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THE LONG RUN BIAS AGAINST MANUAL WORKERS IN BRITISH MANUFACTURING 1920 – 1995

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The Long Run Bias Against Manual Workers in British Manufacturing 1920 – 1995.

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Abstract: This paper presents quantitative estimates of the effects of technological change on the composition of manual and non-manual employment in manufacturing in the United Kingdom for the period 1921 – 1995. The paper separates the effects of relative wage change, biased technological change and changes in sectoral composition and calculates the upward pressure on relative pay exerted by biased technological change.

Keywords: Skill change, United Kingdom, technological change, sectoral composition.

JEL classification: J40, O52.

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1. Introduction.

From the end of the 1970's to the beginning of the 1990's there was an increase in general earnings inequality in the UK. The earnings differentials between highly paid and low paid workers widened and there was an increase in income dispersion within almost any group in the labour market as discussed in Machin [1996a]. This increase in inequality was notable because it reversed a strong tendency towards equality over the previous fifty years, as demonstrated by the Royal Commission on the Distribution of Income and Wealth [1979]. This is similar to movements in inequality in other countries. Although the circumstances of different countries have influenced the detailed patterns of these changes, the widespread nature of the changes has suggested the need for general explanations. Standard explanations rely on changes in the balance of supply and demand in favour of workers with higher skills and ability and more generally towards non-manual, white-collar workers. The two most widely discussed explanations of the changing balance are structural shifts between sectors, particularly the changing balance between the service and manufacturing sectors, perhaps linked to trade, and 'skill-biased' technical change, Freeman [1995].

An important aspect of the growth in inequality in the UK has been the increase in the pay of non-manual workers relative to manuals and this is often interpreted as an indication of the shift towards 'skill'. Although there is too much diversity within these broad groups to identify non-manual work with skill and manual work with lack of skill, the changing fortunes of these two groups do throw light on the nature of biased technological change and the degree to which it can explain changing pay differentials. In this paper we consider the way biased technological change altered the balance between manual and non-manual workers in British manufacturing and the way this may or may not have been related to the relative pay of these two groups. This aspect of biased technological change is discussed by

Berman, Bound and Griliches [1994] for the USA and by Machin and van Reenen [1998], and Acemoglu [2003] in an international context. The UK has experienced similar bias, as discussed in Machin [1996b].

The present paper continues in the spirit of Goldin and Katz [1998] and other economic historians who have emphasised the long-standing nature of technological bias and the way its direction varies over time and between countries. The development of the early factory system in England was biased against highly skilled manual workers, and the development of the integrated production line was motivated at least in part to reduce dependence on the 'labour aristocracy' of skilled, unionised workers. Habakkuk [1967] analysed differences in technological bias between America and Britain in the nineteenth century, showing that there are good reasons for technological developments to vary between countries. Here we look at the very long-term bias against manual workers in British manufacturing. We consider the employment of manual and non-manual workers in fifteen industries in manufacturing over the period 1920 to 1995.

The distinctive features of the paper are:

- It explicitly measures technological bias and the way it has changed.
- The time period considered, 1920 – 1995, is much longer than in most discussions.
- Because we have explicit measures of the technological bias over a long time period we are able to assess whether there was an acceleration in this bias at the beginning of the 1980's
- It explicitly considers whether the increasing bias towards non-manual workers has been sufficient to account for changes in their relative pay over a long period.

The main conclusions of the paper are that the increasing bias against manual workers in British manufacturing is not a recent phenomenon and can be traced as far back as at least 1920. Although there is some evidence that the bias may have accelerated recently, there have been other periods when it was quite pronounced. Despite this long standing increase in the bias against manual workers, from 1920 until the late 1970's there was a general narrowing of the pay differential between manual and non-manual workers. This suggests that the increasing bias can be only part of an explanation for the more recent widening in the pay differential between these groups and growing inequality generally.

2. The Increasing Bias Against Manual Workers in British Manufacturing 1920 – 1995.

The paper is based on data relating to the employment of manual and non-manual workers in British manufacturing from 1920 to 1995. Data for the period 1920 to 1938 are taken from Chapman [1953]. Tables 44 and 45 in Chapman give the numbers of salaried workers and wage earners and wage and salary payments for each year for manufacturing industries. The data are derived from the Censuses of Production conducted at various intervals in this period and from other data sources discussed by Chapman in exhaustive detail. For the period after the Second World War the data are derived from published Census of Production reports. These censuses were again conducted at irregular intervals during the 1950's and 1960's but with the exception of 1974, when there was no census, were conducted every year from 1970 on. There have been changes in the classification of industries and the way the data are presented over this long period, but it is possible to assemble consistent series for fifteen industries. Although a finer level of disaggregation would be desirable, the picture which emerges from the data is consistent and informative. The data is sufficient to show the way the ratio of manual to non-manual workers has varied over this long period, to calculate a

measure of the way the underlying technological bias between the two groups of workers has changed and to derive measures of the contribution of this changing technological bias to the changing relative employment of these two groups.

The relative employment of manuals.

A simple measure of the bias against manual workers is the ratio of manuals (operatives) to non-manuals (administrative and clerical staff). These are given in Table 1 for various years covering 1920 to 1995. It is clear that all industries have experienced the decline in relative employment of operatives. It is also clear that this is not a recent phenomenon. Apart from 'Leather and Fur' and 'Footwear and Clothing' all industries exhibited this decline between 1920 and 1930. Although the disruption of the 1930's and the Second World War resulted in some other interruptions to this general trend, by 1948 only these two industries had not shown this decline. From 1948 to 1995 every industry has shown a consistent decline in the relative employment of operatives.

Table 1 also shows that there is considerable heterogeneity across industries in the ratios of manuals to non-manuals and in the way the ratios have changed over time. There are also clear variations within industries in the pace of change between different time periods. The textile industry was clearly most intensive in the use of manual workers at the beginning of the period, experienced a dramatic fall in the relative use of manual workers up to 1970 since when the decline has continued but at a pace similar to that in other industries. Although the ratios of manuals to non-manuals is more equal across industries at the end of the period than at the beginning, there is still considerable variation, with 'Leather and Fur' showing a ratio more than five times that in 'Instrument Engineering'. Since 1970 all industries show the increasing bias against manuals but it is not obvious that this trend has been greater after 1979 than before. The general implication of Table 1 is that the representation of technological bias

and its change should allow for considerable differences between industries and in rates of change both between industries and within industries between different time periods.

Table1. Ratio of Operatives to Administrative Staff: British manufacturing 1920-1995.

