and Griliches, 1993, Caves and Krepp, 1993, Lawrence and Slaughter, 1993, Revenga, 1993, Sachs and Shatz, 1994). The purpose of this paper is to examine the evidence for the UK. The main innovation is the use of a new data set that allows us to assemble evidence that was not previously available to UK researchers or indeed for other countries.

The key difference in our data refers to the measure of skills. Almost all the papers cited above use the ratio of non-manuals to manual employment (or non-production to production employment) as a proxy for skilled/unskilled (the UK exception is Machin, 1994, see below).\(^1\) Many of the papers note that this is an imperfect skill measure. For example, Hall (1993, p.284) points out that US data measures airline pilots as non-productive workers and copilots as productive workers. Wood (1994) estimates that 45% of OECD manual

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\(^1\) Much of this paper was written whilst visiting the Australian National University, whom I thank for their wonderful hospitality. I thank my colleagues there for very useful comments, especially Tim Besley, Colin Cameron, Paul Gregg and Bob Gregory; and also Richard Disney, Chris Martin and Gyfli Zoega. I thank Robert Jukes for extensive help with NES data and Steve Woodland for very kindly supplying the WIRS data. Finally I thank the Department of Employment and Education for financial support under their grant to the Labour Market Imperfections Programme. The views expressed and any errors are those of the author alone.

\(^1\) For reference to some very recent US exceptions see Richardson (1995).
workers are skilled (have above basic education and experience) and 38% of non-manual workers are unskilled (see his table A1.4). Of course, there is no "correct" definition of skill. But measuring skills in terms of education and experience sits better in the context of the debate about the extent of education and training, where programs are usually designed to raise skills rather than turn individuals into non-manual workers.

To obtain a measure based on education and experience we have used successive years of the UK New Earnings Survey Panel Data Set (NESPD) which classifies individuals into industries and occupational groups. We use standard UK statistical conventions to allocate occupations according to whether they are skilled or unskilled. Due to anonymity restrictions we cannot use individual data. We therefore aggregate across occupations and industries to obtain measures of skilled and unskilled employment in each industry; small cell sizes prevent us from constructing a finer skill classification.

Although the NESPD has data on employment, earnings and hours it has no other data on industry characteristics. To go further we therefore match our skill data with three other data sets. They are firstly the UK Census of Production which gives industry data on output, capital, product market concentration etc. Secondly, to examine the role of trade, we use UK Customs and Excise data on imports and exports. Thirdly, since there has been much interest in the effect of computers raising skilled labour demand, we use data from the 1984 UK Workplace Industrial Relations Survey (WIRS) on the introduction of micro-chips/computers. This yields us data on eighty three-digit industries, 1980 to 1989 (aside from the cross-sectional WIRS data). To the best of our knowledge this is the first paper on UK data that

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2 We are prevented from using data earlier than 1980 due to substantial changes in the industry classification system. Data up to 1989 was available at time of writing. With the substantial lags in the publication of the Census, updating would currently be possible to 1992; we hope to do this in future work.
combines such information.\footnote{Nissim (1984) uses data by skill for the UK engineering industry (as a whole), 1963-1978, based on a (now discontinued) Department of Employment survey to estimate substitution elasticities. Haskel and Jukes (1994) used an earlier version of this data set with information on skills from 1984-1989, but most of the changes took place between 1980 and 1983 so the additional data is of substantial value.}

Our investigations fall into two groups. First, there are those facts and hypotheses that have been considered by others but on non-manual/manual data. Second, there are new hypotheses that we can test with our data. As for the first group, we first calculate changes in skill using our skill definitions rather than the non-manual/manual classification. Second, we examine the accounting question of whether there has been a switch of employment towards the high skill industries, or increases in skilled employment in all industries. Third, we examine the two main hypotheses explaining changes in relative employment: technology and trade.

Turning to the second group, we examine two hypotheses which to the best of our knowledge have not been tested in the literature. We first ask whether the decline in unionisation in the UK over the 1980s has contributed to the growth in skilled employment. It might be argued for example that unions defend the jobs of the unskilled and so a fall in union power might lower unskilled employment. Second, as we document below, there has been an increase in the sub-contracting of services by manufacturing over the 1980s. So for example it might be that a cleaner in a manufacturing firm, previously employed by the firm and hence in manufacturing, is now employed in the service sector. If contracting has predominantly affected unskilled labour this might contribute to the fall in unskilled employment in manufacturing (although not of course in the economy as a whole).

As well as differing from other studies in having more data, our study also differs in its methodology. The differences with the UK studies (of the 1980s) are as follows. First,
Haskel and Jukes (1995) and Machin (1995) analyse data on wage shares. This conflates wage and employment changes, and since our interest here is on relative employment we do not use this measure (our central finding on computers is robust to using wage share models however). Second, Wood (1994) analyses the impact of trade using a factor content method. We use model-based estimates rather than this accounting-based measure. Third, Bean and Pissarides (1991) study manual/non-manual relative employment 1972-1988 using dummies to infer the bias in technical change. We can go further then this since we have an explicit measure of computer technology introduction.

Our main findings are fourfold. First, between 1981 and 1989 the ratio of skilled to unskilled employment rose 4.4%; that of non-manuals rose 6.7%. Second, the "averaging effect" of the flow of workers towards more skill-intensive industries is negligible in explaining the rise in the overall skill proportion. Rather the data suggests that there has been an increase in skill proportions throughout manufacturing. Third, the introduction of computer technology has raised the skill/unskilled employment ratio by around 1.5%. The significance of the contribution of computers is robust to instrumentation, changes in functional form and inclusion of other variables. As we document below, it is also consistent with evidence from case studies and other econometric work. Fourth, we detected no significant impact of the increase in trade, the decline in unionisation, or the increases in subcontracting, the share of small firms or entry.

The paper proceeds as follows. Section 2 documents the fall in unskilled employment. Section 3 investigates some of the causes of this and focuses on the role of microprocessors/computers and trade. Section 4 subjects these and other findings to a variety of robustness checks. Section 5 concludes.
2. Documenting the decline in unskilled employment.

2a. Data sources.

One would ideally like data over time on individuals, their skills, wages and the characteristics of the firm where they work. Since no single UK data set provides this, our empirical work is of necessity based on four matched data sources, details of which are set out in the data appendix. Briefly, individual occupation information is available from the UK New Earnings Survey Panel Data Set (NESPD). These occupations are allocated into standardised occupational groupings (KOS), which are then aggregated up into eight Socio-Economic Groups (SEGs), see table 1. As the table shows, the data classifies workers into manuals and non-manuals. Looking at the manual group immediately shows that many manuals can reasonably be classified as skilled (e.g. foreman/supervisors, skilled manual); the rest we group as unskilled. For non-manuals the situation is not so clear cut. We have chosen to allocate "managers", "professional and technical workers" and "intermediate non-manuals" as skilled. We allocated "junior non-manual workers" into unskilled.

Anonymity regulations rule out the use of individual data. We are forced to aggregate over individuals within each industry, losing some industries owing to small cell sizes. This gives us data on skills, wages and hours in 80 manufacturing industries, 1980-1989. We then matched these data to industrial data from the UK Census of Production, which gives information on capital stock, product market concentration etc. We obtained export and import data by industry from the UK Customs and Excise. Finally, there has been particular recent interest in computer usage. Since there is no data on this in the Census we used data

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4 Besides those mentioned below other data sources are used for miscellaneous series, such as skill shortages, unionisation etc; see data appendix.

