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Gender Segregation in the Academic Staff of Universities in Great Britain, 1980/81–1993/94

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This paper analyses gender segregation within the academic staff of universities in Great Britain over the period 1980/81–1993/94. It finds that the level of gender segregation increased, as measured by the Karmel–Maclachlan index, *IP*. Using a decomposition procedure, it is possible to identify the composition effect, which is the contribution of a change in the gender ratio of individual academic levels to the overall change in the level of segregation. This was found to have decreased over the 12 years, indicating that each grade of appointment became less segregated. However, the decline in segregation at each level of academic employment was six times greater in US institutes of higher education. The small extent of improvement in Great Britain focuses attention on the perceived lack of effectiveness of equal employment opportunity policy and programmes within the university sector identified by both the Commission for Racial Equality and the Hansard Society.

Introduction

Women's work is rarely done by men, men's work is rarely done by women, and it is not often that men and women do the same job. The segregation of the sexes into different occupational categories (horizontal segregation) and within occupations into high-paid high-status and low-paid low-status levels (vertical segregation) is an enduring and pervasive feature of most workplaces. Segregation is seen as one of the major reasons why the earnings differential between men and women persists (see Gunderson 1989, p. 67; Bergmann 1986, p. 86). Most researchers have studied horizontal occupational segregation using aggregated occupational data because of the lack of data at the level of the organization/establishment. The focus of the explanation for the results, however, has been on the processes in the workplace at the firm level.

In 1990, the Hansard Society Commission on Women at the Top noted the segregated nature of the academic workforce in the university sector in Great Britain. The Commission commented that there was 'little empirical evidence available about the processes at work which bar women's progress ... academics have only just begun to research themselves' (Jackson 1990, p. 318). This paper attempts to redress, in part, the Commission's comment by analysing vertical gender segregation of academic staff in universities in Great Britain using data from the Universities' Statistical Records for the period 1980/81–1993/94. The Karmel and Maclachlan index, *IP*, is used to measure the level of gender segregation in a given year. Using a decomposition procedure, the contribution of changes in the sex ratio of individual job categories to the total change in the level of segregation over a given time period can be identified. This is called the *composition effect*.

A factor that influences the ability of universities to increase the proportional representation of women in academia and address the issue of segregation is the availability of suitably qualified individuals. If women and men

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continue to study in courses that reinforce and perpetuate notions of traditional or sex-appropriate areas of interests, it may be difficult for the universities to increase female shares at higher levels of academia. This paper, therefore, analyses gender segregation in student groups by subject of study over the period 1980/81–1993/94.

Using *IP* to measure gender segregation within the university sector over the range of academic classifications, we can identify not only whether the university sector has become more or less segregated, but also the contribution of a change in the gender ratio of individual academic levels to the overall change in the level of segregation. The index, then, is relevant to the consideration of equal employment opportunity policy formulation. This is because equal employment opportunity programmes are designed to redress differential treatment of targeted groups in the selection, hiring, recruitment and promotion process. In the case of female/male differences, this ultimately leads to a change in the gender ratio of individual job categories. As explained above, this can be identified and measured by the composition effect. The composition effect then can assist in the evaluation of the effectiveness of equal employment opportunity policy. It is particularly pertinent given the 1986 Commission for Racial Equality survey of equal employment opportunity policies in the higher education sector, which concluded that the sector was complacent and in many ways ignorant of the issues involved (Jackson 1990, p. 298).

The paper proceeds after outlining the data analysed (Section I) to a discussion of the employment profile of academic staff in Great Britain (Section II). The measurement of segregation and the results obtained are covered in Sections III and IV. Section V looks at the student profile in universities in the United Kingdom. Section VI compares these results to those found for segregation in US institutes of higher education. A discussion of equal employment opportunity in the university sector is presented in Section VII, followed by concluding remarks in Section VIII.

I. The Data

University statistics for the United Kingdom were collected and published by the Universities' Statistical Record (USR) from the 1980/81 academic year to the 1993/94 academic year. The university sector analysed is therefore consistent across the time period considered. The data cover the 'old' university sector only. Those institutions that gained university status in 1992 are included in the statistics provided by the Higher Education Statistics Agency from 1994/95.

The statistics available from the USR relate to full-time academic staff in universities in Great Britain, who represent 92% of all academic staff. They are analysed by grade (level) for Great Britain in aggregate and by departmental cost centre group. Comparable data for all academic staff are not available, so the paper does not analyse the position of women in terms of tenure and part-time status.

Appendix A provides details of the Universities' Statistical Record (USR) classification and grouping of academic departments into cost centres.

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II. Employment Profile of Full-Time Academic Staff in Great Britain

By June 1994, 49.3% of employees in employment in Great Britain were female. However, in the university sector females represented less than a quarter of full-time academic staff (Table 1). This reflected an improvement in workplace shares from 1980/81, when females averaged 41.8% of employees in employment and only 13.1% of academics.