	1920	1930	1938	1948	1970	1979	1989	1995
MetalMan	12.38	9.63	8.95	5.91	3.32	2.90	2.52	2.85
NonMtMn	12.06	0.40	10.37	7.19	3.68	3.25	2.67	2.59
Chemicls	5.35	3.65	2.88	2.64	1.53	1.45	1.08	0.98
MtlGdNes	7.41	7.11	7.94	5.85	3.59	3.04	2.94	2.76
MecEng	7.82	6.60	5.62	3.93	2.21	1.78	1.70	1.19
ElectEng	4.40	3.82	3.42	3.25	2.05	1.76	1.29	1.41
Vehicles	7.18	5.96	6.61	4.72	2.41	2.33	2.08	2.15
InstrEng	6.87	5.09	5.19	3.81	1.80	1.43	1.46	0.93
FdDnkTb	5.37	4.50	3.77	4.85	3.69	3.52	3.53	3.60
Textiles	20.20	15.19	14.43	10.04	4.91	4.23	3.80	3.52
LtherFur	6.46	6.74	7.41	6.66	5.22	4.60	4.08	4.83
FootClth	7.55	7.71	8.61	9.31	6.52	5.52	5.07	4.74
TimbPdct	6.85	6.80	7.53	6.84	3.92	3.31	2.96	2.44
PprPntng	5.78	5.33	4.37	3.68	2.34	1.84	1.29	1.04
OtherMan	7.75	5.75	5.44	5.17	3.24	2.80	2.65	2.51

Measures of Skill Bias.

Although the ratios of manual to non-manual workers show the way employment has swung against manuals, they are not explicit measures of technological bias. The ratios reflect the combined effects of relative pay as well as underlying technology and changes in the ratios are the result of changes in both of these. To disentangle the effects of relative pay and genuine technological bias we take a CES representation of the technology of each industry in each year and calculate the technological parameters which affect the ratio of manuals to non-manuals.

We assume that output in each industry *i* may be represented by the production function:

$$Y_{it} = \left[a_{it} H_{it}^{\delta} + b_{it} L_{it}^{\delta}\right]^{\frac{1}{\delta}} f_i(K_i) \qquad (1)$$

Non-manual workers, H, are combined in CES manner with manuals, L, which are separable from other inputs *K*. This assumption is commonly made, and although restrictive, is parsimonious in parameters and permits calculation of explicit measures of technological bias. Each sector *i* has its own set of parameters which can vary over time, allowing full heterogeneity of production relations, although all are constrained to be CES.

Assuming cost minimisation in competitive conditions:

$$\frac{H_{it}}{L_{it}} = \left[\frac{w_{Hit}}{w_{Lit}}\right]^{1/(\delta-1)} \left[\frac{a_{it}}{b_{it}}\right]^{-1/(\delta-1)} \qquad (2)$$

This shows that changes in relative factor intensities depend on changes in relative pay as well as changes in technology. Changes in factor ratios will only indicate changes in technological bias if relative pay stays constant. Relative pay has changed considerably over the long period considered here however, both within and between industries. An increase in the relative use of non-manuals will understate the magnitude of a shift in technological bias if it takes place against an increase in relative pay and understate it if it is supported by changes in relative pay. It is however straightforward to isolate the technological shifts.

Equation (2) may be inverted to give:

$$\frac{a_{it}}{b_{it}} = \left[\frac{w_{Hit}}{w_{Lit}}\right]\left[\frac{H_{it}}{L_{it}}\right]^{(1-\delta)} \qquad (3)$$

The ratio a_{it}/b_{it} is an explicit measure of the technological bias between these two factors in industry *i* in year *t*. For any value of the elasticity of substitution it may be calculated from

relative pay and relative factor employments. These ratios have been calculated for each of the fifteen industries in Table 1 for each year for which data is available. This method of calculation allows the bias to vary across industries and over time within each industry. There is however an identification issue. The calculations require a value for the elasticity of substitution and the calculated values of the bias parameters are not independent of this value. There appears to be no commonly agreed value for the elasticity of substitution but most authors assume values between 1.2 and 1.6. Accordingly, effects have been calculated for a range of values and results are reported for both of these values. Although details vary, the general pattern of results is robust across these values. It is quite possible that the elasticity of substitution varies over time within industries, but the results from such variations should be bracketed by the results reported here.

3. Increasing Skill Bias.

Table 2 gives values of b/a at regular intervals for each industry for a substitution elasticity of 1.2. The general pattern of changes in the bias parameters in not much affected by the assumed value of the elasticity of substitution. The calculated values for the bias parameters show considerable variation across industries as well as over time. Some industries are consistently more biased than others and there is clearly heterogeneity of industry production relationships even when they are all constrained to belong to the class of CES functions. With a few exceptions in the 1930's, the ratio (b/a) has fallen over time in all industries showing there has been increasing skill-biased technological change against manual workers since the 1920's. In some industries such as Textiles and Metal Manufacture the fall was as dramatic in the 1920's as it has been at any time since in any industry. The rates of change within industries also show considerable variation between time periods but the increasing bias against manual workers has been continuous and pervasive.

Table 2.	Values of b/a parameter ratio for an elasticity of substitution of 1.2							
	1920	1930	1938	1948	1970	1979	1989	1995
MetalMan	7.44	4.28	4.68	3.55	2.43	2.05	1.87	1.83
NonMetMn	5.37	4.49	4.48	3.44	2.37	2.20	1.84	1.68
Chemicals	2.63	1.53	1.27	1.36	1.03	1.08	0.76	0.66
MtlGdNes	2.63	2.56	2.75	2.65	2.16	1.99	1.77	1.65
MecEng	3.78	2.97	2.72	2.38	1.62	1.36	1.22	1.09
ElectEng	2.0	1.56	1.55	1.84	1.25	1.16	0.79	0.77
Vehicles	3.77	2.76	3.23	3.02	1.75	1.57	1.31	1.39
InstrEng	2.87	2.23	2.42	2.30	1.06	0.94	0.87	0.60
FdDnkTob	2.55	1.97	1.80	2.13	2.11	2.10	1.77	1.69
Textiles	7.14	4.55	4.50	3.04	2.37	2.36	1.90	1.70
LtherFur	2.81	2.87	3.17	2.21	2.38	2.17	1.76	1.94
FootClth	2.32	2.19	2.41	2.76	2.71	2.43	1.93	1.72
TimbPdct	3.41	2.93	3.19	3.10	2.41	2.18	1.74	1.37
PprPntng	3.27	2.80	2.44	1.76	1.68	1.54	1.03	0.82
OtherMan	3.08	2.21	2.10	2.40	1.84	1.76	1.47	1.39

Table 2 shows a widespread acceleration in trend bias in the 1980's compared with the 1970's, but in industries such as Metal Manufacture the 1970's appear to show a more sharply increasing bias than the period from 1979 to 1995. Particularly large increases occurred in 'Electrical Engineering', 'Textiles', 'Leather and Fur' and 'Paper and Printing'.