5 Occupational data is also in principal available from the Labour Force Survey. However, there is no LFS for 1980 and 1982. See the data appendix for more discussion.
from the 1984 UK Workplace Industrial Relations Survey (WIRS), a nationally representative sample of around 2,000 establishments. Establishments (with over 25 manual employees) were asked whether over the last three years they had introduced new plant, machinery or equipment and if so whether this had "...included microelectronics technology i.e. microprocessors (chips) or integrated electronic devices?". We have aggregated these data into averages by industry and regard the resulting measure as an industry indication of changes in micro-chip/computer technology. Whilst we would clearly prefer a continuous measure with a larger sample, given the interest in this area it seems worth trying.6

2b. Features of the data.

Table 2 sets out some means and correlations of selected variables (see data appendix for further means and detailed data definitions). Row 1 shows that the ratio of skilled to unskilled employment rose by 7.8% over the period.7 By comparison, the non-manual/manual ratio rose by 8.3%. Rows 3 and 4 show that this rise in relative employment was accompanied by a rise in relative wages; 13.7% in the skilled/unskilled case, and 10.9% for non-manuals/manuals.

Comparison with earlier years is obscured by the lack of consistent data. For non-manuals/manuals the consistent data are available and show that relative employment has risen consistently since the war whilst relative wages have fell until the 1980s (Machin, 1994). For skills, Saunders and Marsden (1981, table 4.15) report a rise from 48% to 49.1%

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6 Machin (1994) uses data on R and D as a proportion of sales, but this is only available at the 2 digit level for 1981, 1983, and 1985-89. He also uses data on innovations, but again this is 2 digit and only available until 1983.

7 The figure in the abstract and introduction is for 1981-89 to be compatible with the regression period, see below.
from 1971 to 1979 in the skilled employment share of full-time manuals in engineering. But this was accompanied by a fall in the relative skill/unskilled wage of 3% for comparable workers (Saunders and Marsden, 1981, table 4.16, see also Elliot and Murphy, 1990, table 3.4).

Returning to table 2, row 5 reports that 51% of industry employment was skilled in 1980. It also shows a correlation of 0.30 with the proportion non-manual (the rank correlation is very similar). This is unsurprising given that plenty of non-manual workers are unskilled and manual workers skilled. In fact the skill-intensive industries are vehicles, Whilst mechanical engineering is the most non-manual intensive.

Concerning computer usage, 39% of firms in the 1984 WIRS had introduced microprocessors/chips over the last three years (standard deviation 0.20), with introduction primarily in skill- and non-manual intensive sectors. The (two digit) industries with the highest rate of introduction are instrument engineering, aircraft/shipbuilding etc., and packaging and paper, whilst those with the lowest rate are footwear and clothing and leather. As a check on the data, it is reassuring that this compares closely with the 1983 PSI survey of 1200 manufacturing firms concerning the extent of use of microelectronics in industry. There the highest users were food, drink and tobacco, electronic, electrical and instrument engineering and paper, printing and publishing, and the lowest clothing, leather and fur and textiles (Northcott, Fogarty and Trevor, 1985, table 12).

What has happened to the skilled sectors over the 1980s? We have already reviewed employment and wage behaviour, and the rest of table 2 sets out a series of correlations from which a number of other interesting facts emerge. First, despite all the turbulence over the period a skilled industry in 1980 was still a skilled industry in 1989. From row 5 of table 2 we see that the correlation between the proportion of skilled employees total employment
in 1980 and 1989 is 0.88 (for non-manuals the figure is 0.94).

Second, we have a number of measures of trade. All show increased dimensions of trade intensity; volume penetration has risen and relative import prices have fallen. Beginning with volumes, the negative sign in row 6 shows that import penetration has risen most strongly in unskilled intensive sectors. Interestingly, this correlation is reversed with the manual/non-manual distinction. As for trade prices, rows 8 and 9 show that relative import prices have risen the least in sectors that are skilled and non-manual intensive. So the volume data suggest that trade has predominantly affected the unskilled-intensive sectors, and the price data the reverse (although the correlation is not strong).¹

Third, there has been increased contracting out of services, predominantly in unskilled intensive sectors (row 10). If each industry contracts out a fixed proportion of its employment this correlation suggests that unskilled employment falls due to contracting out. Finally, union density has fallen most sharply in skilled intensive industries (row 11). This is unlikely to reflect a mix effect since the unionisation is more common among skilled (manual) workers than the unskilled (Moghadam, 1990).

¹ The Stolper/Samuelson effect of trade is much discussed in the literature, see e.g. Lawrence and Slaughter (1993). Krugman (1994) summarises the model as follows: an increase in trade with countries abundant with unskilled labour ("the South") causes a fall in the price of unskilled-intensive goods. At given wage rates, this causes a shift in the industry mix towards skilled labour in "the North". This shift in the mix raises relative wages for the skilled and lowers relative employment. As table 2 shows however the rise in relative wages has been accompanied by a rise in relative employment, and the relative prices of unskilled intensive goods seems not to have fallen (see Lawrence and Slaughter, 1993, for a similar finding, but Sachs and Shatz, 1994, for contrary results on prices). As Davies and Topel (1993) stress, other factors such as biased technical change might have been operating, so one cannot rule out Stolper/Samuelson effects.
3. Explaining the decline in unskilled employment.

3a. Compositional effects.

A possible explanation of changes in aggregate skill levels is a compositional effect whereby employment flows from low skilled to high skilled sectors. With our industry data we are in a position to examine this. Following Berman et al (1993) and Machin (1994) and write the change in the aggregate share of employment of skilled workers as

$$\Delta \frac{N_s}{N} = \sum_i \left( \frac{N_{si}}{N_s} \right) \Delta \left( \frac{N_i}{N} \right) + \sum_i \left( \frac{N_i}{N} \right) \Delta \left( \frac{N_{si}}{N} \right)$$

(1)

where $N_s$ is total skilled employment, $N$ is total employment, $N_{si}$ is skilled employment in industry $i$, $N_i$ total employment in industry $i$, the superscript $A$ denotes an average, and the summation is over $i$ industries.

Equation (1) decomposes the total change of relative skilled employment into two terms. The first term on the right-hand side weights the change in employment between industries by skill-intensity. So this term is large and positive if there is a large flow of employment from unskilled-intensive sectors to skill-intensive sectors. It can be thought of as describing the change in the total due to the change in total employment between industries. The second term is the change due to the change in the proportion of skilled workers within sectors, for it weights the change in the sector skill-intensity by the overall employment share of the sector.

Table 3 sets out the results of this decomposition for the skilled and for non-manuals as a comparison. It reveals a consistent picture. A negligible amount of the change in the aggregate figure can be explained by flows of employment between (three digit) industries. Indeed, if anything employment has shifted away from skill-intensive sectors. Rather, all industries have experienced increases in the share of skilled and non-manual workers. Two
points are worth noting. First, the same picture for manuals/non-manuals holds for most OECD countries, see Berman and Machin (1994, table 9.7). Second, changes within a three digit industry do not preclude changes between firms within the industry.

3b. Within industry effects.