Table 1

Full-Time Academic Staff by Level of Appointment: Great Britain, 1980/81–1993/94

Level	No. of persons 1993/94	Female share of employment 1993/94 (%)	Total employment growth 1980/81 1993/94 (%)	Proportion of employment growth that is female 1980/81–1993/94 (%)	Distribution of employment growth 1980/81–1993/94 All (%)	Female (%)	Male (%)
Professor	5,803	5.50	30.08	14.90	12.32	2.99	26.48
Reader/snr lecturer	10,523	11.96	15.78	46.93	13.16	10.07	17.64
Lecturer/ asst. lecturer	31,815	27.09	23.50	76.18	55.56	69.01	33.43
Others	5,772	42.76	55.75	57.99	18.96	17.93	20.13
Total	53,913	23.47	25.33	61.33	100.00	100.00	100.00

Source: Universities Statistical Record, *University Statistics*, Vol. 1, 1980/81 and 1993/94.

There are very few women in the more senior levels of academia (see Acker 1992; Aziz 1990; Webb 1988 and Whitehead 1987). In 1993/94, less than 6% of professors and 12% of readers/senior lecturers were female (Table 1). However, in the lowest level, below lecturer/assistant lecturer, more than 42% were female. The absence of women at the higher levels is more marked for teaching and research staff than for research-only staff (where the female share was approximately double that at the professorial and reader/senior lecturer levels).

In 1993/94, while less than 3% of female academics were professors and 68% were lecturers, over 13% and 56% of males were, respectively, professors and lecturers. Even though there was 30% employment growth at the professorial level over the period 1980/81–1993/94, only one in seven (approximately) of these positions went to females, while three out of four of the positions at the lecturer/assistant lecturer level went to females. The distribution of employment growth by gender reported in Table 1 indicates the disproportionate growth of female employment overwhelmingly in the lower levels (87% at lecturer or below), while the male pattern of employment growth is more evenly distributed across academic levels.

The female share of employment also varies markedly by cost centre. These shares are reported in Table 2. In education, over one-third of full-time academic staff were female, while women represented less than 10% of engineering and technology. Employment growth has also varied over the period. Some centres, such as architecture, recorded a sharp decline in employment, while others, such as medicine, experienced employment growth of over one-third.

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TABLE 2

FEMALE SHARE AND EMPLOYMENT GROWTH OF FULL-TIME ACADEMIC STAFF BY COST CENTRE, GREAT BRITAIN, 1980/81 AND 1993/94

Cost centre[a]	Female staff as a proportion of total staff 1993/94 (%)	Total employment growth 1980/81–1993/94 (%)
Education	37.01	2.68
Medicine, dentistry etc.	33.79	37.60
Engineering and technology	9.15	25.01
Agriculture, forestry, etc.	25.65	13.83
Biological, mathematical, etc.	16.46	25.04
Administrative, business, etc.	25.48	21.91
Architecture and planning	17.59	–31.16
Language, literature, etc.	33.40	–5.29
Other arts	18.88	9.12
Total	23.47	25.22

[a] See Appendix A for full title and cost centre classifications.
Source: see Table 1.

One implication of low female representation at the highest levels of academic staff is low representation on decision-making bodies of the university. A further implication is a segregated workforce by level and cost centre.

III. THE MEASUREMENT OF SEGREGATION

There has been much discussion over the years on the appropriate measure of segregation. Important contributions in this area are the papers of Taeuber and Taeuber (1976); Cortese *et al*. (1976); James and Taeuber (1985); Karmel and Maclachlan (1988); Watts (1992, 1998); Blackburn *et al*. (1993), Boisso *et al*. (1994) and Charles and Grusky (1995).

Four criteria are used, usually, to assess whether an index provides an appropriate measure of segregation: (i) organizational equivalence, (ii) size invariance, (iii) gender symmetry and (iv) the 'principle of transfers'. Organizational equivalence requires that, if two occupations with the same level of segregation are combined, or if one occupation is divided into smaller occupational groups all with the same level of segregation, then the index does not change. Size invariance requires the index to remain unchanged when there is a proportionate change in both males and females across total employment. The index is said to be gender symmetric when the value of the index is the same when defined in terms of the female or male share of employment. The strong version of the 'principle of transfers' states that the index value should decline when a female moves from a female-dominated occupation to a less female-dominated occupation and a male from the latter group moves to the former group as a replacement, with both occupational structure and gender share of total employment constant. The weak version of the 'principle of transfers' states that the index value should decline when a female moves from a female-dominated occupation to a male-dominated occupation and a male

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from the latter group moves to the former group as a replacement, with both occupational structure and gender share of total employment constant. Blackburn *et al*. (1994) and Watts (1995a) do not regard the strong version of the 'principle of transfers' as an appropriate criterion for a measure of segregation (Blackburn *et al*. 1994, p. 417; Watts 1995a, p. 4).

