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SKILL-BIASED TECHNICAL CHANGE AND THE RELATIVE PAY AND EMPLOYMENT OF MEN AND WOMEN IN THE UK ECONOMY 1971 – 1991.

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Skill-biased Technical Change and the Relative Pay and Employment of Men and Women in the UK Economy 1971 – 1991.

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Abstract: This paper presents quantitative estimates of the effects of technological change in industries and services on skill composition in the United Kingdom for four skill groups, for men and women separately for the period 1971 – 1991. The paper separates the effects of relative wage change, biased technological change and changes in sectoral composition and estimates the effect of biased technological change on relative pay.

Keywords: Skill change, United Kingdom, technological change, relative pay.

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Introduction.

Inequality increased in many dimensions in a number of labour markets after 1980. In the United Kingdom whichever groups are considered there has been an increase in pay inequality, as shown by Machin (1996). Although many factors have probably contributed, skill-biased technological change is generally accepted as an important part of the story. An increase in relative demand from technological change biased towards particular groups will, in the face of less than perfect supply elasticities, lead to an increase in their relative pay. Skill-biased technological change was emphasised in an early article by Berman, Bound and Griliches (1994) and the argument developed in a number of papers. The longer history of such biased technological change is discussed in Goldin and Katz (1998) and its similarity in many countries more recently in Berman, Bound and Machin (1998), Machin and van Reenen (1998) and Acemoglu (2003). The main alternative to biased technological change is demand shifts associated with changes in industrial structure. Expansion of the more 'skill intensive' service sector and the relative decline of manufacturing will shift relative demand towards more skilled workers. It has been suggested that these changes could be associated with freer international trade and globalisation in general. Acemoglu (2001) provides a recent survey and assembles evidence to support the skill-bias hypothesis. Many authors doubt the adequacy of either or both of these explanations. Other factors which affect inequality such as the value of the minimum wage in the United States, the abandonment of incomes policies in the UK and the decline in Trade Unionism generally, changed between the 1970's and the 1980's when growing inequality became apparent. Card and Di Nardo (2002) discuss aspects of the growth in inequality which are not easily explained by many or any of the explanations and emphasise the role of supply factors. Supply to different skill groups and the way this changes in response to education and training systems is generally given less attention than changes in demand. However, despite increases in the supply of workers educationally suited

to higher skilled non-manual jobs, the relative pay of this group rose during the 1980's. This suggests that there must have been substantial shifts in relative demand. Many factors probably contributed to this: the problem is to assess the quantitative contribution of each of them.

There have been many studies of this issue for the United States and some studies comparing international experience, but fewer detailed studies for the UK and Europe. Machin (1996a and b), Nickell and Bell (1996) and Hoskins (2000) show however that similar changes have occurred in the UK. The present paper extends these by developing explicit measures of technological bias in a detailed disaggregation of industries and services which accounts for most civilian employment in the UK. This enables the effects of this bias on relative employment in different skill groups to be separated from the effects of relative pay change. The paper also uses a more detailed disaggregation of skill groups than the manual/ non-manual distinction which is often used and also considers effects on male and female employment separately. The periods considered are the decades from 1971 to 1981 and 1981 to 1991, during which the UK economy experienced rather dramatic deindustrialisation. The paper shows that skill-biased change was prevalent in the decade 1971 to1981 and even more intense between 1981 and 1991. There were many other changes however. There was a marked change in women's employment, incomes policies were abandoned and Equal Pay and Equal Opportunities legislation affected the employment and pay of women. All these will have contributed to some extent to the contrasting movements in relative pay in the two decades. While the earlier decade saw a continuation of a long trend towards equality this was reversed over the subsequent decade. The present paper considers whether the changing bias in technological change has been sufficiently strong by itself to account for observed changes in relative pay.

One of the problems in separating skill bias from other effects is the need for explicit measures of technological bias and the way it has changed over time. Common measures of changing skill bias take employment proportions and changing wage shares of different skill groups. Employment proportions and wage shares are affected by both technology and relative pay however and measuring technological bias in this way confounds the effects of genuinely biased technological change with the effects of changes in relative wages. This is a particular problem when assessing the acceleration of skill-biased technical change between the 1970's and the 1980's. Relative pay narrowed in the 1970's and widened in the 1980's. It is tempting to attribute the change in relative employment proportions in the earlier period to the changed relative pay and conclude that the bias accelerated dramatically in the later period as the employment proportion of skilled workers rose against the change in their relative pay. The present paper separates the effects of changes in relative pay from the effects of changes in technological bias and shows that bias changed quite significantly in the 1970's as well as the 1980's and was the major factor increasing the relative employment of more highly skilled workers in the earlier as well as the later period.

Technology is only one of many changes in the UK labour market. The changing balance between manufacturing and services and between different industries and services within these broad groups affected relative demands. The decline in traditional manufacturing shifted relative demand away from skilled manual workers. The growth of the service sector expanded demand for female employment. It is not clear how this growth of female employment affected males and employment in different skill groups. It is unlikely that men and women were regarded as perfect substitutes or to have been employed in fixed proportions. Imperfect substitution between men and women both within and between skill groups will affect our picture of technological bias. In the decade 1971 to 1981 the growth in female employment was biased more towards secretarial and clerical work. Between 1981 and 1991 the impact of Equal Opportunities legislation and increased participation in higher

education improved opportunities for women to take higher skilled non-manual jobs while the effects of Equal Pay legislation may have worsened their chances of getting them. There is no reason to assume that men and women have been equally affected by technological and other changes or that these changes will have had similar effects in different skill groups.

This paper fills some of these gaps. It develops explicit measures of skill bias as represented in the parameters of a CES production function and shows how this bias has changed over the two decades 1971 to 1991. These measures are given for forty-six industries and services, which account for almost all of civilian employment in the UK, and disaggregates skill into two nonmanual and two manual groups for men and women separately. The importance of distinguishing skill levels within the manual and non-manual groups is emphasised by Colecchia and Papaconstantinou (1996) who note that there is upskilling among white-collar workers in a number of countries and that patterns of change within the broader groups also differ between the manufacturing and service sectors. Machin (1996b) also shows that distinguishing skill levels within the broader categories gives a richer picture of what has been happening.

The next section discusses the calculation of skill and gender bias and the subsequent section indicates the way these biases vary by sector and how they have changed over time. This is followed by a section indicating the quantitative contributions of changes in skill and gender biases, changes in relative pay and changes in the sectoral composition of employment, on the overall move towards a more highly skilled and more feminised workforce. The calculations show the contributions of each of these three factors to the changing structure of a standard economy of 1000 workers. The penultimate section gives estimates of the potential contribution of biased technological change to changes in relative pay.

Measures of Skill Bias.

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

$$Y_i = \left[\sum_{j=1}^{8} a_{ij} L_{ij}^{\delta} \right]^{\frac{1}{\delta}} f_i(K_i) \qquad (1)$$

Here, eight different types of labour input *j*, four each for men and women, are combined in CES manner, which are separable from other inputs *K*. This functional form is commonly assumed and, although restrictive, is parsimonious in parameters and permits calculation of explicit measures of factor bias. Each sector *i* has its own set of parameters allowing full heterogeneity of production relations, although all are constrained to be CES.

Assuming cost minimisation in competitive conditions:

$$\frac{L_{ij}}{L_{ik}} = \left[\frac{w_{ij}}{w_{ik}} \right]^{1/(\delta-1)} \left[\frac{a_{ij}}{a_{ik}} \right]^{-1/(\delta-1)} \qquad (2)$$

Changes in relative factor intensities depend on changes in relative pay as well as changes in technology so that changes in factor ratios only indicate changes in technological bias if relative pay stays constant. Relative pay has changed quite dramatically over the period considered here however. Changes in employment structure, in the supply of different types of worker associated with educational changes, changes in unionisation and the effects of Equal Pay legislation have affected the relative pay of skilled workers and of women. These changes interact with changes in technological bias to generate complex effects on the employment ratios of different types of worker. An increase in relative factor employment understates the magnitude of a shift in technological bias if it takes place against an increase

in relative pay and understates 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:

$$\frac{a_{ij}}{a_{ik}} = \left[\frac{w_{ij}}{w_{ik}}\right]\left[\frac{L_{ij}}{L_{ik}}\right]^{1-\delta} \qquad (3)$$

The ratio a_{ij}/a_{ik} is an explicit measure of the technological bias between the two factors *j* and *k* in industry *i*. For any value of the elasticity of substitution it may be calculated from relative pay and relative factor employments. These technological parameter ratios have been calculated for four occupational groups for men and women separately, i.e. for eight groups of workers, in forty-six industries and services for each of the years 1971, 1981 and 1991. Details are given in Appendix Tables 1 –3.