What has caused the rise in skilled employment? In this section we set out a simple labour demand framework (we consider labour supply below). We begin by supposing that a firm has a production function of the CES type

\[ Y = Z \left[ \delta (\theta_s N_s) \right]^\rho + (1-\delta) (\theta_u N_u)^\rho \]  

(2)

where \( N_s \) is unskilled employment, \( \theta_s \) and \( \theta_u \) convert employment into efficiency units (see below) and \( Z \) is any other factor.\(^9\) Assuming the firm faces a given wage \( W_s \), \( j=s,u \) maximisation of profits gives relative employment demand as

\[ \frac{N_s}{N_u} = \left( \frac{W_s}{W_u} \right)^\sigma \left( \theta_s \right)^{\sigma-1} \left( \theta_u \right)^{-\sigma} \]  

(3)

where \( \sigma = 1/(1+p) \) is the elasticity of substitution. This reveals that changes in the relative demand for skilled labour might be caused by changes in relative wages, and/or changes in the relative efficiency with which employees are used (\( \theta_u/\theta_s \)).

The relative wage explanation is an unlikely candidate, since as noted above, average relative wages of the skilled have risen. This suggests that other factors are at work. Turning

\(^9\) Other studies have used a translog cost function (e.g. Berman et al, 1994, Machin, 1994). The first order conditions yield an equation for the wage share, but since wages have changed we cannot make inferences about relative employment without a wage equation. In any case we show below that our results hold in the translog case.

\(^{10}\) Other factors of production can be added to the brackets of (2) without affecting (3) below.
therefore to the determinants of \((0/0)\) we write it, augmenting e.g. Hanermesh (1993, p.351)
as
\[
\frac{\theta_x}{\theta_u} = \frac{A_x}{A_u} \left( \frac{H_x}{H_u} \right)^{\alpha_1} \left( \frac{E_x}{E_u} \right)^{\alpha_2} \tag{4}
\]
where \(A_x\), \(w_x\), \(u_x\) is the level of (Harrod-neutral) labour-augmenting technology, \(H_x\) hours and \(E_x\) "effort". This simply says that the degree to which a stock of heads becomes an effective input is determined by the technical efficiency of that group of employees, the hours that they work and the "effort", or intensity/utilisation of each hour. Substituting (4) into (3), taking logs and using lower case letters for logs gives
\[
n_x \cdot n_u = -\sigma (w_x - w_u) + (\sigma - 1) (a_x - a_u) + \alpha_1 (\sigma - 1) (h_x - h_u) + \alpha_2 (\sigma - 1) (e_x - e_u) \tag{5}
\]
It is clear that the sign of the marginal effects depends on whether \(\sigma\) is greater or less than one. In what follows we assume that \(\sigma > 1\), since the data generally returns an estimate greater than one (Hanermesh, 1993).\(^{11}\) Looking at the last three terms, the first term shows that an increase in \(a_x\), relative to \(a_u\), increases the relative demand for skilled labour. This simply states that biased-technical progress (BTP) in favour of the skilled, raises their relative demand, a hypothesis that has been extensively investigated (see references in the introduction above).

BTP is of course only one of the determinants of the relative efficiency with which labour is used. Equation (5) shows that there are at least two other factors that might be important, which to the best of our knowledge have not been considered. First, a relative rise in hours of the skilled raises their demand, since in this framework when a firm chooses

\(^{11}\) Table 3.7. For the UK, Nissim (1984) reports \(\sigma = 1.76\) for skilled and semiskilled and 2.31 for semiskilled and unskilled using time series data 1963-1978. Our translog estimates below suggest \(\sigma = 1.47\) for skilled and unskilled.
heads it regards increased hours, at given wages, as an increase in the hourly efficiency of labour. In fact, the relative hours of the skilled have fallen over the period, so this an unlikely candidate in explaining observed upskilling.

The second candidate is a rise in the relative effort/utilisation/intensity of the skilled, \((e_s - e_u)\). But what determines \((e_s - e_u)\)? There are clearly a number of possibilities here. Rosen (1988) suggests that effort is determined in part by work practices which is in turn determined by bargaining between unions and firms. Suppose that unions cause more over-manning than would otherwise be the case, and over-manning causes an inefficient use of the skilled relative to the unskilled. Then a decline in unionisation increases \((e_s - e_u)\) and so skilled employment. The UK has seen a strong decline in union presence, so this is a possible factor. Against this, skilled workers may be more heavily unionised and if unions defend skilled working conditions then a fall in unionisation might lower relative skilled employment. So, the matter is ultimately an empirical one. In addition, there are likely to be other determinants in this bargaining framework. For example, we would expect that overall effort would be lowered in firms with monopoly power who enjoy a Hicksian quiet life (for a formal model, see Haskel, 1991). Finally, monopoly power and relative outside opportunities might also affect relative effort levels as well.

Another possible effect on relative employment might be contracting out, which has been rising over the 1980s, as we saw above. Suppose for example that a firm sacked all its unskilled cleaners and re-employed them on contract. As well as possible indirect effects on wages, effort etc. of the remaining employees this might have a direct compositional effect of reducing relative skilled employment.

To attempt to test these possibilities in the context of (5) we have to take a number of steps. Beginning with \((a_s, a_u)\), it is conventional to measure this by means of dummies and
time trends (see e.g. Bean and Symons, 1989, Hamermesh, 1993). However there has been much recent interest in the hypothesis that the introduction of micro-chip technology/computers has increased demand for the skilled (Berman et al, 1993, Kreuger, 1993, Machin, 1994). We therefore write \((a_i-a_e)\) as

\[(a_i-a_e)_t = \beta_{1i} + \beta_{2i}trend + \beta_{3i}TD + \beta_{4i}COMPUTERS_i\]  

(6)

where \(\beta_{1i}\) an (industry-specific) fixed effect, "trend" a time trend, TD a time dummy, \(i\) refers to the industry and \(t\) denotes time period.

Equation (6) is similar to that used by Bean and Pissarides (1991) to infer biased technical change, although they do not have a computer or a trend term. Like them, the panel nature of our data allows specification of a number of different possibilities for both the level and difference in \((a_i-a_e)\). The \(\beta_{1i}\) term allows an industry-specific level of relative technology. The \(\beta_{2i}\) term allows each industry a trend in its (log) relative technology growth. The time dummy allows a common shift across all industries in relative technology. In fact we shall work in first differences, so a positive \(\beta_{2i}\) implies a common shift in the bias of the growth in technical efficiency for that time period. Finally, we interpret our WIRS measure as an indication of industry average changes in micro-chip/computer technology, which we denote \(\Delta CHIPS_{ij}^{12}\).

Turning to the relative effort term \((e_i-e_e)\), the discussion above suggests that it is affected by unions, product market power and outside opportunities. We have no data on relative union power and so we therefore simply enter union density (UNION) (the precise definitions of these and other variables are set out in the data appendix). A negative sign

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12 CHIPS is subscripted by \(j\) since it is a two-digit measure. We can potentially construct three digit data, but cell sizes become very small. Our results are in fact very similar with a three digit measure (correlation between the two measures = 0.42).
would suggest that declining union power raised the relative efficiency of the skilled. To measure competition we enter the five-firm sales concentration ratio (CONC) and import penetration (IMPORTS). A negative sign on CONC would suggest that increasing domestic competition raises the relative efficiency of the skilled and so their employment. A positive sign on IMPORTS suggests also that rising foreign competition raises the relative efficiency of the skilled and so their employment. As for relative outside opportunities, without a precise measure we experiment with a range of cyclical proxies (see next paragraph) and enter time dummies. We also enter an industry-specific fixed effect to control for unobserved (fixed) relative effort differences between industries.