Studies of occupational segregation comparing the index value at different points in time will invariably find that both gender shares and occupational distribution of employment have changed. Most agree that the changes in the index measurement should be independent of both the occupational and gender shares of total employment (that is, margin-free). Therefore two further criteria need to be satisfied. These are occupations invariance and composition invariance. Occupations invariance requires the index to remain unchanged if the gender shares of the occupation are unchanged but the size of the occupation relative to others changes. To satisfy composition invariance, the index must remain unchanged when there is a proportionate change in both female and male employment of, say, $x\%$ and $y\%$ respectively *and* when in each occupation female employment changes by $x\%$ and male employment changes by $y\%$.

A margin-free measure of segregation can be achieved either by finding a margin-free index, or by a rigorous decomposition of the change in the index over time.

Although many economists have used the Index of Dissimilarity, *ID*, to measure occupational segregation, more recent work has suggested that it is unsatisfactory (Watts 1992; Blackburn *et al*. 1993; Boisso *et al*. 1994). The *ID* index represents the share of either group that must be removed, without replacement, to achieve zero segregation (Cortese *et al*. 1976, pp. 634–5). Underpinning this index calculation is a different occupational structure of employment. *ID* does not satisfy the criteria of occupations invariance. Each occupation does not contribute equal weight to the index calculation. Decomposition of *ID* does not provide a satisfactory method of overcoming the lack of occupations invariance (Watts 1992, pp. 482–3; Charles and Grusky 1995, p. 935).

In the study of segregation, it is important to be able to isolate the effect of changes in the occupational structure, changes in the overall gender shares and changing sex ratios in individual occupations on the overall change in gender segregation. It is also important to isolate the contribution of (skill-based) groups of occupations to the overall level of segregation. This is particularly so given that public policy has been directed at redressing gender imbalance in occupations.

Using *ID* to examine movements in gender segregation within groups of occupations—say, skilled blue-collar occupations in comparison to movements in segregation across all occupations—is, in general, unsatisfactory for the following reason. A decrease in segregation for an occupational group may not be synonymous with lower segregation across all employment. The skilled blue-collar groups' female share of employment may fall to below 10%, but the female share of total employment may have increased. So *ID* for the skilled blue collar group of occupations falls, but indicates merely that there was less dispersion of female shares within this occupational group. Further, *ID* calculated over all occupations could have increased or decreased (Watts 1995a).

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Silber (1989), Hutchens (1991) and Boisso *et al*. (1994) have advocated using the Gini index to measure occupational segregation. However, the Gini index, although commonly used to measure income inequality, has been used very infrequently in the study of segregation. When the Gini index is used to measure gender segregation, changes in the occupational structure of employment affect the index computation. The Gini index is not occupations-invariant, although it does meet all other criteria. A standardization procedure is used for the decomposition of the change in the index to remove this effect (Boisso *et al*. 1994). However, the decomposition procedure does not identify a pure composition effect, as the gender shares of total employment associated with the two indexes of the decomposition are not equal (Watts 1995a, p. 14). Further, the Gini coefficient 'implicitly gives greater importance to more gendered occupations' (Blackburn *et al*. 1994, p. 416).

Silber has decomposed the Gini index into two components, *IW* and *IB* (Silber 1989, pp. 109–10), to measure the contribution of different income groups to the overall inequality of income. *IW* denotes the intra-group (income class) measure of inequality and *IB* the between-group measure. These income groups are non-overlapping, by definition. This is not analogous to occupational groups in measuring gender segregation. The gender ratios of each individual occupation comprising the occupational group do not lie within a prescribed range. The individual occupations comprising the occupational group are defined by skill requirements, not gender ratios. It is not possible to establish the contribution of occupational groups to the overall level and rate of change of segregation. The extent of segregation within occupational groups needs to be assessed with respect to the gender ratios of total employment. The intra-group Gini is not, however, measured with respect to an external gender share (Watts 1995a, p. 19).

A new index, *IP*, has been developed by Karmel and Maclachlan (1988) and is defined as follows:

$$(1) \qquad IP = \left(\frac{1}{T}\right) \sum |M_i - a(M_i + F_i)|$$

$$= \left(\frac{1}{T}\right) \sum |(1-a)M_i - aF_i|$$

where T, a, M_i and F_i are, respectively, total employment, the male share of total employment, and the numbers of males and females in occupation i.

This index denotes the proportion of employed people who would have to change jobs (with replacement) to achieve a sex ratio for each occupation equal to the male/female ratio for total employment. The occupational structure of employment of the workforce and the overall sexual shares of employment are kept constant. Thus, for a particular year, under zero segregation, the number of (fe)male employees in an occupation would be equal to the overall (fe)male share of employment multiplied by the number of employees in the occupation. The absolute difference between the number of (fe)males required for zero segregation and the actual number of (fe)males, in the occupation, represents the number of (fe)males who must relocate to other occupations from this (fe)male-dominated occupation to achieve zero segregation. These absolute differences comprise the calculation of the index.

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Take, as an example, an individual occupation that has a female/male share of employment that is 90/10 while the overall sexual shares of employment are 40/60. Then, to achieve a 40/60 gender ratio, x number of females must be removed and must be replaced by the same number (x) of males. Then the number of females (or males) in each occupation who must be moved are added, and this represents the total number of persons who must relocate for this individual occupation to achieve zero segregation.