This method of calculation allows the bias to vary across industries, between skill groups and also for different variations over time for each industry and skill group. There is however an identification issue since 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 both of these values. The results are robust across these values. It is quite possible that the elasticity of substitution varies over time, across industries and between skill groups but the results from these combinations should be bracketed by the results reported here.

Data on relative factor employments come from the UK decennial population census and on relative pay from the New Earnings Survey. The occupational groups are derived from census measures of 'Social Class' as described in Hoskins (2000). The census gives six social classes. Non-manual workers are subdivided into Professional and Managerial, Administrative and Technical, and Clerical and Secretarial. Manual workers are subdivided into Skilled, Semi-skilled and Unskilled. For many industries there are few employees in the Professional and Managerial groups and the distinction between them and the Administrative and Technical group is not always clear; these groups have been combined for the analysis here. Similarly there are often few unskilled workers in many industries and services and the distinction between these and the semi-skilled is often blurred and these two groups have been combined. Although there is considerably more heterogeneity in the skills of the workforce than is reflected in these four skill classes, the subdivision of manual and non-manual workers into two further skill groups is a richer classification than the identification of non-manual work with skill and manual work with a lack of skill. The analysis in each of these groups is conducted for men and women separately.

Increasing Skill Bias.

The calculated values for the bias parameters in the Appendix tables show considerable variation across sectors as well as over time. There is clear heterogeneity of industry production relationships even when they are all constrained to belong to the class of CES functions. The disaggregation of manual and non-manual workers into further skill groups is particularly revealing when considering gender bias. Not surprisingly there is far less bias against women in clerical employment than in managerial jobs but this is decreasing over time.

With eight groups of workers there are many ways to consider the movements in skill bias as represented by the changing (a_{ij} / a_{ik}) ratios. Although there is considerable variation across industries, between men and women and between decades the general pattern of change is clear. Exact magnitudes vary with the assumed value for the elasticity of substitution but general patterns are much the same. We consider first the bias between skill groups for men and then for women.

For non-manual male workers there is an increase in bias towards high skill. In the decade 1971 – 1981 forty of the forty-six industry/services showed an increase in the relevant parameter ratio. Between 1981 and 1991 only one industry did not exhibit this move towards higher skill. The sector bucking the trend in both decades was 'Education'. The increase in bias became more pervasive in the 1980's. Among manual males between 1971 and 1981 there was a movement towards skill in twenty-seven industry/service groups. In the service sector only three groups showed a move away from skill. Eleven of the nineteen manufacturing industries showed a move away from skill however. In the period 1981-'91 the move away from skilled manual work was more pervasive with twenty-seven sectors showing an increased bias towards semi- and unskilled work. In the service sector ten groups, and in manufacturing nine industries, showed a move away from manual skill. Over the two decades, twenty of the sectors showed the move away from skilled manual work, ten of them in manufacturing. It is clear that among male non-manual workers there has been a pervasive and accelerating bias towards more skill while among manuals there has been as much movement away from skill as towards it. Over the whole period 1971 to 1991 almost equal numbers of industries in manufacturing moved away from manual skill as towards it.

The general picture for women is much the same as that for men. From 1971-'81 there was a move towards more skill among non-manual women in all except six sectors. All industries in

manufacturing showed this move. In the decade 1981 to 1991 all sectors except 'Education' showed a move towards skill. Among manual women there is a general move towards skill, and this move becomes more pervasive in the later decade. Among female manual workers there was a move towards skill in twenty-six sectors between 1971 and 1981. In thirteen of the nineteen manufacturing industries however, the move was away from skill. Between 1981 and 1991, thirty-six sectors showed a trend towards more skill. Eight industries in manufacturing bucked this trend. Only 'Personal Services' in the service sector became less skilled among female manual workers. Despite the increasing bias towards skill among female manual workers, lower skilled work remained dominant among female manuals.

Within skill groups there have been marked changes in the bias between men and women. Technological change in the form of changed working practices may to some extent be responsible for these but moves towards equal opportunities almost certainly had some effect. Cracks in the 'glass ceiling' and improved access to higher education have increased the opportunities for women to move into the higher skill groups and this is very noticeable in the highest skilled non-manual group. Between 1971 and 1981 only seven of forty-six sectors did not exhibit this move to more equal treatment, as reflected in more equal a_{ij} / a_{ik} ratios, and between 1981 and 1991 only three. Despite increased relative pay for women, which interacts with assumed values for substitution elasticities to affect these calculations, these patterns are the same for both assumed values of the elasticities. Despite the general trend towards more equal treatment in the high-skilled non-manual group, there were only four sectors, Education, Health, Personal Services and Domestic Services, where the parameter ratio was either near or below one, indicating equal treatment of men and women. It remains true that there is a general bias against women in the high-skilled group. In the lower-skilled group of non-manuals there is generally more equality of opportunity for men and women but a definite trend towards the employment of women. Between 1971 and 1981 all but seven sectors

showed a move in favour of women with an assumed substitution elasticity of 1.2 and all but twelve with an assumed elasticity of 1.6. Between 1981 and 1991 all but one sector showed this trend. By 1991 all but four or six sectors, depending on the elasticity, showed a bias in favour of women in this low-skill non-manual group, whereas twenty-four or twenty-nine had shown a bias in favour of men in 1971.

Among manual workers there is also a clear trend towards the feminisation of work. Among skilled manuals only five sectors did not exhibit this trend between 1971 and 1981 and only nine between 1981 and 1991. Despite this, skilled manual work remained predominantly male in 1991. In contrast to this general reduction in bias against women, there is a more mixed pattern among semi- and unskilled manual workers. From 1971 to 1981 there is the same general move away from male bias, with only eight sectors failing to follow the trend. The pattern from 1981 to 1991 however shows the bias moving towards male workers in thirty-two or thirty-four sectors, depending on the value of the substitution elasticity.

To summarise, it is clear that the movement towards skill is not just a movement away from manual to non-manual work. Within non-manual work, for both men and women, there is a pervasive and accelerating movement towards higher skilled jobs. Within manual work there is as much movement away from skill as towards it in manufacturing. Similarly, the improvement in the position of women in the labour market is more pronounced among non-manuals than manuals. The more detailed disaggregation by skill and gender also shows that semi- and unskilled manual work is increasingly becoming a male activity. This reinforces a common perception that the economic circumstances of poorly educated men worsened in the 1980's.

The Quantitative Importance of Skill Bias.

It is clear that there has been a strong, pervasive and increasing bias towards higher skilled non-manual work and a noticeable move towards semi- and unskilled manual work among men. The general effect is to increase the importance of the tails of the skill distribution. The effect on relative pay will depend on the quantitative contribution of these changes to the overall demand for skill relative to supply. The overall quantitative contribution of the biases depends on their size and the number of workers affected and this in turn depends on the relative size of the sectors where the biases are most pronounced. This section presents calculations of these contributions to changes in relative demand.

We decompose the total change in employment of the eight groups of workers into three factors:

- the effect of biased technological change
- the effect of relative pay change
- the effect of changes in the composition of employment across the forty six industries and services.

For a standard size of economy of one thousand workers we calculate the size of each of the separate effects. This is done for the decades 1971-1981 and 1981-1991.

Each of the effects is 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 pay changed as it 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:

$$\begin{aligned}\left[\left(e_{L1}\ldots e_{L8}\right)_t-\left(e_{L1}\ldots e_{L8}\right)_0\right]= {} & e_0\left[\left(p_{L1}\ldots p_{L8}\right)_{W_0,(a/b)_t}-\left(p_{L1}\ldots p_{L8}\right)_{W_0,(a/b)_0}\right] \\ & + \; e_0\left[\left(p_{L1}\ldots p_{L8}\right)_{W_t,(a/b)_t}-\left(p_{L1}\ldots p_{L8}\right)_{W_0,(a/b)_t}\right] \\ & + \; \left[e_t-e_0\right]\left(p_{L1}\ldots p_{L8}\right)_{W_t,(a/b)_t} \qquad (4)\end{aligned}$$

Here:

t denotes the end of a decade

0 denotes the beginning of a decade

e_{Lj} denotes employment of workers in group *j*

$\left(p_{L1}\ldots p_{L8}\right)_{W_0,(a/b)_t}$ is a matrix of employment proportions in eight skill/gender groups evaluated at base year relative wages and terminal year technology.

e_0 is the 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. Both of these are weighted by sector employment at the start of a decade. The last term is the effect of changed sector composition.