To allow for subcontracting we add the ratio of brought-in non-industrial services (such as cleaning etc.) as a the proportion of industry output (CONTRACT). Note that this also covers advertising etc. and so might have an adverse compositional effect on skilled workers. Finally, to pick up labour hoarding (and relative outside opportunities) we add in the percentage of firms reporting shortages of plant and capacity (CAPACITY), a measure also used by Bean and Pissarides (1988) (we experiment with other cyclical measures below).

With labour hoarding we would expect this to attract a negative sign, since in recessions firms would sack unskilled before skilled. All this discussion suggests an equation in first differences of the form

$$\Delta (n_j - n_u) = -\sigma \Delta (w_j - w_u) + \gamma_{1H} + \gamma_2 \Delta CHIPS_j + \gamma_3 \Delta (h_j - h_u) +$$

$$+ \gamma_4 \Delta IMPSH_j + \gamma_5 \Delta CONC_j + \gamma_6 \Delta UNION_j + \gamma_7 \Delta CAPACITY_j + \gamma_8 \Delta CONTRACT_j$$

(7)

Note that the first differencing has eliminated the $\beta_1$ term from (6) but introduced a fixed effect ($\gamma_0$) from the difference of the $\beta_0$ term. Note also that our measure for the change in computer usage, $\Delta CHIPS_j$ is indexed by $j$ since it is a (two digit) cross-section, as is UNION_j.

There are a number of issues concerning estimation method. First, identification.
Thusfar we have concentrated on labour demand, but relative employment is presumably determined by the interaction between demand and supply, or demand and some relative wage-setting mechanism. This suggests that the relative wage is likely to be endogenous, depending on inter-industry occupational mobility, the degree of bargaining centralisation and the like. Rather than embark upon the estimation of an (industry) labour supply/wage equation with the attendant difficulties of specification and identification we simply enter the lag of the relative wage and estimate by OLS. This has the merit of simplicity and seems a reasonable step under various interpretations of what underlies the accompanying "supply" relationship. If it is the outcome of decisions by workers to train or not, it seems reasonable to argue that training takes time and so supply cannot respond contemporaneously to relative wage signals. Similarly, if it is the outcome of decisions to "migrate" between industries, this is also likely to take time. Alternatively, if the relation is one where relative wages emerge out of union bargaining then our approach can be defended if one imagines that wages are fixed at the start of the period and then employment is determined.

The second issue concerns the inclusion or otherwise of a lagged dependent variable. We test for serial correlation in the errors to see if an lagged dependent variable is indicated. We also test for the significance of a lagged dependent variable which is instrumented using the generalised method of moments procedure of Arellano and Bond (1988, 1991). In fact neither criterion indicated the need for a lagged dependent variable; our time period is probably not long enough to establish lags accurately. Finally, for all regressions we report heteroscedastic-robust one-step t-statistics, and heteroscedastic-robust test statistics for serial correlation.
3c. Main results.

The results of estimating (7) are set out in table 4 (where we lose 1980 from first differencing and 1981 when the lagged wage term is included). For the purposes of comparison, in the first column we set out a simple specification with relative wages, hours, and the introduction of computer technology. Relative wages are correctly signed, with a coefficient implying an elasticity of substitution of 0.13, which is comparatively very low (Hamermesh, 1993). However it is not as sharply determined as we would like and so we would not want to set too much store by this number. Hours are also correctly signed and significant at the 10% level. CHIPS is correctly signed, and significant. The constant and time dummies (not reported) are jointly insignificant (Wald test distributed $\chi^2(8)=5.69$).\(^{15}\)

Column 2 drops the insignificant wage and hours terms. ΔCHIPS is well determined, and note that the magnitude of the coefficient hardly changes between column 1 and 2.

Both these preliminary regressions suggest that the introduction of computers is associated with increased use of skilled labour, echoing the results of Berman et al (1993) for the US and Machin (1994) for the UK. Column 3 then adds in the other terms suggested by the theory. Of the additional variables, only IMPORTS and CAPACITY have t-statistics above 1. The imports term is positive, suggesting that greater import competition raises relative skilled employment. The CAPACITY term is negative, which is consistent with labour hoarding, since one would expect unskilled employment to fall in recession. The signs on UNION and CONC suggest that falling union density and concentration have raised relative skilled employment, whereas the sign on CONTRACT suggests rising contracting out has raised it. None of these latter three terms are approaching significance however. Column

\(^{15}\) In all subsequent regressions the constant and time dummies are jointly insignificant and are therefore omitted. We also tried adding fixed effects to a equation for $\Delta(n_{it})$ with $\Delta(w_{it})_{it}$ and $\Delta(h_{it})_{it}$ as regressors, but they were jointly insignificant ($F(80, 557)=0.55$).
4 reports the outcome of dropping sequentially the least significant terms from column 3 until all terms have a t statistic greater than 1. Imports and capacity are significant at 25%, but the key point is that the computer term is similar magnitude to columns 1 and 2 (it is significant at the 6.9% level).

It may be felt that \( \Delta \text{CHIPS}_j \) is endogenous. Because it is a two-digit measure this may not be a problem, but even at a two digit level there are some industries with rather small cell sizes in our constructed \( \Delta \text{CHIPS} \) data. Column 5 reports an instrumental variables estimate using \( \Delta \text{IMPORTS}, \lambda \), and \( \text{IMPORTS}_{<j} \) as instruments for \( \Delta \text{CHIPS}_j \). The use of lagged terms should render the instruments valid and the Sargan test for instrument validity (one step, \( \chi^2(1) = 0.69 \)) suggests this is the case. As the table shows \( \Delta \text{CHIPS}_j \) remains significant, with the coefficient increased slightly. This confirms the robustness of the computer term. Interestingly, it also suggests that the effects of trade might work via trade-induced BTP, as Wood (1994) conjectures; we take this up below.

As another check on the robustness of the computer term, we estimated an equation based on a translog cost function, following the work of Berman et al (1993) and Machin (1994) on US and UK data respectively. They used blue and white collar workers as a measure of skill, and assumed these factors to be variable and capital fixed. Their equation is derived from minimising a restricted translog cost function, using the cross equation restrictions implied by adding up and homogeneity, assuming constant returns to scale, and first differencing. This gives

\[
\Delta S_{it} = \alpha_1 + \alpha_2 \Delta (w_\text{w} - w_\text{b})_{it} + \alpha_3 \Delta (k - y)_{it} + \Delta \psi_{it}
\]

(8)

where \( S_i \) is the wage bill of the skilled as a proportion of the total wage bill in industry \( i \), \( k \) is log capital stock and \( y \) log output. \( \alpha_i \) is a measure of the average cross-industry bias in
technical change towards the skilled.  