Karmel and Maclachlan (1988, pp. 190–1) show how a change in their index over time can be decomposed into its constituent composition and mix effects where the latter can be broken up into occupation, gender and interaction effects. Appendix B provides details of the calculations involved in the decomposition procedure.

The composition effect picks up the change in the sexual composition of occupations, after excluding the impact of the change in the occupational structure and the associated change in the levels of male and female employment. This is an appropriate measure of the rate of occupational integration of the sexes (see also Watts 1992).

The occupation effect picks up the impact of the change in the occupational structure over time. This effect is based on the comparison of the first-period index with the magnitude of the index after changing the shares of total employment associated with each occupation in line with their actual changes from period 1 to period 2, while maintaining the first period's gender shares of each occupation. Hence, total employment corresponding to the second period is achieved, but not the overall gender shares.

The gender effect, however, is based on the comparison of the first-period index with one based on female and male employment in each occupation being increased at the same rate as the overall increases in female and male employment between the first and second periods. Hence, the overall gender shares correspond with those of the second period. Changes in the occupational structure of employment and the growth rates of female and male employment are interrelated, so that there is a gender/occupation (interaction) effect, too.

The total percentage change in the index can thus be subdivided into composition and mix effects, where the latter, in turn, can be subdivided into gender, occupation and interaction effects.

IP meets the criteria of organizational equivalence, size invariance, gender-symmetry and the weak principle of transfers. The composition effect is both composition-invariant and occupations-invariant; that is, it is margin-free.

Further, the *IP* calculation can be modified so that the contribution of the occupational groups to the overall segregation index can be examined. In this study the modified index represents the contribution of the cost centre groups to segregation in the university sector as a whole. The modified index is then

$$(2) \qquad IP = \sum_J \left(\frac{T_J}{T}\right) \sum_{j \in J} \left(\frac{|(1-a)M_j - aF_j|}{T_J}\right)$$

$$= \sum_J \left(\frac{T_J}{T}\right) IP_J$$

$$= \sum_J IP_J^*$$

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where IP_J denotes the fraction of those workers employed in occupational group J who must relocate to achieve zero segregation across these corresponding occupations, with respect to the overall sexual shares of the occupational group; T_J is total employment in occupational group J; and IP_J^* denotes the fraction of total employment that is employed in occupational group J and must relocate. The calculations of the total change and the mix effect and its components by occupational group are sensitive as to whether IP_J^* or the index value normalized by the employment share of the occupational group (IP_J) is used.

Although not of direct relevance to this paper, Silber (1992) and Watts (1995b, 1997) show that the Karmel–Maclachlan index can also be extended to the analysis of segregation in the multidimensional case, for example to race and gender.

A reduction of female/male differences in the selection, hiring, recruitment and promotion process ultimately leads to a change in the sex ratio of individual occupations. Using *IP* to measure gender segregation within an organization over a wide range of occupational classifications, we can identify three aspects of segregation: (i) whether the organization has become more or less segregated; (ii) the contribution of groups of individual occupation classifications to the level of segregation; and (iii) the contribution of a change in the sex ratio of individual occupational classifications to the overall change in the level of segregation.

IV. The Results

Segregation by cost centre

The index was calculated for full-time academic staff in Great Britain for each of the nine cost centres and for the university sector in aggregate across the four levels of appointment. A comparison of *IP* with other measures such as *ID* is not reported, as these other measures are not regarded as totally satisfactory, nor are the appropriate decomposition procedures possible with them (see Watts 1992; Charles and Grusky 1995). The results for the *IP* index and the composition, gender and occupation effects are reported in Table 3. The

Table 3

IP, Composition, Gender and Occupation Effects by Cost Centre and Aggregate University Sector, 1980/81 and 1993/94

	IP		Composition effect	Gender effect	Occupation effect	Gender/ occupation effect
Cost centre	1980/81	1993/94	(%)	(%)	(%)	(%)
Education	0.0638	0.0975	–9.66	37.33	3.86	10.34
Medicine	0.0985	0.1081	–9.53	28.27	–10.98	1.54
Engineering	0.0165	0.0393	–8.94	95.42	0.71	–5.48
Agriculture	0.0812	0.0968	–17.51	45.58	–11.53	1.04
Biological	0.0395	0.0711	7.44	50.73	–4.38	3.26
Administrative	0.0581	0.0975	–2.10	32.27	13.24	7.13
Architecture	0.0579	0.0670	–22.84	18.46	11.44	7.50
Language	0.0730	0.1167	4.49	26.71	12.04	2.74
Other arts	0.0449	0.0816	16.72	31.23	5.29	4.84
Total	0.0548	0.0837	–2.73	30.98	1.58	2.96

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male share, a, for these calculations has been set equal to the male share in the academic staff of the relevant cost centre. In aggregate, the male share is set equal to that for the academic staff of the university sector.

From Table 3 we can see that the university sector in Great Britain has become more segregated over the 14 years. Overall, by 1993/94, 8.4% of staff would have had to change levels to equate the share of the sexes at each level to their employment share in the academic workforce as a whole, compared with 5.5% in 1980/81. The level of segregation increased for all nine cost centres.