The results of these decompositions are given in Tables 1 and 2. Table 1 gives the results assuming an elasticity of substitution of 1.2 and Table 2 results for an elasticity of substitution of 1.6. The effects on male workers are given in the first four columns and those for females in the last four. The first row for each effect gives the absolute value change, positive or negative, in an economy with total employment of one thousand. The second row gives the effect as a percentage change on the base value at the beginning of a decade for employment in each group.

It is clear from these tables that the general pattern and relative importance of the different effects is not much affected by the particular assumed value of the elasticity of substitution: effects which are dominant for one value remain dominant for the other. The higher substitution elasticity not surprisingly leads to higher calculated values, in opposite directions, for both the wage and technological change effects but even these quantitative magnitudes are not much different. It is also clear that changes in industry composition are almost irrelevant to the changing skill structure: they are miniscule for all groups in both decades. This suggests that changing trade patterns, at the levels of aggregation used here and in so far as these work through changing the structural balance of the UK economy, have been insignificant in changing the pattern of skill demand.

Table 1. Decomposition of Employment Change in Eight Skill/Gender Groups

for an Economy of 1000 Workers: elasticity of substitution = 1.2.

	Effect	*MMangr*	*MCler*	*MSkd*	*MOthr*	*FMangr*	*FCler*	*FSkd*	*FOthr*
1981 -'91	*TechCng*	30.355	-21.90	-25.89	-16.138	58.149	14.107	-0.281	-38.399
	%	16.910	-29.84	-12.0	-12.367	63.844	9.365	-0.839	-30.565
	WgeCng	-12.344	7.899	10.378	6.339	-21.54	-7.739	-0.494	17.497
	%	-6.877	10.762	4.809	4.858	-23.65	-5.137	-1.477	13.928
	SectCng	0.006	0.004	-0.021	-0.012	0.007	0.016	-0.001	0.0005
	%	0.003	0.005	-0.010	-0.009	0.008	0.011	-0.004	0.0004
1971 -'81	*TechCng*	15.669	-7.195	-23.66	-27.568	8.786	16.657	-0.492	17.805
	%	10.577	-9.548	-9.623	-17.460	13.350	11.783	-1.225	14.207
	WgeCng	11.897	2.571	18.577	10.104	0.095	-16.303	-2.976	-23.965
	%	8.031	3.411	7.555	6.399	0.1451	-11.53	-7.405	-19.122
	SectCng	0.004	0.003	-0.025	-0.010	0.016	0.009	-0.003	0.006
	%	0.003	0.004	-0.010	-0.006	0.025	0.006	-0.008	0.005

Table 2. Decomposition of Employment Change in Eight Skill/Gender Groups

for an Economy of 1000 Workers: elasticity of substitution = 1.6.

	Effect	*MMangr*	*MCler*	*MSkd*	*MOthr*	*FMangr*	*F Cler*	*F Skd*	*FOthr*
1981 - '91	*TchCng*	37.873	-36.119	-2.917	-26.529	61.770	19.200	-9.664	-43.613
	%	21.099	-49.212	-1.352	-20.329	67.819	12.745	-28.891	-34.716
	WgeCng	-19.863	22.118	-12.600	16.730	-25.157	-12.832	8.890	22.712
	%	-11.065	30.136	-5.838	12.820	-27.620	-8.518	26.574	18.0781
	SectCng	0.006	0.004	-0.021	-0.012	0.007	0.016	-0.001	0.0005
	%	0.003	0.005	-0.010	-0.009	0.008	0.011	-0.004	0.0004
1971 - '81	*TchCng*	11.982	-19.457	7.021	-35.901	1.218	22.069	-9.713	22.782
	%	8.088	-25.820	2.855	-22.738	1.850	15.611	-24.168	18.178
	WgeCng	15.585	14.833	-12.11	18.437	7.664	-21.72	6.245	-28.941
	%	10.520	19.683	-4.924	11.677	11.645	-15.36	15.538	-23.09
	SectCng	0.004	0.003	-0.025	-0.010	0.016	0.009	-0.003	0.006
	%	0.003	0.004	-0.010	-0.006	0.025	0.006	-0.008	0.005

The other feature of these results is the dominant effect of technological change. This is particularly clear in the decade 1981- 1991. This raised the demand for high-skilled non-manual men by 16.9% and for high-skilled non-manual women by 63.8%, with a substitution elasticity of 1.2 and by slightly more with the higher elasticity. Together the increased demand for high-skilled non-manuals is 88.5 or 99.5 in our economy of 1,000. The technological change has worked against all other groups except female clerical staff. Male lower skilled non-manual work declined in both decades. With a substitution elasticity of 1.2 technological change increased overall employment of non-manuals by 80.7 or 82.7. Most of this increase was among women, leading to an overall increase in female workers of 33.6 or 27.69. The same general pattern is true of the earlier decade. Technological change shifted employment to non-manuals, and women in general, but particularly towards female clerical employment rather than the higher-skilled female non-manuals of the later decade. This suggests a possibly delayed effect of Equal Opportunities legislation. In this earlier decade the effects of different values for substitution elasticities are more noticeable but do not alter general patterns. It is also noticeable that in both periods, and particularly in the later decade, technological change worked against low-skilled non-manual men. In the 1980's this was sufficiently strong to outweigh the positive effect on the employment of low-skilled non-manual women. This supports the argument put forward by Bresnahan [1999] that the introduction of computers largely substituted for word-processing and routine clerical operations as well as being complementary with higher level cognitive and 'people' skills.

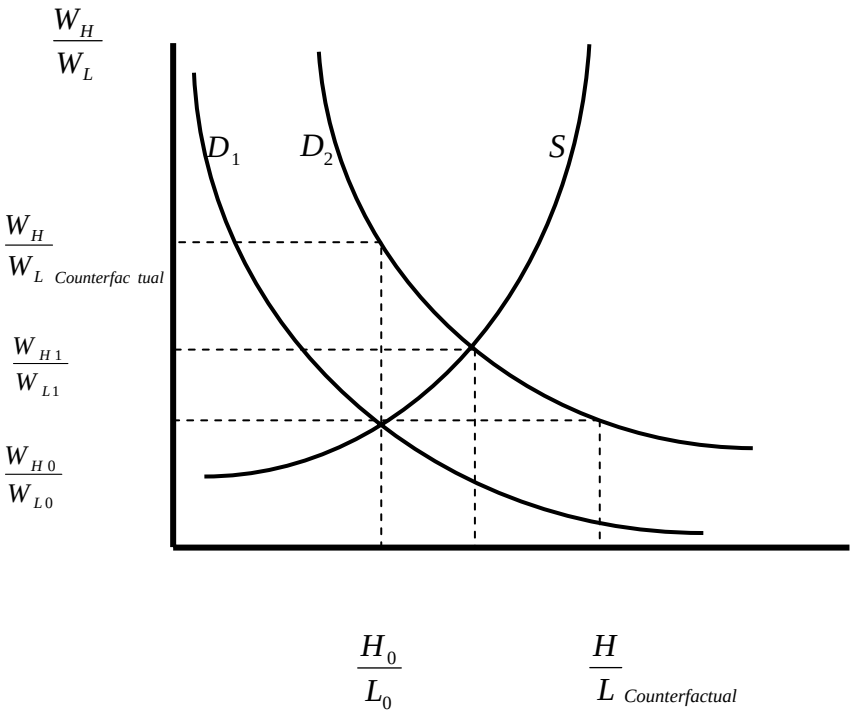
The effects of increasing relative pay in reducing relative employment for higher skilled groups from 1981 to 1991 are clear. The other feature of these results is the rather dramatic way in which technological change has reduced the demand for semi- and unskilled workers in the later decade. Between 1971 and 1981 this reduced the demand for men in this group but

increased it for women. In the later decade the employment of both semi- and unskilled men and women was reduced.

The Effect of Biased Technological Change on Relative Pay.