Equation (8) provides a strong robustness check in two particular regards. First, if computers are really biasing technical progress in favour of the skilled, $\Delta \text{CHIPS}_j$ should be significantly positive when entered as a determinant of $\alpha_t$ in (8). Second, the non-separability of capital in the translog equation provides a hypothesis to explain a rise in the share of the skilled that the CES form does not admit, namely capital accumulation (assuming capital-skill complementarity). The effect of computers should be robust to this. So, replacing $\alpha_t$ by $\Delta \text{CHIPS}_j$ and using lagged $(w_s, w_r)$ and $(k, y)$ gives (t statistics in parentheses)

$$
\Delta S_t = 0.008 \Delta \text{CHIPS}_j - 0.11 \Delta (w_s - w_r)_{t-1} + 0.03 \Delta (k - y)_{t-1}
$$

(3.47) (4.90) (2.14)

(9)

$$
m_1 = -3.40, m_2 = 0.96, \text{Wald}_{\chi^2}(8) = 8.1
$$

where once again the effect of micro-chips is strongly positive and significant. The implied elasticity of substitution is 1.47 confirming our assumption of $\sigma > 1$ above. Capital is complementary to skilled labour, which is in line with other work e.g. Hamermesh (1993). Overall then the positive association between the introduction of computers and a decline in demand for the unskilled seems robust. These results are then consistent with the view that the introduction of computers is associated with a bias in technical progress in favour of the skilled.  

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14 $\alpha_t$ is related to the elasticity of substitution between the labour types by $\sigma = \alpha + S_S, r(S, S)$ where $S = 1 - S_r$, (average $S_r$ over the period=0.63). $\alpha_t$ is positive if capital and skilled labour are complements.

15 In another experiment we took the specification of table 4, column 1 and interacted $\Delta \text{CHIPS}$ with the time dummies; the resulting terms were jointly significant for the whole period.
3d. Discussion.

The key correlation established above is that the introduction of computers is associated with an increase in the ratio of skilled to unskilled labour. In this section we discuss (i) how this relates to other findings, (ii) whether the correlation is causal, (iii) the role of trade and (iv) the quantitative impact of microchips.

(ii) Other findings on microelectronics. It is reassuring that our findings on microelectronics are similar to two other types of study, econometric and case study. In other econometric work, Berman et al (1993) find a significant positive effect of computer investment in raising the wage share of non-production workers in US manufacturing 1979-86. As for UK data, our findings are similar to Machin (1994). Using two digit data on manuals/non-manuals, he finds that technical progress measures such as R&D and innovations data have significantly reduced the manual wage share and employment. He reaches a similar conclusion using data on microprocessor introduction in UK establishments.10

Turning to case studies, Berman et al (1993) summarise a number of US case studies where the introduction of computers has reduced the demand for non-manual labour. However our study relates to the UK and skilled labour, and it would clearly be informative to have evidence for this case.

As would be expected, individual case studies are somewhat mixed. McGloughlan and Clark (1994) survey a number of cases where microprocessors have invalidated traditional

---

10 Using 2 digit data, 1971-88, Bean and Pissarides (1991), find no effects of skilled labour-augmenting technical progress on non-manual/manual employment. They use time dummies to proxy BTP. If we drop ΔCHIPS from column 1 of table 4, add relative skill shortages and CAPACITY (variables used by Bean/Pissarides) and replace it by time dummies they are jointly insignificant (Wald $\chi^2(8)$=7.63). Notwithstanding the differences in data and time period this suggests that time dummies might be too crude to pick up BTP.
skills; for example the programming of biscuit baking recipes which has displaced the skills of master bakers, or word processors removing the need for typesetters. Against this, microprocessors in lens cutting have raised the productivity of skilled lens cutters by reducing the trial and error element of the job.

One seemingly general finding however is that skilled workers are better equipped to deal with the changes in the job that microprocessors bring. In a study of CNC machines, Simpson et al (1987) found that skills have changed from setting the CNC machine to identifying quality problems and breakdowns. However they argue that this does not reduce the demand for skilled labour, because whilst a novice can be trained quickly to operate the CNC machinery the demand for previous skilled operators remains since they have the skill and experience to deal with judging quality and identifying faults.

Three large scale case studies are consistent with the idea that microprocessors/computers augment the productivity of the skilled. First, in the 1984 WIRS survey of 458 firms experiencing advanced technical change, only 15% of managers stated that such new technology would reduce the skill of manual workers (Daniel, 1987). Second, the 1985/6 Social Change and Economic Life survey of 1000 individuals in Aberdeen, Coventry, Kirkcaldy, Northampton and Rochdale and Swindon, surveyed those using automated or computer equipment in their jobs and those not using such equipment. Of those not using, 62% of individuals reported having received no training, and only 37% reported that O levels were a requirement for new recruits. On the other hand, of those using the equipment, only 39% had received no training and 73% said that at least O levels were required (Gallie, 1994). Finally, a survey of 1,200 factories in 1984 carried out by PSI (Northcott, Fogarty and Trevor, 1985) found that the introduction of microelectronics was
associated with a higher loss of unskilled employment. As table 5 shows, manufacturing employers reported a decline in unskilled jobs of 26,000 between 1981 and 1983, as against a decline of 4,000 in skilled jobs. They also expected declines of 23,000 and 2,000 respectively. It is also interesting to note that shopfloor jobs have declined (and were expected to decline) disproportionately to other jobs due to microprocessors, which is in line with the American studies.

(ii) Correlation and causation. Nonetheless it may still be asked what inference about causation can be drawn from our econometric correlation. A number of points are worth noting. First, it might be argued that there is spurious correlation. Suppose for example that there was some unobservable variable, such as technological opportunity, that raised both the probability of introducing micro-chips and also the demand for skilled labour. Then the observed correlation would be a spurious one, driven by this unobservable. Unobservables are by definition unmeasurable, and so the only feasible step is to include as many dummies as the data permits. As explained above the panel nature of the data allows us to include time dummies, and fixed effects in both the level of $n_t-n_n$ and the change in $n_t-n_n$. Thus if some unobservable is driving our results it would have to be over and above the effects of the included regressors, the mean of $(n_t-n_n)$, the mean change in $(n_t-n_n)$, and common shifts in $(n_t-n_n)$.

A second possibility is reverse causation. For this to affect our results it would have to be the case that the introduction of computers is determined by the change in relative

17 Of course we need to assume here that respondents ignore possible general equilibrium effects of computers on relative wages and product prices; if so, a predicted fall in unskilled relative to skilled labour is consistent with the view that microprocessors augment the efficiency of skilled labour.
employment, so that a firm finding itself with increasingly skilled employment is more likely to introduce computers. For example, firms might hire skilled electronic engineers to develop microelectronic technology and then introduce it. Three factors suggest this effect is unlikely to be unduly influencing our results. First, in an econometric sense our results are robust to instrumenting the introduction of computers by a variable that is a statistically valid instrument. Second, the case study evidence indicates that product market conditions determine the introduction of computers via competition or the expectation that firms can gain market share. This suggests that causation runs from the product market to the introduction of microchips to the effect on the labour market. Third, a 1985 survey found that only 3% of firms adopting microelectronics-based process innovations had designed and made the system in their own factory. In 67% of cases the system was a catalogue item from an outside supplier (Northcott, 1986).

A final possibility is that we have detected a merely "mechanical" relation, in the sense when computers are introduced a worker’s occupation is re-classified which makes them into skilled workers. This is not the case since the job titles in the KOS system (e.g. toolmaker) typically refer to the tasks a worker undertakes rather than the means with which the task is performed.

(iii) Trade. We have found no strong effects of trade in the above regressions (a similar finding emerges from experiments below). If for example we multiply average value of ΔIMPORTS (0.077) by its coefficient from column 4 of table 3 we obtain 0.9% which is non-negligible, but based on a coefficient insignificantly different from zero. However it might be that trade effects are obscured since they might determine the introduction of

\footnote{For this reason we have lagged CONC and IMPORTS.}
microprocessors or indeed the bias in technical progress in other ways. Wood (1994) for example argues that the effect of imports might have been to induce technical progress in favour of the skilled. There is also a growing literature suggesting that unions might affect innovation, see e.g. Beath, Katsoulacos and Ulph (1988) and Dowrick and Spencer (1985).