For the aggregate university sector, the decomposition procedure calculated a total change in segregation of 41.79%. This consisted of a mix effect of 44.52% (gender, occupation and gender/ocupation effects) and a composition effect of –2.73%. Thus, the composition effect, recording the contribution of a change in the sex ratio at each academic level to the total change in the level of segregation, indicates that *each grade of appointment* became less segregated for the university sector. The interpretation of the composition effect is that just under 3% fewer people had to change grades in 1993/94, compared with 1980/81, to equalize the distribution of females and males across the appointment levels.

The composition effect was negative for six of the cost centres and varied from –22.84% for architecture and other professional and vocational groups (owing to a loss of over one-third of the male academic staff compared with a loss of 13% of females) to a modest –2.1% for administrative, business and social studies. Three cost centres—language, literature and area studies; biological and physical sciences; and other arts—recorded positive composition effects. In the case of the language cost centre, individual levels became more segregated because male employment fell even though total and female employment increased. In the biological and other arts cost centres, employment grew for both males and females.

Overall, the increase in the level of segregation is due largely to the increase in the number of females in the university sector (the gender effect) with a small effect from the change in the distribution of employment across the appointment levels (the occupation effect). This increase was moderated by the decline in segregation at each grade of appointment.

A modified *IP* was calculated for 1993/94, to assess the contribution of each cost centre to the total level of segregation in universities. The male share for these calculations is the male share for the university sector in aggregate. This is applied to the total employment levels in each centre. As one cost centre group—libraries, museums, etc.—is omitted from the data (because it is not available for 1980/81), the results do not sum exactly to the university total. Table 4 reports the results for the modified *IP* (IP_J).

The contribution of each cost centre to the total level of segregation can be ranked by 'normalizing' the level of segregation calculated for each centre by the centre's share of total employment. Approximately three-quarters of the level of segregation in 1993/94 was attributable to three cost centres (in descending order of contribution: medicine, engineering and biological.

Further calculations of the level of segregation

When applying an index of measurement to vertical job categories within an organization, it is not immediately obvious what the benchmark for the male

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TABLE 4
MODIFIED *IP*, BY COST CENTRE, GREAT BRITAIN, 1993/94

Cost centre	Modified *IP* 1993/94	Share of total employment (%)
Education	0.1354	3.83
Medicine	0.1032	24.25
Engineering	0.1432	13.38
Agriculture	0.0218	2.23
Biological	0.0701	26.58
Administrative	0.0201	16.65
Architecture	0.0588	0.94
Language	0.0993	6.72
Other arts	0.0459	5.24

share should be. For example, should the sex ratio in job categories be equal to the workforce share in the organization, or to the share of employment in the total workforce? More specifically, in the case of universities, should the male share be equal to that in the departmental cost centre, the university sector as a whole, or the employed workforce in Great Britain?

The rationale for setting *a* in each cost centre equal to the male share in the cost centre is that the current pool of applicants (or labour supply) will differ according to the discipline/department. Recent statistics on university graduates show an increase in female numbers and female shares across a variety of subjects of study. This will be discussed in more detail in Section VI below. However, the effect of past choices would mean that some fields such as engineering, may not have a large pool of female applicants; therefore, even over a period of five to ten years, it would not be possible for the engineering and technology area to achieve workforce shares equal to, for example, education or social studies. However, we are interested in the possibility of change. It may be that some improvement in the cost centre is expected so as to achieve workforce shares approaching the gender shares in the total university sector. It may be that in the long run the university sector may seek (or need) to approach the gender shares of employment in the workforce of Great Britain.

Table 5 reports the results of two calculations—the constructed *IP* minus *IP* and the adjusted *IP* minus *IP*—both expressed as percentages. The former indicates the extra proportion of the cost centres' workforce that needs to change positions so that the sex ratio at each position is the same as the sex ratio of the total university sector. The latter indicates the extra proportion that needs to shift to achieve proportions at each level equal to those in employment in Great Britain. These two calculations suggest the 'depth' of segregation in the universities. The measurements indicate that engineering areas, to a greater extent, and education, medicine, language and biological areas, to a lesser extent, have low female representation in their cost centres and would need to achieve a significant increase in female numbers to approach anywhere near the female proportion in the university sector.

In comparison, by 1993/94 for all centres except education, even greater levels of change would be needed to achieve economy-workforce proportions.