The previous sections dealt with the effects of technological and other changes on the relative demands for different skill groups. The way relative pay responds to these changes also depends on changes in relative supply. The natural adaptability of workers and changes in training and educational systems alter these relative supplies. Higher education has expanded and access has become more equal for men and women. There have also been attempts to encourage recruitment from social groups with traditionally low rates of participation. It is beyond the scope of this paper to assess the impact of these changes in detail. The aim here is more limited and seeks only to give an idea of the extent to which changes in relative pay are consistent with the changes in relative demands which have resulted from the technological changes. We do this in two ways: by calculating the relative pay which would have resulted from biased technological change if markets worked freely and there was inelastic supply and also by estimating the actual effects of increased changing relative demands on relative pay. These approaches are illustrated in figure 1. Skill biased technical change shifts the relative demand curve for two types of workers, H and L, to the right and in the face of inelastic supply, S, will raise relative pay if market forces work freely. The supply curve S reflects supply response to changing educational policy to reflect policymakers changing appreciation of educational needs, as well as response to changing relative pay.

Figure 1. Shifting relative demand and changing relative pay.



The first question we seek to answer is: 'What would relative pay have been at the end of a decade if technological change had occurred the way it did but there had been no change in the employment structure over the decade?' This is equivalent to supposing that the supply of each 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 actual increase. The hypothetical increases in relative pay are counteracting the increased demand and restraining it to its initial levels. The level of increased pay required to achieve this, and indicated in diagram 1 by $W_H / W_{L\,Counterfactual}$, will depend on the substitution elasticity. The higher the substitution elasticity, the lower the pay increase required to compensate for increased technological bias towards any particular group. For each industry the relative pay has been calculated which would sustain skill group employment at the previous levels. The reported relative pay is a weighted sum of the pay structures in each industry, the weights being the relative industry total employment.

The results are given in Table 3. The pay of each group is given relative to the pay of semi- and unskilled ('other') female workers. For each of the years the actual pay structure is reported together with the counterfactual pay structure for each of the assumed values of the substitution elasticity. Since the estimated change in technological bias is affected by the substitution elasticity, the counterfactual relative pay structure is affected by the substitution elasticity in two ways, via the effect on the estimated employment change due to technological change and via the wage change required to compensate for this. The reported results reflect both of these.

Table 3. Actual and Counterfactual Relative Pay.

	MMan/FOtr	*MCler/FOtr*	*MSkd/FOtr*	*MOtr/FOtr*	*FMan/FOtr*	*FCler/FOtr*	*FSkd/FOtr*
Actual '91	2.663521	1.581342	1.697432	1.479413	1.967792	1.279836	1.270484
CFSub1.2	3.659569	1.666965	1.84505	1.66149	4.021311	1.722631	1.617444
CFSub1.6	4.529755	1.581412	2.236618	1.834177	3.858308	2.003473	1.195263
Actual '81	2.07806	1.424612	1.562051	1.34403	1.416042	1.027974	1.053185
CFSub1.2	2.744369	1.670364	1.779455	1.352725	2.353217	1.185998	1.800785
CFSub1.6	3.127405	1.530976	2.059804	1.529607	1.867836	1.30788	1.150134
Actual'71	2.683104	1.820443	2.065155	1.792275	1.565699	1.146402	1.160297

Note: The first line for each year gives the actual relative pay structure, the second and third lines the relative pay needed to sustain employment at the levels and structure of the previous decade for an assumed substitution elasticity of 1.2 or 1.6, all relative to the pay of female semi- and unskilled workers.

The reported pay structures have many expected features. The narrowing of actual differentials from 1971 to 1981 and their subsequent widening from 1981 to 1991 is quite apparent. This is particularly clear in the case of managers and professionals. The pay of male managers relative to semi- and unskilled women fell from 2.68 to 2.08 and then rose back to 2.66 by 1991. The pay of female managers fell from 1.57 to 1.42 and then rose to 1.97. The increase in inequality however, would have been much greater had there been no increase in the supply of workers to these groups. This is particularly clear from 1981 to 1991 when the effects of biased technological and other changes which cannot be distinguished from it, were largest. The increase in the relative pay of male managers would have been 3.65 or 4.53 times that of semi- or unskilled women workers rather than 2.66, and female managers relative pay would have increased to 4.02 or 3.85 times that of semi- or unskilled workers instead of 1.97 had there been no increase in supply. Technological change has benefited all groups relative to semi- and unskilled female workers though to considerably varying degrees.

The second approach we take is to ask whether the increased relative demand for some groups of workers was in fact associated with the increase in their relative pay. The evidence presented above indicates that although there was pervasive and significant bias towards several highly skilled groups, there was also a general narrowing of pay differentials in the decade 1971 to 1981 but a widening in the 1980's. To investigate this further the relative pay of different groups of workers has been regressed on the associated increased relative demand generated by biased technological change between the groups. In terms of diagram 1 relative pay between groups, and pairs of groups, has been regressed on the excess demand represented by the difference between H_0 / L_0 and $H / L_{Counterfactual}$. The equations are estimated in logarithmic form and where the comparison groups involve both men and women a dummy variable for men is included to capture the effects of equalising pay. The equations are estimated without a constant term.

$$\log\left(\frac{W_H}{W_L}\right)_{Cnterfact} - \log\left(\frac{W_H}{W_L}\right)_0 = \alpha\left(\log\left(\frac{H}{L}\right)_{Cnterfact} - \log\left(\frac{H}{L}\right)_0\right) + \beta\, MaleDummy \qquad (5)$$

Detailed results for many comparison groups are presented in Table 4. The general conclusion is that whereas excess demand resulting from biased change had a highly significant effect on relative pay in the 1980's this was not so in the 1970's, and whereas the equalisation of pay between men and women had a significant effect in the intended direction in the earlier decade, this was somewhat reversed in the later decade.

Lines 1 to 8 compare relative pay for all groups relative to female semi- and unskilled manual workers. Although there is a clear general effect of increased demand from biased technical change on general relativities in the 1980's, this was not so in the 1970's. The coefficient on the 'male dummy' shows that equal pay legislation raised the relative pay of women in the earlier decade by about 24% overall. The comparisons between particular groups and 'female other' workers support this general picture. In the 1970's equal pay legislation raised the pay of women relative to men by between 18 % and 28 %, depending on the groups considered, but this effect is reversed by between 8% and 10% in the later decade. All excess demand variables are significantly positive at the 1% level in the 1980's whereas this is so only for the pay of clerical workers relative to female others in the 1970's. In the case of skilled manual workers increased relative demand is apparently having a significantly perverse effect in the 1970's. These results support the general perception of the 1970's compared with the 1980's. Whereas the earlier decade was a turbulent decade with incomes policies and influential trade union activity interfering with the working of market forces, the later decade was characterised by deregulation, the abandonment of incomes policies and a weakening of union influence. The apparently perverse effect of excess demand on the pay of skilled manual workers relative to female others in the 1970's is consistent with incomes policies, delivered

largely through union influence, flattening the pay structure and affecting unionised manual workers more than others.

The remainder of Table 4 gives results for specific pairs of worker groups. Lines 9 to 20 show that increased relative demand from biased change affected relative pay of different groups of male workers in a significant way in the 1980's, and this was also true for females apart from the relative pay of female clericals and female skilled manual workers. In the earlier decade there is no evidence for the effects of market forces affecting relative pay.

Lines 21 to 28 take particular skill groups and compare the pay of men and women. The consistent and significant effects of equalising pay are clear in the earlier decade, but this is only so for the relative pay of male and female clerical workers in the later decade. Some perverse effects reversing this in the 1980's are apparent for male and female managers and 'others'. The effects of changed relative demands are clear in the later period but also in the earlier period for male and female managers and clerical workers. Whether these changes arose from biased change or the effects of equal opportunities legislation, it seems clear that they have affected the relative pay of men and women, and have affected non-manuals more than manuals.

Table 4. Effects of excess demand and pay equalisation on relative pay.