Although the increasing bias has been pervasive and continuous, an important issue is whether there was a general increase in the bias at the beginning of the 1980's which could explain the sudden emergence of widening pay dispersion. To answer this question linear splines have been fitted to the ratios (a/b) with knots defining sub periods. The knots in the splines were fixed at 1920, 1948, 1970 and 1995 but a series of additional moving knots were fixed sequentially at annual dates from 1975 to 1982 to assess whether there were particular years in this period when the bias noticeably accelerated. Each industry is treated separately and the splines have been fitted for (a/b) ratios corresponding to values for the elasticity of substitution of 1.2 and 1.6. The general picture is not affected by the alternative values for the

substitution elasticity. The slope values of the splines are tested for significant increases after the moving date compared to the period from 1970 to the moving date. The general picture which emerges from this procedure is clear: there is no specific year in any industry when there is a clear structural break. Six of the industries show a statistically significant increase in bias wherever the knot is placed between 1975 and 1982 but there is no clear peak in the profile of statistical significance and no obvious year when the slope parameters change in a particularly dramatic way. These industries are 'Non Metallic Metal Products', 'Chemicals', 'Electrical Engineering', 'Instrument Engineering', 'Textiles' and 'Paper and Printing'. The only safe conclusion is that in these industries the bias was more marked after the mid 1970's than before, but that there was no obvious acceleration in any particular year in any of these industries. For 'Non metallic Mineral Products' the 't' value is consistently about 2.5 for any position of the knots between 1975 and 1982 but for the other industries in this group 't' values are much higher. The 'Paper and Printing' industry consistently returns 't' values above 6 and the rest of the industries in this group clearly show similar highly statistically significant faster bias towards the end of the period, even if there is no obvious year when it accelerated. Of the remaining industries, five show no statistically significant increase in the rate of change of the bias for any position of the knots, indicating that there was no acceleration in the bias in the period after 1974 compared to before. These are 'Mechanical Engineering', 'Vehicles', 'Leather and Fur' and 'Other Manufacturing'. Here the increasing bias is just consistent and smooth with no indication of acceleration in the later 1970's or early 1980's. In 'Metal Manufacture' there is a consistently significant negative change in bias for the period after 1974 with a substitution elasticity of 1.2 and no significant change with the higher elasticity. For 'Timber Products' there is no indication of any acceleration with a substitution elasticity of 1.2 but with a substitution elasticity of 1.6 there is a marginally significant increase for any position of the knots. For 'Food, Drink and Tobacco' there is a statistically significant acceleration for knots placed up to 1978 which disappears

thereafter with the lower substitution elasticity but not with the higher elasticity. The only industry which clearly shows any change in the rate of increase in the bias after 1974 is 'Metal Goods nes'. Here for both values of the substitution elasticity, knots placed in 1981 and 1982 show a significant fall the rate of change of the bias.

Although time variations in the bias and their statistical significance are interesting, the overall quantitative impact of the bias determines changes in the relative demands for workers and consequent impact on relative pay. At the economy level, several small changes in bias in industries employing many people may have a large impact on overall employment and relative pay, even if none of the changes are individually statistically significant. In the present case, even though changes in bias from one year to the next show no particular change in statistical significance, their quantitative aggregate impact may vary substantially. In the next two sections we address these questions. The next section assesses the impact of the increasing bias on relative employment and section 5 considers movements in relative pay.

4. The Quantitative Significance of the Bias.

Overall employment of manual and non-manual workers is determined by the technological bias and relative pay in each industry and the total size of each industry. Over the long period considered here all of these factors have changed. This section assesses the contributions each has made at various times. Ideally the analysis would be economy wide and allow for the changing balance between manufacturing and the service sector. The service sector is generally more intensive in non-manuals and the balance of employment will shift towards them as the service sector expands. However we have data only for manufacturing and can consider only the changing balance between industries within manufacturing. Table 1 shows that some are more relatively intensive in the employment of manuals than others and the

changing relative balance of employment between industries within manufacturing will alter the overall balance between manuals and non-manuals.

The change in employment of manual and non-manual workers in the manufacturing sector is decomposed into three factors:

- the effect of biased technological changes
- the effect of relative wage changes
- the effect of industry composition changes

The individual effects are isolated by answering the hypothetical questions:

- What would employment of a skill group have been at the end of a decade, compared to the actual employment, if the biased technical change had occurred but there had been no changes in relative pay or the relative importance of each industry?
- What would employment in different groups have been at the end of a decade compared to the actual employment, if relative wages changed as they did but there had been no biased technical change and there had been no changes in the relative importance of each industry?
- What would employment in different groups have been at the end of a decade compared to the actual employment, if the sectoral composition had changed as it did but there had been no biased technical change and no changes in relative pay?

The decomposition may be expressed as:

$$\left[(e_L, e_H)_t - (e_L, e_H)_0\right] = e_0\left[(p_L, p_H)_{W_0,(a/b)_t} - (p_L, p_H)_{W_0,(a/b)_0}\right]$$

$$+ \quad e_0\left[(p_L, p_H)_{W_t,(a/b)_t} - (p_L, p_H)_{W_0,(a/b)_t}\right]$$

$$+ \quad \left[e_t - e_0\right](p_L, p_H)_{W_t,(a/b)_t}$$

Here:

t denotes the end of a ‘decade’

0 denotes the beginning of a ‘decade’

e_L denotes employment of manual workers

e_H denotes employment of non-manual workers

$(p_L, p_H)_{W_0, (a/b)_t}$ denotes employment proportions of manual and non-manual workers, evaluated at base year relative wages and terminal year technology.

e_0 is base year total employment weight for evaluating the relative wage and technological change effects.

The first term on the right is the changed technological bias effect.

The second term is the changed relative wage effect.

The last term is the effect of changed industry composition.

For a standard size of manufacturing sector of 1000 we calculate the size of each of the separate effects. Tables 3 to 9 give the contributions of each of these effects for various sub periods. These are roughly ten years long, apart from the period from 1948 to 1970, which is much longer due the infrequency of data. The period covering the Second World War is included to capture effects of changes introduced to cope with mass war production. The 1980’s are generally considered to have experienced the largest impact of biased change, but the short period from 1989 to 1995 is distinguished to assess whether these persisted. The tables are constructed for a standard economy of one thousand workers and give the effects for each industry and for the whole economy. The effects for the whole economy are the sum of the individual industry effects. The percentage total change given for each effect is relative to the number of manual or non-manual workers in the standard economy at the beginning of the period. Hence, an apparently large effect in terms of numbers may convert to a small percentage effect. This is particularly noticeable between 1920 and 1930, where biased technical change produces a large absolute decline in the employment of manual workers

compared to other periods but which converts to a rather small percentage fall since manuals accounted for a large proportion of total employment at the beginning of the decade.

These tables show that almost all industries in all periods exhibit the bias against manual workers. The prevalence of the bias in the 1920's and after the Second World War is quite clear. It is also noticeable that the degree of bias and its rate of increase vary across industries. Apart from the 1930's, when there was generally little change and all effects are comparatively small, all periods have experienced significant effects from biased technological change. Biased technological change is by far the most important of the three effects in all periods except the 1930's. This is true even in the period from 1949 to 1979 when there is a temptation to attribute the rise in the relative employment of non-manuals to the decline in their relative pay. Although changing relative pay was important, it was not as important as the underlying change in bias. It is also clear however, that the effects of biased change since 1979 have been larger than in any of the other periods. Between 1979 and 1989 the decline in manual work, whether measured as a decline in total numbers or as a percentage fall, is similar to their decline in the much longer period from 1948 to 1970. The magnitude of the effect of the bias in this period comes from the isolation of this effect from the wage effect. In this period the relative pay of non-manuals rose and masks the full magnitude of the underlying bias in their favour.

Table 3. The Effects of Different Components of Structural Change on Employment 1920-1930.