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TABLE 5

THE EXTRA PROPORTION OF THE COST CENTRE WORKFORCE THAT WOULD HAVE TO CHANGE APPOINTMENT LEVELS TO ACHIEVE A FEMALE SHARE EQUAL TO THAT IN THE DESIGNATED TARGET WORKFORCE, GREAT BRITAIN, 1980/81 AND 1993/94

	Constructed IP minus IP		Adjusted IP minus IP	
Cost centre	1980/81 (%)	1993/94 (%)	1980/81 (%)	1993/94 (%)
Education	2.74	5.90	16.20	2.53
Medicine	2.07	4.33	11.49	6.89
Engineering	9.10	10.39	36.96	36.21
Agriculture	0.10	1.09	19.44	14.54
Biological	3.49	2.35	28.86	25.72
Administrative	1.01	0.60	20.43	14.06
Architecture	0.05	0.89	21.96	25.00
Language	2.86	3.17	14.28	7.23
Other arts	–0.33	–0.75	24.56	22.25
Total	0.00	0.00	22.37	17.43

V. STUDENTS IN THE UNIVERSITIES OF THE UNITED KINGDOM 1980/81–1993/94

Female shares in subjects of study

One aspect of the focus on equality of opportunity in education over the last decade has been the issue of whether there exists any differential treatment of female and male students in the school system. In particular, are there significant differences in subject choice, classroom 'treatment' and opportunity for, and access to, higher education? The absence of choice or reduced choice for girls in particular subjects such as mathematics, as well as a lack of encouragement to make such choices, has been identified as an impediment to their choosing to take up further post-school study in areas seen as traditionally male. One target since the 1980s has been to increase female representation in non-traditional areas such as engineering.

As mentioned earlier, whether much has been achieved is of particular relevance for the current and potential labour supply to the academic workforce. The pool of potential recruits to academia increases with a rise in the number of graduates, particularly at the higher degree level. Some caution should be expressed here as to whether this will have a marked impact on academic employment. Research in the mid-1970s by Blackstone and Fulton showed that the ratio of female staff to total staff fell as the proportion of graduate students that were female rose (Blackstone and Fulton 1974). Given the recent changes in universities in particular affecting academic job requirements, it may be that young people have been/will be deterred from seeking employment and starting careers in this area. Of course, whether this has/had affected women more than men is a point that requires investigation.

To assess any change in segregation that has occurred among students, it is necessary to examine gender shares of enrolments and graduates by subject

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of study. Female shares of new entrants at both the undergraduate and postgraduate level have increased over the 14 years to 1993/94. The Universities Statistical Record for 1980/81 and 1993/94 show that females now represent 47% of undergraduates and 42% of postgraduate new entrants (table available from the author). They have also increased their share of first degrees up to 46%, and higher degrees up to 38%, by 1993/94.

Over 50% of the growth in the new entrants has been female. In addition, nearly 70% of the growth in first degree graduates from the university sector and close to 50% of the increase in higher degree graduates was female. (Of course, students do not have unrestrained choice as to subject of study, their choices being limited by the availability of places.)

Statistics on students by subject of study are reported for 1985/86–1993/94. Before 1985/86 a different classification of subjects of study existed. Table 6 reports female shares for graduate students. The shares of women graduating with first degrees has fallen for mathematical science, architecture, librarianship and information science, and language and related studies. In some cases, such as librarianship and information science, this represents a decrease in the dominance of women in a field of study. For others, including mathematical sciences, it represents a fall on already low proportions. The increase in some subjects, such as education, also means that female over-representation has risen. In all subjects of study, the share of women taking higher degrees has risen. However men still represent over 50% in 12 of the 16 subject areas.

TABLE 6

FEMALE SHARES OF GRADUATES BY SUBJECT OF STUDY, FIRST AND HIGHER DEGREES, 1985/86 AND 1993/94 (%)

Subject of study	First degree		Higher degree	
	1985/86	1993/94	1985/86	1993/94
Medicine and dentistry	41.7	47.2	35.8	47.1
Studies allied to medicine	66.6	72.7	43.9	59.3
Biological sciences	54.6	59.5	36.7	47.3
Veterinary science, agri. etc.	42.4	32.5	25.2	36.3
Physical sciences	24.6	52.5	15.7	24.7
Mathematical sciences	28.3	26.0	20.9	24.4
Engineering technology	8.2	13.9	8.2	13.4
Architecture and related studies	24.0	23.1	23.5	31.5
Social sciences	46.2	48.4	37.5	44.8
Business and financial studies	38.0	43.7	22.5	29.9
Librarianship and info science	80.5	64.6	61.3	62.9
Language and related studies	70.7	69.9	47.0	60.0
Humanities	47.6	49.7	33.4	40.9
Creative arts	57.0	62.3	39.2	44.4
Education	74.0	77.6	41.8	56.2
Multi-disciplinary studies	47.1	50.8	33.7	45.4
Total	42.0	46.1	29.3	37.7

Source: Universities Statistical Record, *University Statistics*, Vol. 2, 1985/86 and 1993/94.

There has also been an increase in the female share of new entrants over the period in all subjects except librarianship and information science (*Universities Statistical Record*, Vol. 1, 1985/86, 1993/94), so it is reasonable to expect this pattern of change in the gender share of graduates to continue.

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The increased representation of women graduates at both first and higher degree levels is particularly encouraging for reduced gender segregation of the labour market as a whole and the university sector in particular.