	Decade	Groups compared	ExcessDemand	Male dummy	$\overline{R}^2$
1	1981 – '91	All relative to female others	0.211 ***	0.088 ***	0.605 ***
2		All managers /fem others	0.219 ***	0.101 ***	0.776 ***
3		All clerical/fem others	0.241 ***	0.093 ***	0.443 ***
4		All skilled manual/fem others	0.167 ***	0.085 ***	0.428 ***
5	1971 - '81	All relative to female others	0.003	- 0.235 ***	0.601 ***
6		All managers /fem others	0.017	- 0.222***	0.599 ***
7		All clerical/fem others	0.061 ***	- 0.183 ***	0.575 ***
8		All skilled manual/fem others	- 0.082 ***	- 0.282 ***	0.611 ***
9	1981 – '91	Male mangrs/male clerical	0.199 ***	-	0.745 ***
10		Male clercl/male skd manual	0.113 ***	-	0.272 ***
11		Male skd manl/male others	0.230 ***	-	0.442 ***
12		Fem mangrs/Fem clerical	0.103 ***	-	0.616 ***
13		Fem clercl/Fem skd manual	0.008	-	- 0.092
14		Fem skd manl/Fem others	0.173 ***	-	0.390 ***
15	1971 - '81	Male mangrs/male clerical	- 0.006	-	- 0.017
16		Male clercl/male skd manual	0.010	-	- 0.018
17		Male skd manual/male others	0.003	-	- 0.022
18		Fem mangrs/Fem clerical	0.004	-	- 0.010
19		Fem clercl/Fem skd manual	- 0.030	-	0.017
20		Fem skd manual/Fem others	- 0.100 ***	-	0.243 ***
21	1981 – '91	Male mangrs/fem mangrs	0.244 ***	0.080 ***	0.376 ***
22		Male clerical/fem clerical	0.081 ***	- 0.070 ***	0.031 ***
23		Male skd man/fem skd manl	0.058 *	- 0.001	0.050 *
24		Male othr/fem others	0.138 **	0.086 ***	0.110 **
25	1971 - '81	Male mangrs/fem mangrs	0.050 *	- 0.123 ***	0.039 *
26		Male clerical/fem clerical	0.128 ***	- 0.082 ***	0.179 ***
27		Male skd manl/fem skd manl	- 0.056	- 0.184 ***	0.012
28		Male othr/fem othr	0.050	- 0.244 ***	- 0.002

Note: *** significant at 1% ** significant at 5% * significant at 10%

Results are estimates of coefficients from equation 5 estimated across 46 industries and services.

Assessment.

The derivation of explicit measures of technological skill bias, separate from the effects of changes in relative pay, reveals the magnitude of its effects and the way it increased in importance in the decade 1981 to 1991 compared with the earlier decade. Technological change has been real and has accelerated. It has also dominated the effects of changes in the sectoral composition of employment, which have been shown to be negligible.

Although the treatment of supply side changes is limited, it is also clear that technological change by itself has been sufficiently strong and prevalent to change the structure of relative pay in quite dramatic ways and by itself could have accounted for the observed changes. The effects on relative pay however were suppressed by the turbulence and institutional arrangements of the 1970's and only emerged in the 1980's. The inequality of pay which emerged in the 1980's was due not so much to the emergence of biased change, though this was stronger in the 1980's than the 1970's, as to a changed institutional setting which permitted its effects to assert their full force on relative pay. This is not to say that changed relative demands were the only factor which has in fact been responsible. It is also clear that there must have been significant flexibility on the supply side of the economy to attenuate these effects or relativities would have widened further.

Although data availability often limits the degree to which worker groups can be disaggregated by skill level and gender, the value of this is clear. Men and women have been affected differently by technological and other changes. Technological changes have affected the demand for different levels of skill within manual and non-manual workers.

Disaggregating by skill within these groups and gender reveals the technological bias towards the tails of the skill distribution, a point analysed in some detail by Machin (1996a).

These issues require an analysis of the effectiveness of educational and training systems in responding to changing demands for different skills. Although these systems have worked to counteract some of the effects of technological change on the inequality of pay, they have not been particularly effective in rescuing those at the bottom of the skill hierarchy. The hollowing out of demand in the middle of the spectrum of skills has increased the supply of workers at the bottom end faster than demand while the supply at the top has grown more slowly than demand. Although access to higher education has broadened, it has apparently not developed sufficiently to help those from manual worker backgrounds, particularly women, to compete for the rapidly expanding jobs at the top end of non-manual skill hierarchy.

The general lesson is that biased technological change has been powerful and pervasive. It was evident even in the 1970's when the pay structure became more equal but its effects were counteracted by other features and developments such as the equalising effects of incomes policies. The bias and its effects accelerated into the 1980's and are sufficiently strong to explain the growing inequality of pay. As noted by many authors however, there has been increasing inequality in many dimensions not easily explained by skill bias. The trend toward equality in the 1970's also occurred despite this bias. The mere presence of the bias is not a sufficient condition for growing inequality. The reversal of many policies of the 1970's, such as pay restraint, and the expansion of sectors with less institutionalised forms of pay determination, contributed to the growth of inequality of the 1980's. It is also likely that the labour market tensions caused by biased technological change working against the 1970's policies were instrumental in their collapse.

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Appendix Table 1.

Bias calculations 1991
Elasticity of substitution =1.2.

	a/b MMan/MCler	b/c MCler/MSkd	c/d MSkd/MOtr	d/e MOtr/FMan	e/f FMan/FCler	f/g FCler/FSkd	g/h FSkd/FOtr
AG&HOR	90.9344	0.135732	0.142236	3.479558	3.127074	3.424916	0.111382
FOR	15.62224	0.160381	0.276877	11.57873	0.750462	8.40578	0.26139
FISH	20.84008	0.239941	0.105319	20.09555	1.128293	4.276656	0.256315
COAL	4.172871	0.083391	2.287023	14.41058	0.496154	6.598547	0.335107
COKE	3.390415	0.203828	1.190828	18.33996	0.590496	2.794073	0.584184
MINPROC	6.684027	0.387227	1.084581	2.851689	0.776154	14.07791	0.444288
ELECGAS	3.384328	0.313645	2.583104	2.403783	0.36858	14.65852	0.58282
WATER	5.852662	0.344985	0.742193	3.329633	0.711746	11.90571	0.652941
METMAN	5.276303	0.133313	1.422641	7.441367	0.70721	4.907482	0.346137
EMINNES	8.009259	0.20745	1.226085	3.652704	0.773518	13.07725	0.486453
MANNON	5.411107	0.134442	1.830875	3.992735	0.712328	1.039141	1.370021
CHEM	5.956588	0.395421	0.913233	2.162398	0.975542	3.789189	0.344543
MMFIBRE	10.32799	0.136282	0.676102	11.16665	0.672615	2.986792	0.355899
METNES	6.615678	0.102072	1.904256	5.170735	0.634166	3.533269	0.304874
MECENG	4.645963	0.201113	1.902106	3.094754	0.613881	8.146325	0.254547
ELELENG	7.02214	0.283428	1.514746	1.804409	1.036901	2.950815	0.245919
MOTVPTS	6.221665	0.142978	1.059347	9.849889	0.795138	3.433491	0.224283
OTHTRAN	6.051891	0.157833	1.914517	4.684179	0.749278	5.508269	0.429579
INSTENG	6.578005	0.229787	1.79629	1.763675	0.903497	2.14531	0.486597
FOODDT	4.716974	0.182155	1.62273	2.772501	0.812687	1.266002	0.522138
TEXT	6.609483	0.121143	1.572162	2.667391	0.984852	0.615078	0.673262
LEATHER	6.838288	0.086349	3.578815	1.173087	0.989113	0.417468	3.427083
FOOTCLO	6.847975	0.145973	1.809624	1.092767	1.266379	0.558615	0.447059
TIMB	6.460065	0.058905	5.492151	2.295279	0.725154	1.784951	0.93164
PAPPRNT	4.497835	0.189492	5.889515	0.438867	1.324391	1.378752	2.116294
RUBPLAS	7.41865	0.150754	1.175118	5.01102	0.739896	1.722175	0.581142
OTRMAN	4.33417	0.216558	1.989733	1.566943	0.853217	1.19112	0.967375
CONSTRN	10.42894	0.043457	2.767101	6.711695	0.524769	9.137708	0.975224
WHOLESL	3.679837	0.591551	2.139797	0.848139	0.812698	9.130226	0.454964
RETAIIL	3.018276	1.116566	1.574514	0.284907	0.535356	15.46497	0.470112
HOTELCT	3.752448	0.567013	0.995781	0.820581	1.435599	1.049371	0.401945
REPAIR	9.242716	0.066002	4.70873	1.868655	0.605278	3.482311	1.576856
RAIL	2.502214	0.216168	2.295847	8.095683	0.459524	4.350573	0.607505
OTINTRAN	4.317228	0.052449	8.442439	2.365883	0.552268	1.800524	2.393576
SEATRAN	7.972683	0.518462	0.732507	3.495905	0.512433	4.446215	1.21761
AIRTRAN	5.935797	0.272382	2.515754	0.939033	1.034916	0.819055	8.257564
MISCTRA	3.880813	0.426267	1.340111	1.167554	0.840336	7.179857	0.514368
POSTCOM	3.874394	0.273649	0.951557	3.811001	0.63364	9.858668	0.182134
BUSSER	4.777624	3.701947	0.958497	0.18212	0.811146	42.64494	0.369942
PUBADM	1.805529	3.614282	0.577052	0.495805	0.863039	9.360855	0.450476
EDUCATN	14.0172	1.470512	0.510523	0.08609	6.156098	1.992403	0.374396
MEDHLT	21.83157	0.248766	1.214203	0.063637	4.943013	4.14699	0.377708
OTHSER	7.79465	0.580515	0.494869	0.455332	2.426902	1.877758	0.264521
RECSER	3.979251	1.350621	0.53904	0.640694	1.245541	6.881899	0.318751

PERSER	0.933339	1.535625	1.143192	0.766223	0.417236	1.008278	1.294498
DOMSER	3.372987	0.042103	0.453914	6.95906	0.817552	0.069334	0.313975

Appendix Table 2.