	Effect of Technical Change on		Effect of Wage Change on		Effect of Change in Industrial Structure on	
	Operatives	Admin/Cler	Operatives	Admin/Cler	Operatives	Admin/Cler
MetalMan	-5.46454	5.464542	3.715135	-3.71513	-24.9734	-2.59454
NonMetMn	-0.52703	0.527028	0.174465	-0.17446	11.75594	1.130683
Chemicals	-4.11439	4.114393	1.900942	-1.90094	1.721755	0.471083
MtlGdNes	-0.155	0.154998	-0.05179	0.051786	-0.865	-0.12173
MecEng	-6.13972	6.139717	2.719414	-2.71941	-65.3385	-9.89314
ElectEng	-1.31381	1.313811	0.723949	-0.72395	8.419634	2.205516
Vehicles	-1.61475	1.614755	0.861556	-0.86156	25.83679	4.337071
InstrEng	-0.63677	0.636765	0.003901	-0.0039	1.854438	0.364566
FdDnkTob	-4.0866	4.086602	1.880177	-1.88018	18.79694	4.175013
Textiles	-6.16839	6.168387	3.283998	-3.284	-9.30739	-0.61277
LtherFur	0.04178	-0.04178	0.024137	-0.02414	0.316852	0.046995
FootClth	-0.7963	0.7963	1.009364	-1.00936	7.073937	0.917952
TimbPdct	-0.86432	0.864317	0.827057	-0.82706	3.126587	0.459924
PprPntng	-1.44292	1.442923	0.837532	-0.83753	16.10562	3.022087
OtherMan	-1.21708	1.217081	0.344165	-0.34416	1.335052	0.232092
Total	-34.4998	34.49984	18.254	-18.254	-4.14079	4.140792
	3.8% fall	*32.2% rise*	*2% rise*	*17% fall*	*0.4% fall*	*3.8% rise*

Table 4. The Effects of Different Components of Structural Change on Employment 1930-1938

	Effect of Technical Change on		Effect of Wage Change on		Effect of Change in Industrial Structure on	
	Operatives	Admin/Cler	Operatives	Admin/Cler	Operatives	Admin/Cler
MetalMan	0.543166	-0.54317	-0.9403	0.9403	1.940621	0.216722
NonMetMn	-0.0108	0.010795	0.002516	-0.00252	1.498411	0.144452
Chemicals	-1.58566	1.585659	-0.17975	0.179749	0.962422	0.334735
MtlGdNes	0.41716	-0.41716	0.099547	-0.09955	4.689461	0.5905
MecEng	-1.37956	1.379562	-0.83927	0.839267	12.70835	2.262955
ElectEng	-0.02476	0.02476	-0.66275	0.662746	10.60085	3.097349
Vehicles	1.402119	-1.40212	-0.5938	0.593796	13.29371	2.010066
InstrEng	0.253854	-0.25385	-0.20282	0.202824	-2.67059	-0.51489
FdDnkTob	-1.82305	1.823051	-1.29345	1.293455	1.230227	0.326317
Textiles	-0.13885	0.138847	-0.42924	0.429237	-31.041	-2.15082
LtherFur	0.174227	-0.17423	-0.03294	0.032937	-0.61967	-0.08358
FootClth	1.280168	-1.28017	-0.06683	0.066832	-10.749	-1.24859
TimbPdct	0.487785	-0.48778	-0.00996	0.009955	-1.6813	-0.22341
PprPntng	-1.77909	1.779091	-0.37325	0.373253	-2.59003	-0.59243
OtherMan	-0.2193	0.219305	0.019849	-0.01985	-1.47115	-0.27067
Total	-2.40259	2.402591	-5.50244	5.50244	-3.89871	3.898705
	0.3% fall	*1.9% rise*	*0.4% fall*	*4.3% rise*	*0.4% fall*	*3.1% rise*

Table 5. The Effects of Different Components of Structural Change on Employment 1938-1948.

	Effect of Technical Change on		Effect of Wage Change on		Effect of Change in Industrial Structure on	
	Operatives	Admin/Cler	Operatives	Admin/Cler	Operatives	Admin/Cler
MetalMan	-2.21011	2.210109	-0.65799	0.657989	12.05923	2.040916
NonMetMn	-1.34211	1.342114	-0.23651	0.236514	-2.74197	-0.38152
Chemicals	0.629101	-0.6291	-1.31828	1.318281	4.486755	1.696816
MtlGdNes	-0.23125	0.231251	-1.47842	1.47842	16.6107	2.839223
MecEng	-2.85645	2.856445	-3.77902	3.779017	-9.79776	-2.49613
ElectEng	1.710869	-1.71087	-2.17708	2.177082	18.04671	5.552835
Vehicles	-0.7308	0.730796	-2.77306	2.773059	12.06637	2.5569
InstrEng	-0.12993	0.12993	-0.61421	0.614211	-3.05986	-0.80398
FdDnkTob	3.549049	-3.54905	0.847638	-0.84764	-6.8709	-1.41553
Textiles	-5.43392	5.433917	1.455032	-1.45503	-20.2199	-2.01398
LtherFur	-0.69212	0.692123	0.540706	-0.54071	-2.47483	-0.37143
FootClth	1.414283	-1.41428	-0.70325	0.703248	-20.5896	-2.21149
TimbPdct	-0.15165	0.151649	-0.27504	0.275043	-0.90047	-0.1316
PprPntng	-4.86493	4.864933	2.851435	-2.85143	-6.82111	-1.85321
OtherMan	0.508767	-0.50877	-0.67736	0.677362	6.032763	1.166051
Total	-10.8312	10.8312	-8.99541	8.995414	-4.17386	4.173862
	1.3% fall	*7.8% rise*	*1.0% fall*	*6.5% rise*	*0.5% fall*	*3.0% rise*

Table 6. The Effects of Different Components of Structural Change on Employment 1948-1970.

	Effect of Technical Change on		Effect of Wage Change on		Effect of Change in Industrial Structure on	
	Operatives	Admin/Cler	Operatives	Admin/Cler	Operatives	Admin/Cler
MetalMan	-5.17537	5.175367	-1.67204	1.672044	-3.79213	-1.14279
NonMetMn	-2.41007	2.410072	-1.52168	1.521684	-4.0074	-1.08822
Chemicals	-3.45548	3.455483	-2.42031	2.420308	3.804929	2.494622
MtlGdNes	-2.29996	2.299958	-2.69568	2.695677	1.227128	0.341735
MecEng	-9.70015	9.70015	-2.8129	2.812902	12.74828	5.762093
ElectEng	-6.88744	6.88744	-0.02285	0.022845	16.69517	8.156075
Vehicles	-11.0164	11.01643	-0.28601	0.28601	5.565947	2.313657
InstrEng	-2.33839	2.338394	0.528378	-0.52838	6.768601	3.757021
FdDnkTob	-0.13013	0.130131	-4.30166	4.301661	-2.57072	-0.69593
Textiles	-3.69218	3.692179	-6.71062	6.710622	-40.3125	-8.21775
LtherFur	0.095453	-0.09545	-0.40214	0.402139	-3.68611	-0.70585
FootClth	-0.15421	0.154206	-2.64545	2.64545	-17.6498	-2.70868
TimbPdct	-1.52663	1.526629	-1.55651	1.556506	-5.5946	-1.42676
PprPntng	-0.62518	0.625182	-4.90408	4.904079	8.949066	3.821975
OtherMan	-1.56521	1.565207	-0.86443	0.864432	8.55089	2.642111
Total	-50.8814	50.88137	-32.288	32.28798	-13.3033	13.30331
	6.1% fall	*31% rise*	*3.9% fall*	*19.8% rise*	*1.6% fall*	*8.1% rise*

Table 7. The Effects of Different Components of Structural Change on Employment 1970-1979.