To investigate this we therefore entered the level of IMPORTS, UNION, and CONC as a determinant of $\Delta(n_t-n_t)$; so if for example imports have induced BTP we would expect a positive impact of the level of IMPORT on $\Delta(n_t-n_t)$. The results of this exercise are set out in table 6, column 1. The signs suggest that imports raise BTP whereas unions inhibit it. But, none of the included variables approach significance, and a Wald test suggests they are jointly insignificant ($\chi^2(3)=1.43$). It is likely that the inducement of BTP is a longer term and more complicated process than the limited time period and crude measure in our data can detect.18

(iv) Quantifying the $\Delta$CHIPS effect. Between 1981 and 1989 $(n_t-n_t)$ rose by 4.43%. If we multiply the coefficient in column 2 of table 3 by the average value of $\Delta$CHIPS over the period (0.39) and the number of time periods (9) we obtain 1.52%. So computers explain about a third of the rise in $(n_t-n_t)$.

18 Wood (1994) finds that between 1950 and 1990 increased imports from the South caused a loss of 9 million manufacturing person-years in the North (p.10), about 12% of 1990 Northern manufacturing person-years (table 4.9). He argues that almost all of this reduction is in unskilled employment, that much of it happened in the 1980s and that taking account of labour saving technical change might double the figure (pp.10-11). Comparison of his figures is obscured since he uses a longer data set which included manufacturing and services. In addition, Wood’s estimates are based on a factor-content approach, whereby import volumes are multiplied by an assumed employment output coefficient, the resulting figure giving the employment embodied and therefore displaced by in imports (see e.g. his chapter 4). See Freeman (1995), Krugman (1984) and Burtless (1995) for criticisms of this approach.
4. Robustness checks and further experiments.

4a. Lagged dependent variable.

The serial correlation tests do not indicate the need for lagged dependent variables, but to check on this we took the baseline specification of column 1, table 4, and entered a lagged dependent variable. Due to Nickell (1981) bias, we need to instrument this variable and we implement the Arellano-Bond procedure as set out above. Using all available instruments on \((n_t-n_s)\) dated t-2 and before we obtain an insignificant coefficient on the lagged dependent of 0.09, \(t=0.74\), see column 2 of table 6. The other coefficients are not much affected.

4b. Other trade measures.

There is some controversy as to whether it is preferable to use price variables to measure the impact of trade rather than volume measures (see the discussion in Burtless, 1995). To examine this we tried entering a number of different price variables, namely \(\Delta(p_{it}-p_{st})\) and \(\Delta(p_{it}-p_{jt})\). As columns 3 and 4 of table 6 show, none of them were significant.

4c. Other cyclical measures.

It may be felt that we have failed to pick up adequately labour hoarding, or changes in the relative outside opportunities that might affect relative effort. We therefore added to the basic specification three digit relative skill shortages, two digit capacity constraints, two digit changes in real output, and industry unemployment (not reported). Our basic equation was unaltered, with \(\Delta\text{CHIPS}\) remaining significant.

4d. Entry.

We added entry to our basic specification to see if those industries where entry has
been larger have raised their skilled employment. As column 5 of table 6 shows although the
effect is positive, it is not significant (neither was the lag) and the effect on \( \Delta \text{CHIPS} \) is
negligible.

4e. Small firms.

An increasing proportion of manufacturing employment has been in small firms over
the 1980s (see data appendix, section 4). If small firms are employing more skilled labour
there may be a batting average effect whereby more small firms cause upskilling. To
examine the effect on relative skills we entered this in the regression. However the effect was
not significant, column 6. Another potential effect is that case study evidence shows that
microelectronics tend to be adopted in large firms. We therefore entered the small firm
proportion as a level in the change equation, but this was insignificant (0.01, \( t=1.34 \)).

4f. Manuals and non-manuals.

For comparison we estimated the same equation for non-manuals and manuals. We
entered the same variables as in column 3 of table 4, except that we did not have any relative
hours data. The best version of this specification is set out in table 6, column 7. Computers
are still significant. There are some differences however; the time dummies are jointly
significant and there is a significant effect from subcontracting. Finally, if we estimate the
translog equation for manuals and non-manuals we obtain a coefficient on \( \Delta \text{CHIPS} \) of 0.004,
\( t=2.39 \), confirming the importance of computers.

We have assembled a new data set to analyse the fall in unskilled employment in the UK over the 1980s. Our point of departure from other studies is to use data on relative skills rather than the manual/non-manual distinction. We have matched data from four main sources: the NESPD to measure employment, hours and wages by skill, the Census of Production to measure industrial structure variables, the UK Customs and Excise to measure foreign trade, and the 1984 Workplace Industrial Relation Survey. This has given us a data set of 80 three-digit industries, 1980-1989.

Our key findings are fourfold. First, between 1980 and 1989 the share of skilled employment in manufacturing employment rose 4.4% non-manuals rose 6.7%. Second, there is has been no contribution to this rise from the averaging effect of workers flowing to more skill-intensive industries. Third, the introduction of microprocessors/computers caused an increase of 1.5% in the skill/unskilled employment ratio. The significance of the contribution of computers is robust to instrumentation, changes in functional form and inclusion of other variables. It is also consistent with evidence from case studies and other econometric work. Finally, we find no significant effect on the employment ratio of trade, unionisation, subcontracting, small firms or entry.

How unique is the computer revolution? Some authors have argued that the effects of computers are so far-reaching as to differentiate them from innovations that are continually being introduced, or those that have industry-specific/localised effects (e.g. nylon), Freeman and Perez (1988). Whatever the truth of this, the evidence in this paper suggests that the impact of microelectronics detected in other papers in raising non-manual employment is also important in raising the relative demand for skilled workers.
Table 1
Allocation of socio-economic groups (SEGs) to skill categories

<table>
<thead>
<tr>
<th>S.E.G.</th>
<th>Skilled/Unskilled</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non Manual</strong></td>
<td></td>
</tr>
<tr>
<td>1. Managers</td>
<td>Skilled</td>
</tr>
<tr>
<td>2. Professional and technical workers</td>
<td>Skilled</td>
</tr>
<tr>
<td>3. Intermediate non manual workers</td>
<td>Skilled</td>
</tr>
<tr>
<td>4. Junior non manual workers</td>
<td>Unskilled</td>
</tr>
<tr>
<td><strong>Manual</strong></td>
<td></td>
</tr>
<tr>
<td>5. Foremen and Supervisors</td>
<td>Skilled</td>
</tr>
<tr>
<td>6. Skilled manual</td>
<td>Skilled</td>
</tr>
<tr>
<td>7. Semi-skilled manual</td>
<td>Unskilled</td>
</tr>
<tr>
<td>8. Unskilled manual</td>
<td>Unskilled</td>
</tr>
</tbody>
</table>

**Note:** The first column shows the official method of allocating SEGs to manual/non-manual and the second the authors' chosen allocation of workers between skilled and unskilled. Cell sizes are too small to permit a finer disaggregation.
Table 2
Correlations