Segregation in subjects of study

The *IP* index can be applied to the statistics for subjects of study to identify the composition effect. This can control for gender effects from the increase of females relative to males and from changes in the distribution of course completions that may have occurred over the time period. Two measures are calculated, owing to the break in the series caused by the reclassification of subjects of study in 1985/86. These two series are 1980/81–1984/85 and 1985/86 to 1993/94).

The index is calculated for first degree graduates, higher degree graduates and full-time new entrants so as to identify any tendency for females to crowd into areas in which they are already over-represented. The change in Ph.D. graduates is of particular interest for academic employment, but this could not be investigated as data on graduates by types of higher degree are not available. The decomposition procedure of the Karmel–Maclachlan index, when applied to student course completions/enrolments, is interpreted as follows. The composition effect represents the impact of changes in the gender ratio of graduates/enrolments by individual subjects of study. The gender effect represents the effect of changes in the female share of all graduates/enrolments. The occupation effect represents the effect of changes in the distribution of graduates/enrolments across subjects of study. The results for *IP* and these three effects in the decomposition of the change in *IP* over the two time periods are reported in Table 7.

TABLE 7

IP, COMPOSITION, GENDER AND OCCUPATION EFFECTS FOR GRADUATES (FIRST AND HIGHER DEGREES) AND NEW ENTRANTS (FULL-TIME), UNITED KINGDOM, 1980/81–1984/85 AND 1985/86–1993/94

Student group	*IP*		Composition effect (%)	Gender effect (%)	Occupation effect (%)
	1980/81	1984/85			
1980/81–1984/85					
Graduates					
First degree	0.1286	0.1300	–2.97	2.90	–0.40
Higher degree	0.0870	0.0840	–7.76	9.45	–5.39
	1985/86	1993/94			
1985/86–1993/94					
Graduates					
First degree	0.1438	0.1345	–8.94	1.97	–1.10
Higher degree	0.1167	0.1261	–7.76	9.45	–5.39
New entrants					
Full-time	0.1406	0.1393	–2.42	2.19	–2.52

The increased female share of graduates overall in first degree holders and in all subjects of study for higher degrees is complemented by a reduction in gender dominance across subjects. The composition effect is negative for all

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graduates, particularly for graduates over the period 1985/86–1993/94. This indicates that among students completing degrees there is less segregation across subjects, which may reflect a combination of changes in decisions by both females and males. Females are either choosing to enter courses in which they have been under-represented and/or are choosing to study less often in areas where they have been over-represented. On the other hand, males could be deciding to study in previously female-dominated subject areas and/or are deciding to study less in previously male-dominated subject areas.

The results for new entrants over the period 1985/86–1993/94 suggest that the trend of reduced segregation in degree completion should continue in the near future. The negative composition effect of –2.42% for new entrants indicates that there is less tendency for males and females to choose subjects in which they are currently over-represented.

VI. Comparison with US Institutions of Higher Education

Segregation in academic employment

Comparable data are available from the United States on full-time instructional (teaching and research) staff by academic rank, over the period Autumn 1981 to Autumn 1993. There are more women in full-time academic employment in the United States (33.4%) than in Great Britain (23.5%). Table 8 shows a similar pattern of fewer women in the more senior levels of academia, although their representation at these levels is higher than in Great Britain. Academic employment in the United States grew by 21% over the period 1981–93. Nearly two-thirds of this growth was in female employment. The overwhelming majority of employment growth at the assistant and associate professorial level was female. However, at the professorial level, females accounted for only 35% of the employment growth.

The results for the measurement of segregation across US academic levels, using *IP* are reported in Table 9. These results indicate that over the period the level of segregation declined in US academic employment from 0.1114 to 0.1098. This small decline masks large changes which the decomposition picks up. The growth of female employment caused segregation to rise by 12.81%. The changing distribution of employment across academic levels had minimal impact (0.22%). However, there was a decline in segregation at each academic level. In 1993 compared with 1981, nearly 18% fewer people would have had to change academic level to equalize the sex ratios at each level to the overall sex ratio of academic employment. This composition effect for the United States is six times larger than that found for Great Britain over the same time period. So, in contrast to Great Britain, the decline in segregation at each level of academic employment has been much greater in the United States.

Ransom (1990) used the Gini index to measure segregation in US academia over the period 1969–84. A modest decline in the level of segregation from 1969 to 1977 was driven by decreasing segregation in male areas of employment. Ransom found that there was little change from 1977 to 1984 owing to the growth in female fields of employment.

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TABLE 8

FULL-TIME INSTRUCTIONAL STAFF BY ACADEMIC RANK AND EMPLOYMENT GROWTH: UNITED STATES, AUTUMN 1981, 1993

Level	Total no. of people 1993	Female share of employment 1993 (%)	Total employment growth 1981–93 (%)	The proportion of employment growth that is female 1981–93 (%)	Distribution of employment growth 1981–93		
					All (%)	Female (%)	Male (%)
Professor	157,253	17.0	36.5	35.3	44.7	24.1	83.7
Associate professor	120,696	30.0	14.3	93.9	16.1	23.0	2.8
Assistant professor	129,159	42.1	16.4	94.4	19.3	27.9	3.1
Instructor	67,700	49.3	–16.7	–10.4	–14.4	–2.3	–37.3
Lecturer	13,714	51.2	64.1	63.7	5.7	5.5	6.0
Others	57,164	43.2	89.2	49.8	28.6	21.8	41.7
Total	545,706	33.4	20.9	65.5	100.0	100.0	100.0

Source: US Department of Education, *Digest of Education Statistics* 1996.