	Effect of Technical Change on		Effect of Wage Change on		Effect of Change in Industrial Structure on	
	Operatives	Admin/Cler	Operatives	Admin/Cler	Operatives	Admin/Cler
MetalMan	-2.85734	2.857345	1.035452	-1.03545	-7.84302	-2.70173
NonMetMn	-0.58592	0.585924	-0.24539	0.245391	-0.72462	-0.2232
Chemicals	0.685905	-0.68591	-1.36504	1.365041	3.272995	2.259761
MtlGdNes	-1.26597	1.265971	-0.86682	0.866821	0.912477	0.300634
MecEng	-6.33116	6.331161	-0.24585	0.245848	-1.98605	-1.11878
ElectEng	-2.05613	2.056129	-1.29783	1.29783	0.836318	0.474514
Vehicles	-2.86351	2.863514	2.198529	-2.19853	6.858386	2.940426
InstrEng	-0.73816	0.738164	-0.5046	0.504603	-0.242	-0.16937
FdDnkTob	-0.13944	0.139437	-0.69993	0.699929	5.984814	1.700758
Textiles	-0.04929	0.049294	-1.79005	1.790049	-12.8994	-3.05222
LtherFur	-0.08856	0.088564	-0.01367	0.013673	-0.37771	-0.08205
FootClth	-0.89225	0.892251	-0.26657	0.266568	-1.99049	-0.36033
TimbPdct	-0.69965	0.699648	-0.26665	0.266653	1.60098	0.483265
PprPntng	-1.66633	1.666334	-2.45452	2.454523	0.667145	0.363269
OtherMan	-0.45391	0.453913	-0.7514	0.751399	3.767602	1.347582
Total	-20.0017	20.00174	-7.53435	7.534348	-2.16252	2.162524
	2.7% fall	*7.7% rise*	*1.0% fall*	*2.9% rise*	*0.3% fall*	*0.8% rise*

Table 8. The Effects of Different Components of Structural Change on Employment 1979-1989.

	Effect of Technical Change on		Effect of Wage Change on		Effect of Change in Industrial Structure on	
	Operatives	Admin/Cler	Operatives	Admin/Cler	Operatives	Admin/Cler
MetalMan	-1.37377	1.373769	-0.41243	0.412432	-24.6207	-9.78484
NonMetMn	-1.50853	1.508531	0.148776	-0.14878	5.671564	2.121916
Chemicals	-6.23862	6.238615	1.901675	-1.90167	0.276281	0.255569
MtlGdNes	-1.88231	1.882313	1.454895	-1.45489	-3.61455	-1.22895
MecEng	-3.86618	3.866175	2.626959	-2.62696	-7.60548	-4.46277
ElectEng	-11.0954	11.09538	3.636653	-3.63665	11.21167	8.673436
Vehicles	-5.23773	5.237729	2.491633	-2.49163	-3.04813	-1.46372
InstrEng	-0.56606	0.56606	0.667937	-0.66794	-2.64137	-1.81401
FdDnkTob	-4.02872	4.028716	4.081013	-4.08101	9.53907	2.703288
Textiles	-2.95937	2.959365	1.797355	-1.79735	-18.8046	-4.95443
LtherFur	-0.20953	0.209531	0.112834	-0.11283	-1.23487	-0.30242
FootClth	-2.16444	2.164436	1.537585	-1.53759	4.772841	0.941014
TimbPdct	-1.83259	1.832587	1.082998	-1.083	4.71709	1.595985
PprPntng	-9.18371	9.183705	2.552043	-2.55204	8.990725	6.983121
OtherMan	-2.12041	2.120409	1.603735	-1.60374	12.43492	4.692322
Total	-54.2673	54.26733	25.28366	-25.2837	-3.95551	3.955514
	7.6% fall	*18.7% rise*	*3.6% rise*	*8.7% fall*	*0.56% fall*	*1.4% rise*

Table 9. The Effects of Different Components of Structural Change on Employment 1989-1995.

	Effect of Technical Change on		Effect of Wage Change on		Effect of Change in Industrial Structure on	
	Operatives	Admin/Cler	Operatives	Admin/Cler	Operatives	Admin/Cler
MetalMan	-0.1398	0.139798	0.854567	-0.85457	1.755936	0.616087
NonMetMn	-1.03585	1.035854	0.760982	-0.76098	-5.4783	-2.11367
Chemicals	-2.67825	2.678248	1.13388	-1.13388	2.025064	2.074057
MtlGdNes	-1.11819	1.118193	0.311142	-0.31114	17.70724	6.40698
MecEng	-4.05623	4.056232	-6.17442	6.174419	-0.04683	-0.03923
ElectEng	-0.72147	0.721473	3.343529	-3.34353	-17.8678	-12.6444
Vehicles	1.536545	-1.53654	-0.77622	0.776222	-8.94514	-4.15933
InstrEng	-1.93169	1.931693	-0.02298	0.022979	6.526265	6.981586
FdDnkTob	-1.18526	1.185256	1.613888	-1.61389	-0.0368	-0.01022
Textiles	-0.97758	0.977583	0.422787	-0.42279	0.877039	0.249072
LtherFur	0.065871	-0.06587	0.029045	-0.02904	6.973995	1.443455
FootClth	-1.21851	1.218507	0.634351	-0.63435	-15.0648	-3.18057
TimbPdct	-2.40877	2.408768	0.803246	-0.80325	-17.5627	-7.20607
PprPntng	-6.49733	6.497332	1.434314	-1.43431	4.027515	3.882314
OtherMan	-0.93136	0.931362	0.231813	-0.23181	23.47397	9.335178
Total	-23.2979	23.29788	4.599925	-4.59992	-1.63531	1.635245
	3.4% fall	*7.2% rise*	*0.68% rise*	*1.4% fall*	*0.2% fall*	*0.5% rise*

Although there has been a clear acceleration in the bias against manual workers in the period since 1979, one of the difficulties in appealing to this acceleration as an explanation of the increase in inequality which has frequently been noted is that the increase in inequality seemed to appear in the space of a few years at the beginning of the 1980's. Technological change is usually regarded as being gradual and it is difficult to believe that the acceleration could be sufficiently sudden to explain this. Since the increasing bias has been so clear for such a long time and seems to have followed the steady if varying pace usually assumed for technological change, it is difficult to believe that it accelerated suddenly. To investigate this further Tables 10 and 11 give a breakdown of the various effects for smaller intervals and, where data permit, on a year-to-year basis. In Tables 10 and 11 the effects for any year are for the interval since the preceding year in the table.

The dominance of the biased technological change is again apparent, but a surprising feature is the way this effect can vary over short periods of time. In 1981 the effect reached its highest level since 1922 but there is a clear indication that the effect had been building in magnitude since 1977 and continued into the early 1980's. Although it declined somewhat in the mid 1980's it then accelerated again at the beginning of the 1990's. This suggests that although biased technological change has been pervasive and almost continuous over this long time period, it has varied in intensity. The increase at the end of the 1970's is consistent with the increase in inequality observed at the beginning of the 1980's.