<table>
<thead>
<tr>
<th>Variable (increase refers to 1989 less 1980)</th>
<th>Row</th>
<th>Mean</th>
<th>Correlation with proportion of industry employment skilled, 1980</th>
<th>Correlation with proportion of industry employment non-manual, 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase employment skilled/unskilled</td>
<td>1</td>
<td>7.8%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Increase employment non-man/man</td>
<td>2</td>
<td>8.3%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Increase wage skilled/unskilled</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Increase wage non-man/man</td>
<td>4</td>
<td>10.9%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proportion industry employment skilled, 1980</td>
<td>5</td>
<td>0.51</td>
<td>0.88*</td>
<td>0.30</td>
</tr>
<tr>
<td>Microchip introduction, 1980-1983</td>
<td>6</td>
<td>0.39</td>
<td>0.28</td>
<td>0.48</td>
</tr>
<tr>
<td>Trade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase in import penetration</td>
<td>7</td>
<td>0.08</td>
<td>-0.18</td>
<td>0.06</td>
</tr>
<tr>
<td>% increase in import prices relative to domestic prices</td>
<td>8</td>
<td>-0.10</td>
<td>-0.01</td>
<td>-0.25</td>
</tr>
<tr>
<td>% increase in import prices relative to export prices</td>
<td>9</td>
<td>-0.03</td>
<td>-0.07</td>
<td>-0.26</td>
</tr>
<tr>
<td>Increase in contracting out</td>
<td>10</td>
<td>0.02</td>
<td>-0.22</td>
<td>0.03</td>
</tr>
<tr>
<td>Increase in union density</td>
<td>11</td>
<td>-21.33</td>
<td>-0.07</td>
<td>-0.45</td>
</tr>
</tbody>
</table>

Notes: Means are unweighted averages across the 80 industries (weighted averages are very similar). * denotes correlation with column variable dated 1989. For definitions of variables see data appendix.

Source: Author’s calculations using industry database.
<table>
<thead>
<tr>
<th>Labour type</th>
<th>Total change in share</th>
<th>change between industries</th>
<th>change within industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-manuals</td>
<td>0.020</td>
<td>0.002</td>
<td>0.018</td>
</tr>
<tr>
<td>Skilled</td>
<td>0.047</td>
<td>-0.002</td>
<td>0.050</td>
</tr>
</tbody>
</table>

Note: numbers may not add due to rounding.

Source: calculations based on 80 industries data set.
Table 4
Relative employment of skilled and unskilled labour: panel estimates of (7)
(dependent variable: $\Delta(n_s-n_u)$)

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta(w_s'-w_u)$</td>
<td>-0.13</td>
<td>-0.12</td>
<td>-0.13</td>
<td>-0.13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.56)</td>
<td>(1.57)</td>
<td>(1.54)</td>
<td>(1.62)</td>
<td></td>
</tr>
<tr>
<td>$\Delta(h_s'-h_u)$</td>
<td>0.34</td>
<td>0.36</td>
<td>0.35</td>
<td>0.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.67)</td>
<td>(1.68)</td>
<td>(1.69)</td>
<td>(1.70)</td>
<td></td>
</tr>
<tr>
<td>$\Delta$CHIPS$^*$</td>
<td>0.44</td>
<td>0.43</td>
<td>0.23</td>
<td>0.42</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>(2.01)</td>
<td>(2.60)</td>
<td>(0.91)</td>
<td>(1.81)</td>
<td>(2.91)</td>
</tr>
<tr>
<td>$\Delta$IMPORT$^*$</td>
<td>0.12</td>
<td>0.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.18)</td>
<td>(1.15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta$CONC$^*$</td>
<td>-0.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.72)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta$UNION$^*$</td>
<td>-0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.82)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta$CONTRACT</td>
<td>0.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.81)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta$CAPACITY</td>
<td>-0.04</td>
<td>-0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.16)</td>
<td>(1.16)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$m_s, N(0,1)$</td>
<td>-4.12</td>
<td>-3.67</td>
<td>-4.18</td>
<td>-4.17</td>
<td>-4.09</td>
</tr>
<tr>
<td>$m_u, N(0,1)$</td>
<td>-0.68</td>
<td>-0.25</td>
<td>-0.72</td>
<td>-0.66</td>
<td>-0.68</td>
</tr>
<tr>
<td>Estimation</td>
<td>OLS</td>
<td>OLS</td>
<td>OLS</td>
<td>OLS</td>
<td>IV</td>
</tr>
</tbody>
</table>

Notes to Table:
(i) Data for 80 three digit industries. Absolute t statistics in brackets. $m_s$ and $m_u$ are the Arellano-Bond (1988) one-step heteroscedastic robust test against first and second-order serial correlation. We expect an $m_s$ error from first differencing. $m_u$ checks there is no correlation between the differenced errors and their second lag (necessary condition for undifferenced errors to be white noise). See Arellano and Bond (1988). * denotes that reported coefficient is multiplied by 100.

(ii) All columns estimation period is 1982-89, except for column 2 which is 1981-89.

(iii) In column 5 estimation is by instrumental variables. Instruments comprise $\Delta(w_s'-w_u)$, $\Delta(h_s'-h_u)$, IMPORTS, and $\Delta$IMPORTS.
Table 5
Changes in employment due to use of microelectronics in UK manufacturing
(data from PSI survey)

<table>
<thead>
<tr>
<th></th>
<th>Changes 1981-3 ('000)</th>
<th>Changes expected 1983-85 ('000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skilled shopfloor jobs</td>
<td>-4</td>
<td>-2</td>
</tr>
<tr>
<td>Unskilled shopfloor jobs</td>
<td>-26</td>
<td>-23</td>
</tr>
<tr>
<td>Shopfloor jobs</td>
<td>-30</td>
<td>-25</td>
</tr>
<tr>
<td>Other jobs</td>
<td>-4</td>
<td>-5</td>
</tr>
</tbody>
</table>

Source: Northcot, Fogarty and Trevor (1985)
Table 6

Robustness checks
(dependent variable: Δ(\(w, n\)),)

<table>
<thead>
<tr>
<th></th>
<th>(1) BTP endog</th>
<th>(2) idv trade</th>
<th>(3) trade entry</th>
<th>(4) small firms nonmanual/ manual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ((w, n))(t-1)</td>
<td>-0.13</td>
<td>-0.12</td>
<td>-0.13</td>
<td>-0.13</td>
</tr>
<tr>
<td></td>
<td>(1.54)</td>
<td>(1.53)</td>
<td>(1.55)</td>
<td>(1.57)</td>
</tr>
<tr>
<td>Δ((h, n))(t-1)</td>
<td>0.34</td>
<td>0.38</td>
<td>0.33</td>
<td>0.34</td>
</tr>
<tr>
<td></td>
<td>(1.69)</td>
<td>(1.62)</td>
<td>(1.63)</td>
<td>(1.67)</td>
</tr>
<tr>
<td>Δ(IMPORTS)(t)</td>
<td>0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.53)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNION(t)</td>
<td>-0.01</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.31)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONC(t)</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.66)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ((n, n))(t-1)</td>
<td>0.09</td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>(0.74)</td>
<td></td>
<td></td>
<td>(0.56)</td>
</tr>
<tr>
<td>ΔENTRY(t)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔSMALL FIRM(t)</td>
<td>0.06</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.41)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔCONTRACT(t)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(m_1, N[0,1])</td>
<td>-4.13</td>
<td>-3.30</td>
<td>-4.12</td>
<td>-4.17</td>
</tr>
<tr>
<td></td>
<td>(2.11)</td>
<td>(2.08)</td>
<td>(2.13)</td>
<td>(2.14)</td>
</tr>
<tr>
<td>(m_2, N[0,1])</td>
<td>-0.71</td>
<td>-0.40</td>
<td>-0.67</td>
<td>-0.71</td>
</tr>
<tr>
<td></td>
<td>(0.81)</td>
<td>(0.79)</td>
<td>(0.84)</td>
<td>(0.84)</td>
</tr>
</tbody>
</table>

Notes to Table:

(i) See note (i) to table 4. Estimation period 1982-89.