Bias calculations1981
Elasticity of substitution =1.2.

	a/b MMan/MCler	b/c MCler/MSkd	c/d MSkd/MOtr	d/e MOtr/FMan	e/f FMan/FCler	f/g FCler/FSkd	g/h FSkd/FOtr
AG&HOR	75.24006	0.135025	0.172644	4.836495	2.748788	3.30534	0.092209
FOR	6.452282	0.152666	0.441243	27.16705	0.268007	58.97186	0.05651
FISH	12.11091	0.201246	0.147591	41.15858	0.703114	3.263413	0.569528
COAL	2.851625	0.073574	2.42653	33.07364	0.304336	7.264095	0.210041
COKE	2.753168	0.131938	1.112011	36.22495	0.29455	5.863508	0.281113
MINPROC	3.86521	0.356472	1.208802	6.023449	0.476983	10.09793	0.261621
ELECGAS	2.135443	0.349168	3.032602	7.201442	0.140784	14.44657	0.345073
WATER	3.511912	0.349014	0.949641	10.94595	0.263756	12.96187	0.343682
METMAN	3.004251	0.147536	1.4681	17.23752	0.304146	3.69041	0.346858
EMINNES	4.000718	0.218834	1.401444	9.798585	0.35019	14.19334	0.324662
MANNON	2.983697	0.172194	1.684995	10.11643	0.320785	1.038376	1.151365
CHEM	3.408087	0.427284	0.947861	4.851334	0.547958	3.467087	0.304475
MMFIBRE	4.152317	0.22721	0.658432	16.30886	0.498823	1.626412	0.543521
METNES	3.622989	0.137481	1.742813	10.25516	0.338637	2.742299	0.242866
MECENG	2.761193	0.243105	1.670875	11.98087	0.269149	6.450414	0.256696
ELELENG	4.311481	0.302672	1.499534	5.231755	0.386037	1.897568	0.362134
MOTVPTS	2.954849	0.180537	1.130108	21.74388	0.30684	4.116313	0.231774
OTHTRAN	2.820965	0.207225	2.052244	12.72063	0.292031	5.175446	0.343846
INSTENG	4.358595	0.239184	2.157101	3.658536	0.405951	1.236495	0.864295
FOODDT	2.625508	0.226641	1.484158	6.375028	0.380783	1.558918	0.388011
TEXT	4.389083	0.138442	1.431567	5.966628	0.500961	0.493177	0.739926
LEATHER	5.047043	0.089142	3.244416	4.099968	0.417042	0.375909	2.160375
FOOTCLO	4.864327	0.147658	2.024633	2.095149	0.706681	0.41732	0.486979
TIMB	3.96199	0.080695	4.190929	5.687467	0.377185	1.792119	0.705186
PAPPRNT	2.643333	0.22387	4.575906	1.541327	0.564936	1.184626	2.041739
RUBPLAS	3.92191	0.18535	1.271041	9.533552	0.374644	1.420353	0.451254
OTRMAN	3.178866	0.259945	2.05398	3.203617	0.398026	1.361395	0.492591
CONSTRN	6.648778	0.052263	2.90881	13.05587	0.287398	9.783821	0.544635
WHOLESL	2.139541	0.685364	1.995491	2.249813	0.576119	5.409201	0.31044
RETAIIL	2.627989	0.911819	2.20808	0.441565	0.401336	15.91354	0.385007
HOTELCT	2.672443	0.749097	0.968678	0.901469	1.308394	1.019981	0.261303
REPAIR	4.074608	0.092251	5.564004	2.662415	0.280394	5.806796	0.774501
RAIL	1.280638	0.25777	2.210612	26.0386	0.198877	5.203747	0.31523
OTINTRAN	2.588377	0.078267	6.397819	7.079549	0.236763	2.577761	0.83972
SEATRAN	5.733697	0.673965	0.694819	11.29827	0.250327	5.611506	0.626499
AIRTRAN	3.076638	0.385353	2.635322	2.079549	0.493886	1.342986	3.473522
MISCTRA	2.254008	0.648769	0.980735	3.952285	0.352599	10.77847	0.306954
POSTCOM	1.287821	0.38343	1.087885	9.589117	0.247623	11.58118	0.105939
BUSSER	2.663059	3.998745	0.891983	0.659416	0.431356	26.44684	0.251203
PUBADM	1.424572	2.999392	0.888108	0.989822	0.438221	10.5578	0.311022
EDUCATN	15.584	0.909628	0.590008	0.12284	6.067475	2.111982	0.203346
MEDHLT	18.32026	0.185875	1.397241	0.131912	4.056355	3.144143	0.137815
OTHSER	5.532176	0.541289	0.518208	0.864586	1.809065	2.151602	0.186998
RECSER	2.838398	0.997274	0.604375	1.379371	0.761277	9.78208	0.162207

PERSER	0.779214	1.064955	1.543471	1.425633	0.313466	0.69198	1.885562
DOMSER	2.43358	0.057178	0.367814	7.947857	1.481139	0.056744	0.24017

Appendix Table 3.

Bias calculations 1971
Elasticity of substitution =1.2.