Table 10. Year by year Decomposition of Change in Aggregate Relative Employment of Manual and Non-manual workers 1920 – 1949.

	Agg Ind Cnge Effct		Agg Contbn Tech Cnge *Elas Sub = 1.2*		Agg Contbn Wge Cnge *Elas Sub = 1.2*	
	Non M	*Man*	*Non M*	*Man*	*Non M*	*Man*
1921	3.243	-3.243	1.421	-1.421	-0.425	0.425
1922	-3.400	3.400	12.177	-12.177	-10.576	10.576
1923	0.279	-0.279	9.838	-9.838	-7.659	7.659
1924	-0.209	0.291	1.137	-1.137	0.165	-0.165
1925	0.718	-0.718	-0.659	0.659	2.326	-2.326
1926	1.080	-1.080	1.508	-1.508	0.639	-0.639
1927	-1.265	1.265	-0.077	0.077	0.974	-0.974
1928	0.783	-0.783	2.275	-2.275	-0.563	0.563
1929	0.684	-0.684	0.070	-0.070	1.476	-1.476
1930	2.686	-2.686	3.970	-3.970	-2.232	2.232
1931	0.542	-0.542	2.920	-2.920	-1.556	1.556
1932	-0.643	0.643	2.299	-2.299	-1.107	1.107
1933	-0.550	0.550	1.402	-1.402	-0.546	0.546
1934	0.488	-0.488	-0.609	0.609	1.606	-1.606
1935	0.351	-0.351	-0.767	0.767	1.654	-1.654
1936	0.312	-0.312	-0.070	0.070	0.778	-0.778
1937	0.850	-0.850	-1.580	1.580	2.487	-2.486
1938	2.691	-2.691	-1.494	1.494	2.346	-2.346
1948	4.174	-4.174	10.815	-10.815	9.011	-9.011
1949	-1.286	1.286	3.543	-3.543	0.165	-0.165

Table 11. Year- by- year Decomposition of Change in Relative Employment of Manual and Non-manual workers 1963 – 1995.

	Agg Ind Cnge Effct		Agg Contbn Tech Cnge *Elas Sub = 1.2*		Agg Contbn Wge Cnge *Elas Sub = 1.2*	
	Non M	*Man*	*Non M*	*Man*	*Non M*	*Man*
1963	3.547	-3.547	15.669	-15.669	2.329	-2.329
1968	2.357	-2.357	13.013	-13.013	4.681	-4.681
1970	0.915	-0.915	-1.632	1.632	3.099	-3.09861
1971	-0.181	0.181	7.584	-7.584	-0.322	0.322
1972	-0.986	0.986	-0.564	0.564	0.692	-0.692
1973	0.021	-0.021	-10.207	10.207	5.235	-5.235
1974	na	na	na	na	na	na
1975	na	na	na	na	na	na
1976	0.236	-0.236	-1.497	1.497	4.842	-4.842
1977	0.535	-0.535	2.608	-2.608	-0.431	0.431
1978	0.543	-0.543	5.056	-5.056	-2.376	2.376
1979	0.533	-0.533	7.347	-7.347	-1.430	1.430
1980	2.311	-2.311	7.062	-7.062	0.848	-0.848
1981	0.568	-0.568	15.298	-15.298	-5.541	5.541
1982	0.103	-0.103	5.764	-5.764	-0.460	0.460
1983	0.053	-0.053	3.931	-3.931	-1.274	1.274
1984	-0.618	0.618	-2.289	2.289	-1.276	1.276
1985	0.321	-0.321	4.606	-4.606	0.393	-0.393
1986	-0.584	0.584	2.724	-2.724	-4.526	4.526
1987	-0.320	0.320	8.501	-8.501	-2.941	2.941
1988	0.018	-0.018	4.903	-4.903	-6.165	6.165
1989	0.813	-0.813	6.095	-6.095	-5.377	5.377
1990	0.691	-0.691	7.487	-7.487	-3.187	3.187
1991	0.731	-0.731	9.119	-9.119	-3.782	3.782
1992	-0.060	0.060	3.137	-3.137	0.160	-0.160
1993	-2.488	2.488	0.794	-0.794	-1.951	1.951
1994	0.469	-0.469	-2.544	2.544	-2.175	2.175
1995	3.496	-3.496	6.293	-6.293	4.143	-4.143

5. Movements in Relative Pay.

The previous sections have dealt with the effects of technological and other changes on the relative demands for different skill groups. In this section we look at the changes in manual/non-manual relative pay and consider whether skill bias is sufficient to explain them. We consider long-term movements in relative pay in general terms before considering the period since the middle of the 1970's in more detail. The general conclusion is that skill bias is insufficient in general as an explanation over the longer period but over the more recent period is consistent with changes in relative pay. This however raises a problem of reconciling the short and long run movements.

Long Run Movements in Relative Pay.

Table 12 gives the pay of manuals relative to non-manuals in each industry at regular intervals over the whole of the period. There are some clear features of the structure of relative pay and its movements. There is considerable variation across industries. At the beginning and end of the period the highest relativity is at least twice that of the lowest. There is also stability in the rankings. These are generally recognised features of industrial pay structures as noted by many authors such as Routh (1980), Krueger and Williams(1987) and Dickens and Katz(1987). From 1920 to 1930 the relative pay of operatives fell. During the 1930's and through the Second World War the relative pay of operatives rose in the group of industries associated with metals and chemicals. Other industries, particularly those exposed to international competition and the effects of the decline in world trade, show more stability. From 1948 to1970, with some exceptions like 'Electrical Engineering', 'Instruments' and 'Vehicles' the relative pay of operatives rose and there was a general narrowing in pay differentials. This continued until the end of the 1970's since when there has been a steady widening.

The widening of relativities after 1979 left the relative pay of operatives lower in 1989 and 1995 compared with 1979 in fourteen of the fifteen industries and there is a temptation to attribute this to the skill biased technical change. Long run trends however give a different picture. Despite the persistent bias against manual workers, their relative pay rose in fourteen industries over the period 1948 to 1970 and in 1995 was no lower in eleven of the fifteen industries than in 1920 despite seventy-five years of biased change. This suggests that the long run and persistent technological bias against manual workers is insufficient by itself to explain the movements in their relative pay. If it was, we would expect their relative pay to have fallen consistently over the period and to be substantially lower at the end of the period than at the beginning

Table 12. Long run trends in relative pay
Wage of Operatives relative to Salaries of Administrators.