(ii) Column 2: estimated by IV. Instruments comprise Δ(\(w, n\)), Δ(\(h, n\)), and all available lags on Δ(\(n, n\)) from t-2 back. Column 3: trade variable is Δ\(w, p_1\), Column 4: trade variables is Δ\(w, p_2\), Column 7: dependent variable is Δlog(non-manual employment/manual employment) and (\(w, n\)) the corresponding relative wage term, constant and time dummies included.
References


1. Employment, wage and hours data (NESPD)
The NESPD uses National Insurance numbers of individuals surveyed to contact employers who are asked for the individual’s job description. This job description is then classified into an standard occupation (KOS). KOS are the Key Occupations for Statistical purposes derived from the CEDOT system. Details are available from the Employment Gazette 1980 or Gregory and Thompson (1990). Using these data we have been able to derive Socio Economic Groupings (SEG) from which we have largely based our occupation groups, a mapping of SIC 1968 to SIC 1980, and average gross weekly pay and average total hours. The SEG groupings are based on the format of Gregory and Thompson (1990). On pp. 500-512 they set out how the COS groups relate to the SEG groups. But since their work there are some extra COS numbers. These were allocated to SEGs by inspection. The SEGs were then allocated to skills and unskilled as per table 1.

Our wage data comes from the New Earnings Survey (NES) is carried out on behalf of the Employment Department (ED) each year, and provides the main source of information on the structure of earnings in Great Britain. The sample frame is approximately one per cent of employees in employment, and is constructed using the same last two digits of the individuals NI numbers. The New Earnings Panel Dataset (NESPD) has been created using the NI number to link individual records through time. The NESPD currently runs from 1975 to 1990 and contains information on 430,000 individuals, making some 7½ million cells of information on each variable. Because the NES and hence NESPD is collected under the Statistics of Trade Act 1947, information leaving ED must relate to not less than three people. This restriction implies some form of aggregation. In our case we have aggregated over the Standard Industrial Classification (SIC 1980) and KOS or SEG groupings, to match in with the Census Of Production and Customs and Excise data. Details of these procedures are as follows. By creating a three digit mapping between MLH and AH we have been able to aggregate over SIC 1980 for the whole sample. A statistical mapping was used in the absence of adequate disaggregation possible from a one to one mapping. A Gauss program is available from the authors upon request. The wage is calculated as pre-income tax hourly earnings times total hours worked with national insurance contributions added by multiplying the NIC contribution for the whole industry (from the Census) by the wage share of the skilled or unskilled.

Further information on all aspects of the NESPD is available from Robert Jukes, Department of Education and Employment, Caxton House, Tothill St., London SW1H 9NF, UK.

2. The NES and the LFS.
An alternative source of data on occupation is the Labour Force Survey (LFS). The LFS relies on individuals to report their occupation during interview. These are then allotted into standardised occupations by the interviewer at the time of interview, allowing the interviewer to probe the respondent directly. This avoids the necessity of a centralised classification as used by the NES, and so might be felt to provide more accurate occupation information. The LFS has three significant problems however which make us use the NES. First, there is no LFS for 1980 and 1982 when many significant changes are occurring. Second, there is a discontinuity in sample frame between the biannual LFS in 1980 and 1982 and the annual LFS in 1983 onwards. Thirdly, the LFS is felt to be susceptible to misclassification of industries since it relies on information provided individuals rather than employers.
3. Other industry data.

These data are mainly drawn from the UK Census of Production.

Output (Y)
Output is measured by the ‘index of volume of output’, from the Quarterly Returns. This is essentially a gross output measure.

Capital stock (K)
Capital stock data was obtained on the 1968 SIC from R. Allard. It was then converted to the 1980 SIC by a translation matrix devised by A. Vlassopoulos of London Business School that is based on overlapping Census reports for that year. Data for 1980-1989 was generated using net capital expenditure data (from Annual Report), an assumed depreciation rate of 4% and capital goods deflators from the Blue Book.

Import penetration (IMPORTS)
Value of imports divided by sales plus imports less exports, all from Quarterly Returns.

Prices
Import prices (p_u) are prices of imported goods by industry from the LBS, likewise export prices (p_e). Domestic prices (p_mw) are two-digit wholesale prices from the Annual Abstract.

Unionisation (UNION)
Percentage of industry unionised (2 digit). Update of Bain and Price.

Contracting out (CONTRACT)
Cost of non-industrial services received divided by gross output, from Census.

Capacity constraints (CAPACITY)
Percentage of firms in an industry replying yes to the question "over the next quarter do you expect your output to be constrained by a shortage of plant and capacity". Owing to confidentiality requirements the data is only available between the two and three digit level.
Source: authors' calculations from the CBI Quarterly Industrial Trends Survey.

Employment and wages of manuals and non-manuals
Non-manuals are defined as "administrative, technical and clerical employees". Manuals are defined as "operatives". Wage and employment data come from the Census of Production. To the average wage we add in national insurance contributions pro rata.

Concentration (CONC)
Five-firm concentration ratio by sales. From Census of Production.

Entry
Change in the number of enterprises. From Census of Production.

Small firms
Proportion of industry employment in firms under 100 employees. From Census of Production.
Skilled and Unskilled Shortages.
Percentage of firms in an industry replying yes to the question "over the next quarter do you expect your output to be constrained by a shortage of skilled labour?", and similarly for unskilled labour. Owing to confidentiality requirements the data is only available between the two and three digit level. Source: authors' calculations from the CBI Quarterly Industrial Trends Survey.

4. Other data averages (same notes apply as in table 2).

<table>
<thead>
<tr>
<th>Variable (Increase refers to 1989 less 1980)</th>
<th>Mean</th>
<th>Correlation with proportion of industry employment skilled, 1980</th>
<th>Correlation with proportion of industry employment non-manual, 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in industry employment (%)</td>
<td>-0.29</td>
<td>-0.10</td>
<td>0.08</td>
</tr>
<tr>
<td>Increase in prop. small firms</td>
<td>0.09</td>
<td>0.02</td>
<td>0.09</td>
</tr>
<tr>
<td>Increase in capacity constraints</td>
<td>11.67</td>
<td>0.12</td>
<td>-0.04</td>
</tr>
<tr>
<td>Increase in real output (%)</td>
<td>0.12</td>
<td>-0.02</td>
<td>0.27</td>
</tr>
<tr>
<td>Increase in real capital stock (%)</td>
<td>0.39</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>Increase in relative hours (%)</td>
<td>-0.03</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>Increase in relative skill shortages (%)</td>
<td>0.17</td>
<td>0.25</td>
<td>0.15</td>
</tr>
<tr>
<td>Increase in industry prices (%)</td>
<td>2.00</td>
<td>0.09</td>
<td>0.32</td>
</tr>
</tbody>
</table>
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Australian National University

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