	a/b MMan/MCler	b/c MCler/MSkd	c/d MSkd/MOtr	d/e MOtr/FMan	e/f FMan/FCler	f/g FCler/FSkd	g/h FSkd/FOtr
AG&HOR	63.23635	0.151328	0.161097	5.762217	3.144829	6.868147	0.040973
FOR	13.72255	0.113952	0.604865	44.53676	0.184361	54.95164	0.074807
FISH	1.968224	0.197432	0.211741	317.9735	0.100151	5.490551	0.232127
COAL	1.678445	0.059188	5.57657	29.446	0.213227	13.41571	0.153653
COKE	2.172689	0.147938	0.911724	77.1673	0.191541	31.91739	0.072306
MINPROC	2.934096	0.41318	0.983784	16.59231	0.203585	24.93385	0.127138
ELECGAS	1.429283	0.270875	2.245671	28.17081	0.087995	16.9675	0.231168
WATER	1.82467	0.308215	1.019101	39.36825	0.130158	16.82327	0.243129
METMAN	2.017491	0.1632	1.529265	33.7145	0.202058	3.106466	0.46309
EMINNES	2.547963	0.152157	1.424253	44.26789	0.166876	16.85651	0.153993
MANNON	2.177655	0.11544	1.437388	4.645272	1.988444	0.210112	1.383509
CHEM	2.578506	0.491365	0.822644	8.356662	0.398546	4.899687	0.218426
MMFIBRE	3.404831	0.219996	0.557956	18.91437	0.525631	1.800088	0.443431
METNES	2.741299	0.130757	1.952451	22.40301	0.195713	1.875182	0.301572
MECENG	1.763766	0.229093	2.383585	20.48669	0.162145	5.047732	0.29413
ELELENG	2.338586	0.360467	1.592291	10.50319	0.244908	1.533982	0.379696
MOTVPTS	1.727029	0.174257	1.21043	62.80497	0.141916	3.797837	0.232827
OTHTRAN	1.817501	0.197109	2.270513	29.0795	0.171159	4.687353	0.351921
INSTENG	2.586146	0.252572	2.506402	8.76402	0.194435	1.168575	0.830206
FOODDT	1.725164	0.315491	1.175485	11.35133	0.310331	1.694297	0.305277
TEXT	2.765487	0.157464	1.237851	12.69887	0.337152	0.384065	0.911338
LEATHER	4.008364	0.079805	3.225653	6.653977	0.375332	0.295606	3.440694
FOOTCLO	3.218214	0.143808	2.473627	4.050149	0.399675	0.328009	0.675936
TIMB	2.259486	0.094658	4.346184	13.18293	0.205722	1.259341	1.131712
PAPPRNT	2.501539	0.195799	3.670221	4.871462	0.313217	0.940213	2.111104
RUBPLAS	2.779793	0.17395	1.359566	16.99814	0.245255	1.101651	0.609397
OTRMAN	2.873564	0.223995	1.670568	9.401915	0.314683	1.14205	0.353026
CONSTRN	5.114707	0.060815	2.48035	34.67444	0.185609	16.52695	0.344742
WHOLESL	1.495239	0.869584	1.34287	6.694704	0.233534	14.73574	0.16132
RETAIIL	2.965607	0.734694	1.597616	0.802006	0.430965	12.07143	0.490728
HOTELCT	2.599533	0.963721	0.780911	1.120925	1.421397	2.240691	0.175709
REPAIR	1.995749	0.274169	3.668749	7.013367	0.190024	11.03654	0.393354
RAIL	1.364456	0.326562	1.66941	63.59581	0.105659	6.248985	0.226284
OTINTRAN	2.300386	0.096017	4.065527	16.9043	0.183137	3.739909	0.31356
SEATRAN	2.231765	0.632304	0.644848	50.93767	0.120045	15.25305	0.154416
AIRTRAN	1.808467	0.608339	1.655444	10.24357	0.14706	22.0586	0.07404
MISCTRA	1.256613	0.963713	1.281371	6.583588	0.150245	9.53932	0.312487
POSTCOM	0.949628	0.364271	0.962871	29.6513	0.119067	10.16237	0.085785
BUSSER	2.069054	5.390188	0.811704	1.303265	0.183322	52.6873	0.119367
PUBADM	1.830171	1.419758	0.825092	2.745707	0.367795	17.78412	0.164441
EDUCATN	28.60033	0.5968	0.370549	0.160749	5.832565	1.681652	0.230313
MEDHLT	13.53885	0.236434	1.021237	0.186965	4.064431	5.569894	0.159507
OTHSER	3.413536	1.657827	0.351385	1.060096	1.101506	5.964796	0.13269
RECSER	2.231424	1.085522	0.857617	1.708554	0.476287	18.26264	0.115473

PERSER	2.795074	0.093211	3.305687	1.190137	0.526382	0.32292	2.488106
DOMSER	0.1654	0.455795	0.165279	8.743106	0.169451	4.143085	0.075227

Appendix Table 4.

Bias calculations relative to female other: Changes over time. Substitution Elasticity =1.2

		a/h MMan/FOtr	b/h MCler/FOtr	c/h MSkd/FOtr	d/h MOtr/Fotr	e/h FMan/FOtr	f/h FCler/FOtr	g/h FSkd/FOtr
AG&HOR	1991	7.286977	0.080134	0.590388	4.15076	1.192898	0.381474	0.111382
	1981	7.106847	0.094456	0.699541	4.051917	0.83778	0.304781	0.092209
	1971	7.861371	0.124317	0.821511	5.099486	0.884987	0.28141	0.040973
FOR	1991	13.24463	0.847806	5.286195	19.09222	1.648905	2.197187	0.26139
	1981	10.54603	1.634466	10.70615	24.26363	0.893127	3.332476	0.05651
	1971	31.92487	2.326453	20.41599	33.75299	0.757868	4.110793	0.074807
FISH	1991	13.08916	0.628076	2.617629	24.85419	1.236801	1.09617	0.256315
	1981	19.34804	1.597571	7.938384	53.78651	1.306812	1.858606	0.569528
	1971	3.339512	1.696714	8.593929	40.58708	0.127643	1.274506	0.232127
COAL	1991	12.58208	3.015208	36.15766	15.80993	1.097106	2.211221	0.335107
	1981	7.818502	2.741771	37.26556	15.35755	0.464344	1.525761	0.210041
	1971	7.170273	4.271975	72.17579	12.94268	0.43954	2.06137	0.153653
COKE	1991	14.54687	4.290588	21.04999	17.67677	0.963839	1.632252	0.584184
	1981	7.104211	2.580377	19.55755	17.58755	0.485509	1.648306	0.281113
	1971	9.996232	4.600857	31.09981	34.111	0.44204	2.307804	0.072306
MINPROC	1991	38.8614	5.81407	15.01465	13.84372	4.854569	6.254646	0.444288
	1981	12.64171	3.27064	9.175028	7.590185	1.260106	2.641828	0.261621
	1971	12.77114	4.352666	10.53456	10.70821	0.645372	3.17004	0.127138
ELECGAS	1991	20.7541	6.132412	19.55208	7.569218	3.148877	8.543275	0.58282
	1981	11.42837	5.351758	15.32719	5.054137	0.701823	4.985114	0.345073
	1971	8.453517	5.914516	21.83486	9.723087	0.345148	3.922352	0.231168
WATER	1991	27.6072	4.717033	13.67314	18.42261	5.532925	7.773732	0.652941
	1981	14.97016	4.262681	12.2135	12.86117	1.174971	4.454756	0.343682
	1971	12.01208	6.583153	21.35893	20.95861	0.532373	4.090222	0.243129
METMAN	1991	8.945506	1.695412	12.71752	8.939377	1.201308	1.698659	0.346137
	1981	4.36689	1.453571	9.85232	6.710934	0.389321	1.280049	0.346858
	1971	4.934461	2.44584	14.98674	9.799962	0.290675	1.438572	0.46309
EMINNES	1991	36.61586	4.571691	22.03751	17.97388	4.920704	6.361463	0.486453
	1981	19.40047	4.849247	22.15946	15.81188	1.61369	4.60804	0.324662
	1971	10.58816	4.155542	27.31095	19.17563	0.433172	2.595777	0.153993
MANNON	1991	5.393035	0.99666	7.413293	4.049043	1.014102	1.423645	1.370021
	1981	3.358772	1.125708	6.537427	3.87979	0.383514	1.195549	1.151365
	1971	0.970234	0.445541	3.859499	2.685078	0.578024	0.290692	1.383509
CHEM	1991	5.923939	0.994519	2.515085	2.754046	1.273608	1.305539	0.344543
	1981	3.87344	1.136544	2.659927	2.806241	0.578447	1.055642	0.304475
	1971	3.715071	1.440784	2.932209	3.564373	0.426531	1.070218	0.218426
MMFIBRE	1991	7.59779	0.73565	5.398003	7.984006	0.714987	1.062996	0.355899
	1981	4.467304	1.075858	4.73509	7.191461	0.440954	0.88399	0.543521
	1971	3.31669	0.974113	4.427857	7.935847	0.419567	0.798216	0.443431
METNES	1991	4.542103	0.686566	6.726315	3.532254	0.683124	1.0772	0.304874
	1981	2.00779	0.55418	4.030974	2.312912	0.225536	0.666011	0.242866
	1971	1.735244	0.633001	4.841063	2.47948	0.110676	0.565503	0.301572
MECENG	1991	7.001493	1.507006	7.493319	3.939485	1.272956	2.07362	0.254547
	1981	5.988559	2.168831	8.921358	5.339334	0.445655	1.655794	0.256696
	1971	4.749993	2.693097	11.75549	4.931855	0.240735	1.484691	0.29413

ELELENG	1991	4.093157	0.582893	2.056585	1.357709	0.75244	0.725662	0.245919
	1981	2.715802	0.6299	2.081132	1.387853	0.265275	0.687174	0.362134
	1971	2.011046	0.859941	2.385628	1.498236	0.142646	0.582446	0.379696

Table 4 contd.