	1920	*1930*	*1938*	*1948*	*1970*	*1979*	*1989*	*1995*
MetalMan	0.91	0.65	0.75	0.81	0.90	0.84	0.87	0.77
NonMtMn	0.67	0.64	0.64	0.66	0.80	0.83	0.81	0.76
Chemicls	0.65	0.52	0.53	0.61	0.72	0.79	0.71	0.67
MtlGdNes	0.49	0.50	0.49	0.61	0.75	0.79	0.72	0.71
MecEng	0.68	0.62	0.65	0.76	0.84	0.84	0.79	0.94
ElectEng	0.58	0.51	0.56	0.69	0.69	0.72	0.64	0.58
Vehicles	0.73	0.62	0.67	0.83	0.84	0.77	0.71	0.73
InstrEng	0.58	0.57	0.61	0.76	0.65	0.70	0.63	0.64
FdDnkTb	0.63	0.56	0.60	0.57	0.71	0.74	0.62	0.58
Textiles	0.58	0.47	0.49	0.44	0.63	0.71	0.62	0.60
LtherFur	0.59	0.59	0.60	0.46	0.60	0.61	0.55	0.52
FootClth	0.43	0.40	0.40	0.43	0.57	0.59	0.50	0.47
TimbPdct	0.68	0.59	0.59	0.62	0.77	0.80	0.71	0.65
PprPntng	0.76	0.69	0.71	0.59	0.83	0.93	0.83	0.79
OtherMan	0.56	0.51	0.51	0.61	0.69	0.75	0.65	0.64

Can the Bias Explain Movements in Relative Pay?

Changes in relative pay depend on changes in relative supply compared to changes in relative demand. The natural adaptability of workers and changes in training and educational systems alter these relative supplies. A possible explanation for the fall in relative pay on non-manuals over the period up to 1979 is the significant improvement in the level of general education. The increasing participation rates of women over this period also increased the supply of non-manuals. It is likely that the relative supply of non-manual workers expanded more rapidly than relative demand in the period up to 1979. The reversal of the trend in relative pay may therefore be due to the acceleration in the pace of biased change detected from the late 1970's leading to relative demand outstripping relative supply. It is also possible that the structure of demands for skills within the non-manual and manual groups changed. Within manual work, the spread of pre-assembled parts and more automated production may have reduced the demand for skill, while among non-manual workers many authors have argued that there was a marked shift towards higher skills in the 1980's, possibly associated with the advent of computer technology. Whereas the shift towards non-manual work in the period before 1980 was towards skills which could easily be provided by the existing educational system, the later shift required more fundamental changes. In particular the higher skills may have required education at University level. The late 1970's and early 1980's however, saw a restriction in this sector in the UK and it was not until the mid 1980's that the sector commenced the very significant expansion which is still under way. Access for men and women has become more equal and has been widened to groups with traditionally low participation rates. The disaggregation of manual and non-manual workers into further skill groups would be desirable. Colecchia A and G.Papaconstantinou (1996) have shown that there have been changes in the balance between high and low skilled jobs within the manual and non-manual groups in a number of countries and Hoskins (2000) considers this for the

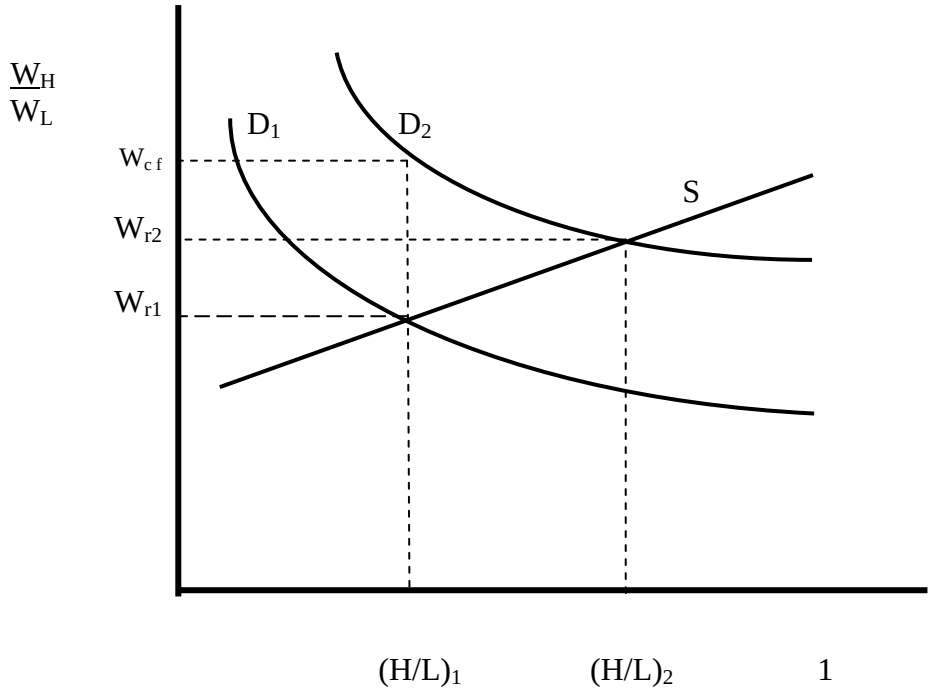
recent period in the UK but limitations of the data prevent detailed analysis of this for the long period considered here.

The changes in relative pay after 1979 however are so significant that we consider their consistency with the increased rate of biased change in some detail. We do not attempt a full structural model of supply and demand for relative skills but examine the extent to which the changes in relative pay which might have resulted from biased change have been attenuated by whatever changes in relative supply actually occurred. The question we seek to answer is: 'What would relative pay have been at the end of a year if technological change had occurred the way it did over the year but there had been no change in the employment structure?' This is equivalent to supposing that the supply of the different types of worker to each industry was completely inelastic. The technological change will have increased relative demand for some groups and in the face of inelastic supply would have raised their relative pay more than the increase actually observed. The hypothetical increases in relative pay are counteracting the increased demand and restraining it to its initial levels. The level of the increased pay required to achieve this will depend on the substitution elasticity. The higher the substitution elasticity, the lower will be the pay increase required to compensate for increased technological bias towards any particular group. For each industry in each year the relative pay has been calculated which would sustain skill group employment at the levels of the previous year. The 'counterfactual' relative pay in each industry is then aggregated to give a picture of relative pay in our standard economy of 1,000.The reported relative pay is a weighted sum of the pay structures in each industry, the weights being the relative industry total employment.

The procedure may be illustrated with diagram 1. Biased technological change shifts the demand for non-manual workers H relative to manuals from D_1 to D_2, raising their relative pay from W_{r1} to W_{r2}, given the supply S. The more responsive are educational and training

systems, the more elastic the supply function and the less relative pay has to change to accommodate the effects of technological change. If relative supplies were completely inelastic, relative pay would rise to the counterfactual level W_{cf} . The more inelastic are relative supplies, the closer will actual relative pay, W_{r2} , be to the counterfactual level.

Diagram 1. Relative Demand Shifts and Relative Pay.



Actual and counterfactual relative pay have been calculated for each industry for each year for the period after 1976, when annual data are available. A weighted average of these relativities for a standard economy of one thousand workers is given in Table 13.These counterfactual relativities give a direct measure of the upward pressure exerted by biased technological change on relative pay.

Table 13 shows that except for 1984 and 1986, biased technological change has been sufficiently strong to account for actual changes in relative pay. Apart from these two years, and independently of the value of the elasticity of substitution, counterfactual relative pay has been above actual relative pay. It is also noticeable that actual and counterfactual relative pay are very close, suggesting that the short run relative supply elasticity is very low.

Table 13. Skill Bias and Relative Pay Change: Actual and Counterfactual Relative Pay.

	Actual Relative Pay NonM/Man	*Col 2.* Counterfactual Relative Pay Elas Sub 1.2	*Col 3.* Counterfactual Relative Pay Elas Sub 1.6
1976	1.276	1.295	1.290
1977	1.280	1.291	1.289
1978	1.291	1.306	1.302
1979	1.298	1.331	1.322
1980	1.293	1.339	1.327
1981	1.317	1.367	1.354
1982	1.319	1.348	1.340
1983	1.326	1.336	1.334
1984	1.337	1.308	1.315
1985	1.340	1.367	1.360
1986	1.367	1.354	1.357
1987	1.380	1.409	1.402
1988	1.415	1.410	1.411
1989	1.445	1.448	1.447
1990	1.459	1.483	1.477
1991	1.480	1.510	1.502
1992	1.478	1.492	1.489
1993	1.486	1.486	1.485
1994	1.499	1.476	1.481
1995	1.472	1.527	1.512

Note: Counterfactual relative pay is calculated using the current year technology and the previous year NonManual/Manual Employment Ratio for an elasticity of substitution of 1.2 (*Col 2)* and 1.6 *(Col 3)*

6. Conclusion.

There has clearly been biased technological change and it has been pervasive in British manufacturing for most of the twentieth century. The pay of non-manual workers relative to that of manuals however fell for most of the sixty-year period from 1920 to 1979 so that the relative pay of operatives in 1979 is much higher than in 1920. We cannot infer that because technological change has been biased against a particular group of workers its relative pay

must fall. One of the lessons of considering long run changes is that monocausal explanations of changes in relative pay are unlikely to get very far. It is currently suggested that the bias against manual workers is associated with the adoption of computers and associated equipment. This may be so, but this paper shows that the bias was prevalent long before computers could have had any impact. Berman et al [1994] note at the end of their article, that technological change biased against manual workers was also apparent in the United States long before the advent of computers. The technological changes of the 1920's were associated with the spread of electrification but many of the changes in production techniques which have occurred over this long time period have been associated with organisational change as well as changes associated with the use of particular pieces of new capital equipment.

Changes in relative pay also require an understanding of supply responses. The transformation of workers, who in earlier periods would have provided manual work, into non-manuals, depends on the flexibility of education and training systems. Although the general British education system has not had a good record of providing for the less academically inclined, it does seem to have supplied workers in sufficiently well educated numbers to more than meet the demand for increased non-manual work in the period up to 1980. The increasing participation rates of women throughout the 1960's and 1970's no doubt contributed to this. Technological change requiring higher levels of education in the more recent period however, may well have put too large a demand on a higher education system which traditionally supplied small numbers of highly educated manpower from a University system with restricted entry. Until the recent expansion this was particularly true of recruitment of men from manual worker backgrounds and women in general. Entry is still unequal and delays and difficulties in transforming the system are probably an important part of the story of increased inequality.

Although the origins of biased technology are beyond the scope of this paper, the decline in relative non-manual pay up to the end of the 1970's and subsequent increase is consistent with the hypothesis of induced bias in Acemoglu [1998]. The expansion in general education in the early part of the century initially increased relative supply of non-manuals faster than demand. Eventually the availability of non-manuals with good basic education became so general as to provide a market sufficiently large for innovations and organisational changes which raised the productivity of relatively low-skilled non-manuals to justify the development of innovations biased towards this group. These are the changes which became more noticeable in terms of the a/b ratios from the mid 1970's. This process may now have run its course. Bresnahan [1999] argues that the introduction of computers, largely used for word-processing and low-skilled non-manual operations, has taken this generation of innovations so far forward that they are now acting as a substitute for the skills associated with general education rather than a complement to the skills associated with higher education. The computerisation of many operations in banking from the end of the 1980's for example displaced many clerical workers. Continuing technological substitution for the skills of generally educated non-manual workers may in future lower their pay. The further expansion of higher education may compound this effect on non-manual pay by reducing the relative pay of University graduates as their supply increases faster than demand. The prevalence of University graduates in its turn may stimulate the development of a new generation of more sophisticated innovations biased towards this more highly educated group and beyond that a generation of innovations which substitute for it.

As well as supply variations and the degree to which innovations substitute or complement skills at different levels, there are many other factors contributing to the sudden widening of pay differentials. The abandonment of the incomes policies of the 1970's, the reduction of union power and the steep rise in unemployment in the early 1980's compounded the effects

of biased change but it seems clear that biased technological change accelerated over this period and was strong enough to explain the widening differentials. There remain interesting questions however as to why the rate of biased technological change has apparently varied so much over short periods of time.

References.

Acemoglu, Daron 'Why do new technologies complement skills? Directed technical change and wage inequality' *Quarterly Journal of Economics* (1998) 1055-1089

Acemoglu, Daron 'Cross-country inequality trends' *Economic Journal* (2003) vol 113 (February) F121-F149.

Berman, Eli, J.Bound, and Z.Griliches 'Changes in the demand for skilled labor within US manufacturing: evidence from the Annual Survey of Manufactures' *Quarterly Journal of Economics* CIX (1994) 367 – 397.

Bresnahan, Timothy F *'Computerisation and wage dispersion: an analytical reinterpretation'* The Economic Journal 109 (1999) F390-F415

Chapman, Agatha *'Wages and Salaries in the U.K. 1920 – 1938'* (1953) Cambridge University Press

Colecchia A and G.Papaconstantinou 'The evolution of skills in OECD countries and the role of technology' (1996) *STI Working Paper 1996/8 OCDE/GD(96)183*

Dickens, William T and Lawrence F. Katz 'Interindustry wage differences and industry characteristics' Chapter 3 in K.Lang and J.S.Leonard eds 'Unemployment and the structure of labor markets' Blackwell 1987.

Freeman, Richard 'Are your wages set in Beijing?' *Journal of Economic Perspectives Summer* (1995)

Goldin, Claudia and Lawrence F.Katz 'The origins of technology-skill complementarity' *Quarterly Journal of Economics* CXIII (1998) Pp693 – 732.

Habakkuk, H.J. *'American and British Technology in the Nineteenth Century: The Search for Labour-Saving Inventions'* Cambridge University Press 1962.

Hoskins, M. 'The effects of sectoral and technological changes on the skill structure of employment in the united kingdom 1951-1991' *Economics Letters* 69 (2000) Pp101-107.

Krueger, Alan B and Lawrence H.Summers 'Reflections on the interindustry wage structure' Chapter 2 in K.Lang and J.S.Leonard eds 'Unemployment and the structure of labor markets' Blackwell 1987.

Machin, Stephen *'Wage Inequality in the UK'* Oxford Review of Economic Policy 12 1 (1996a) 47-63

S.Machin *'Changes in the relative demand for skills'* Chapter 7 in A.Booth and D.Snower eds 'Acquiring Skills'(1996b) Cambridge University Press.

S.Machin and John van Reenen 'Technology and changes in skill structure: evidence from seven OECD countries' Quarterly Journal of Economics (1998) Pp 1215 – 1244.

Machin, Stephen '*Wage Inequality in the UK'* Oxford Review of Economic Policy 12 1 (1996) 47-63

Routh, Guy 'Occupation and pay in Great Britain 1906 – 79' Macmillan 1980.

Royal Commission on the Distribution of Income and Wealth *Report No 8 Fifth report on the Standing Reference* (1979) *Cmnd.7679* London HMSO