MOTVPTS	1991	5.683546	0.913509	6.389177	6.031238	0.612315	0.770074	0.224283
	1981	3.837446	1.298694	7.193516	6.365334	0.292741	0.954053	0.231774
	1971	2.870928	1.662351	9.539673	7.881229	0.125487	0.88424	0.232827
OTHTRAN	1991	15.18737	2.509525	15.89988	8.304901	1.772968	2.366235	0.429579
	1981	7.930833	2.81139	13.56684	6.610734	0.519686	1.779559	0.343846
	1971	6.678266	3.674422	18.64159	8.210297	0.28234	1.649577	0.351921
INSTENG	1991	4.516486	0.686604	2.988001	1.663429	0.943161	1.043901	0.486597
	1981	3.569305	0.818912	3.42378	1.587214	0.433839	1.068697	0.864295
	1971	2.706507	1.046541	4.143532	1.653179	0.188633	0.970159	0.830206
FOODDT	1991	2.076656	0.440252	2.41691	1.48941	0.537208	0.661027	0.522138
	1981	1.296756	0.493907	2.17925	1.46834	0.230327	0.604878	0.388011
	1971	1.165708	0.675709	2.14177	1.822031	0.160513	0.51723	0.305277
TEXT	1991	1.369411	0.207189	1.710286	1.087856	0.407835	0.414108	0.673262
	1981	0.948803	0.216173	1.561478	1.090748	0.182808	0.364914	0.739926
	1971	0.807788	0.292096	1.854999	1.498564	0.118008	0.350013	0.911338
LEATHER	1991	3.508064	0.513003	5.941055	1.660062	1.415122	1.430698	3.427083
	1981	2.026875	0.401596	4.505144	1.388584	0.338682	0.812105	2.160375
	1971	2.62103	0.65389	8.193578	2.54013	0.381746	1.017088	3.440694
FOOTCLO	1991	0.625159	0.091291	0.625399	0.345596	0.316258	0.249734	0.447059
	1981	0.437567	0.089954	0.609206	0.300897	0.143616	0.203226	0.486979
	1971	0.410868	0.127669	0.887776	0.358896	0.088613	0.221713	0.675936
TIMB	1991	5.784595	0.895439	15.20137	2.767836	1.205882	1.662933	0.93164
	1981	3.632562	0.916853	11.36199	2.711091	0.476678	1.263777	0.705186
	1971	3.592918	1.590148	16.79889	3.865204	0.293198	1.425211	1.131712
PAPPRNT	1991	8.513028	1.892695	9.988272	1.695941	3.864366	2.917843	2.116294
	1981	5.70295	2.157485	9.637238	2.106083	1.366409	2.418698	2.041739
	1971	5.444399	2.17642	11.11559	3.028588	0.6217	1.984888	2.111104
RUBPLAS	1991	4.876753	0.657364	4.360518	3.710707	0.740509	1.000828	0.581142
	1981	2.115142	0.539314	2.909715	2.289237	0.240124	0.64094	0.451254
	1971	1.839922	0.661892	3.805075	2.798742	0.16465	0.671343	0.609397
OTRMAN	1991	2.876993	0.663793	3.065195	1.540505	0.983128	1.15226	0.967375
	1981	1.451349	0.456562	1.756378	0.85511	0.26692	0.67061	0.492591
	1971	1.282642	0.446359	1.992721	1.19284	0.126872	0.403174	0.353026
CONSTRN	1991	39.36128	3.774235	86.84956	31.38648	4.676386	8.911316	0.975224
	1981	20.20942	3.039568	58.15929	19.99419	1.531432	5.328607	0.544635
	1971	28.29039	5.531185	90.95112	36.66867	1.057513	5.697538	0.344742
WHOLESL	1991	13.3367	3.624264	6.12671	2.863221	3.375886	4.153922	0.454964
	1981	6.368845	2.976734	4.343289	2.176551	0.967436	1.679231	0.31044
	1971	6.489304	4.339977	4.990865	3.716566	0.55515	2.377169	0.16132
RETAIIL	1991	5.88417	1.949514	1.745991	1.108908	3.892181	7.270267	0.470112
	1981	5.744935	2.186057	2.397468	1.08577	2.458913	6.126821	0.385007
	1971	7.12708	2.403245	3.271085	2.047479	2.552947	5.923793	0.490728
HOTELCT	1991	1.052742	0.280548	0.494782	0.496879	0.605521	0.421789	0.401945
	1981	0.609609	0.228109	0.304512	0.314359	0.348718	0.266524	0.261303
	1971	1.2272	0.472085	0.489856	0.627288	0.559617	0.393709	0.175709
REPAIR	1991	17.84046	1.930218	29.2447	6.21074	3.323642	5.491104	1.576856
	1981	7.021759	1.723297	18.68058	3.357399	1.261035	4.49737	0.774501
	1971	11.6143	5.819523	21.22602	5.78563	0.824943	4.341262	0.393354
RAIL	1991	12.21	4.87968	22.57358	9.832356	1.214518	2.642993	0.607505
	1981	6.198934	4.840506	18.77841	8.494663	0.326233	1.640379	0.31523
	1971	7.067845	5.179972	15.86215	9.50165	0.149407	1.414045	0.226284
OTINTRAN	1991	10.76466	2.49342	47.53981	5.631052	2.380105	4.309691	2.393576

	1981	4.702555	1.816797	23.21289	3.62825	0.512497	2.164597	0.83972
	1971	3.260038	1.41717	14.75954	3.630411	0.214763	1.172686	0.31356

Table 4 contd.

SEATRAN	1991	29.36494	3.683194	7.104075	9.698298	2.774188	5.413754	1.21761
	1981	26.69706	4.656169	6.90862	9.943056	0.880051	3.515601	0.626499
	1971	13.10584	5.872412	9.287328	14.40234	0.282744	2.35532	0.154416
AIRTRAN	1991	26.73482	4.503999	16.53558	6.572812	6.999551	6.763401	8.257564
	1981	14.96945	4.865523	12.62614	4.791118	2.303922	4.664889	3.473522
	1971	4.480833	2.477697	4.072889	2.4603	0.24018	1.633208	0.07404
MISCTRA	1991	8.032759	2.069865	4.855794	3.623427	3.103434	3.693088	0.514368
	1981	6.612376	2.933607	4.521806	4.610627	1.166573	3.308497	0.306954
	1971	4.575493	3.641132	3.778231	2.948584	0.447869	2.980918	0.312487
POSTCOM	1991	4.374452	1.129067	4.125974	4.336022	1.137764	1.795602	0.182134
	1981	1.564957	1.215197	3.169279	2.913249	0.303808	1.226897	0.105939
	1971	1.025147	1.079525	2.963523	3.077798	0.1038	0.871779	0.085785
BUSSER	1991	39.50837	8.269459	2.233813	2.330537	12.79674	15.77614	0.369942
	1981	17.9496	6.74022	1.685584	1.889705	2.865723	6.643522	0.251203
	1971	13.60224	6.574133	1.219648	1.502577	1.152933	6.289126	0.119367
PUBADM	1991	6.79469	3.763268	1.041222	1.80438	3.639295	4.216837	0.450476
	1981	5.405029	3.794142	1.26497	1.424344	1.43899	3.283707	0.311022
	1971	6.331558	3.459545	2.436715	2.953266	1.075594	2.924438	0.164441
EDUCATN	1991	4.160164	0.29679	0.201828	0.395335	4.59213	0.745948	0.374396
	1981	2.677146	0.171788	0.188855	0.32009	2.605754	0.429463	0.203346
	1971	2.296728	0.080304	0.134558	0.363131	2.258989	0.387306	0.230313
MEDHLT	1991	3.249061	0.148824	0.598249	0.492709	7.742499	1.566352	0.377708
	1981	1.103168	0.060216	0.323959	0.231856	1.757654	0.433309	0.137815
	1971	2.207015	0.163014	0.689468	0.67513	3.610989	0.888436	0.159507
OTHSER	1991	1.229079	0.157682	0.271625	0.548883	1.205456	0.496706	0.264521
	1981	0.976539	0.17652	0.32611	0.629303	0.727867	0.402344	0.186998
	1971	1.837784	0.538381	0.324751	0.924203	0.87181	0.791471	0.13269
RECSER	1991	5.071363	1.274452	0.943604	1.750527	2.732234	2.193612	0.318751
	1981	2.850493	1.004261	1.007007	1.666196	1.207939	1.586726	0.162207
	1971	3.56496	1.597616	1.47175	1.716091	1.004412	2.108836	0.115473
PERSER	1991	0.683696	0.732526	0.477022	0.417272	0.544583	1.305214	1.294498
	1981	0.746825	0.958434	0.899976	0.583086	0.409001	1.304771	1.885562
	1971	0.433494	0.155092	1.663884	0.50334	0.422926	0.803459	2.488106
DOMSER	1991	0.007984	0.002367	0.056219	0.123854	0.017798	0.021769	0.313975
	1981	0.008211	0.003374	0.059008	0.16043	0.020185	0.013628	0.24017
	1971	0.005753	0.034785	0.076317	0.46175	0.052813	0.311671	0.075227