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TABLE 9

IP, COMPOSITION, GENDER AND OCCUPATION EFFECTS, FOR FULL-TIME ACADEMIC STAFF, AGGREGATE HIGHER EDUCATION SECTOR, UNITED STATES, 1981–93

Aggregate institutes of higher education	*IP*		Composition effect (%)	Gender effect (%)	Occupation effect (%)	Gender/ occupation effect (%)
	1981	1993				
Total	0.1114	0.1098	–17.86	12.81	0.22	3.39

Students in US institutes of higher education

The female share of degree recipients has increased over the period 1981–94 for Bachelor's (49.8% to 54.5%), Master's (50.3% to 54.5%) and Ph.D.s (31.1% to 38.5%). Table 10 reports the level and decomposition of the change of segregation for US students by field of study and degree conferred, over the period 1981–94.

The level of segregation increased for doctoral degrees. However, the decomposition of the total change in segregation for Ph.D.s finds that 7% fewer students had to change field of study in 1994 to equalize the distribution of the sexes across the 23 fields of study. This is approximately the same magnitude that was found in the United Kingdom over the same period for graduates completing higher degrees. The occupation effect indicates that a greater number of Ph.D. students were studying in the more segregated fields of study. The increasing *level* of segregation was due to the growth in the number of females completing their Ph.D.s. In comparison, the decline in the level of segregation recorded for Bachelors' and Masters degrees was due to stronger declines in segregation in the individual fields of study.

Ransom (1990) and Jacobs (1995) also found that gender segregation increased for Ph.D. recipients. This increasing segregation for Ph.D. recipients was due to the greater growth in more gender segregated fields of study. Further, gender segregation among Bachelor's and Master's degree recipients fell dramatically from 1980 to 1985 (Jacobs 1995). Only small declines were recorded from 1985 to 1990. The fall in segregation for Bachelor's graduates was due to the growth of gender-integrated fields of study. The growth in gender-segregated fields of study slowed the decline in segregation for Master's graduates. These findings are consistent with those reported in Table 10.

TABLE 10

IP, COMPOSITION, GENDER AND OCCUPATION EFFECTS FOR DEGREE CONFERRED, UNITED STATES, 1980/81–1993/94

Degree conferred	*IP*		Composition effect (%)	Gender effect (%)	Occupation effect (%)
	1980/81	1993/94			
Bachelor	0.1731	0.1394	–13.20	–0.88	–7.19
Masters	0.2067	0.1958	–10.04	–0.81	4.72
Ph.D.	0.1424	0.1671	–7.20	9.99	4.29

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VII. Equal Employment Opportunity in the University Sector

Differential treatment of women and men in academia may be due to different levels of productivity (for example qualifications and experience). This analysis has not attempted to establish the main reason for, or the contribution of discrimination to, the persistence of segregation. However, the continuing low proportions of women at the top levels, the slow pace of change and the variation of change across cost centres that have been found raise the issue of equal employment opportunities in the university sector.

The Commission for Racial Equality reviewed equal opportunity policies in higher education in 1986 by conducting a survey of universities and the (then) polytechnics (Williams *et al*. 1989). The review found that, 'Out of the 42 universities which replied to the survey, 20 cited their charter as sufficient evidence of commitment to equal opportunities; six universities and four polytechnics stated the existence of an equal opportunities policy but no evidence was provided, while three universities and two polytechnics had no policy and regarded the question as irrelevant' (Jackson 1990, p. 298). The claim made by some of the institutes that the issue of equal employment opportunity was irrelevant is indicated by two replies, the first of which stated that: 'The only criteria for entry is [sic] academic merit irrespective of colour, creed, sex and physical fitness. It has not been thought necessary to have any kind of policy which further interprets or modifies this objective.' The second claim was that 'Equality of opportunity is inherent in the concept of a university' (Heward and Taylor 1992, p. 113).

The report concluded that 'What is evident from our survey is the lack of understanding and progress to date. A tone of moral superiority and complacency plus ignorance of the issues and available evidence was pervasive. Individual merit was seen as a natural and non-negotiable attribute, and discrimination or bias as unacceptable but most unlikely to occur' (Jackson 1990, p. 298). Summarizing their findings on equal employment opportunity they commented: 'The majority of institutions of higher education have barely begun to consider the issues seriously' (Acker 1992, p. 59).

The universities were also subject to condemnation by the Hansard Society Commission on Women at the Top (Hansard Society 1990). This report noted that there was 'little empirical evidence available about the processes at work which bar women's progress . . . academics have only just begun to research themselves' (Jackson 1990, p. 318). Jackson (1990), commenting on the report, felt that the university sector as a whole was unperturbed by the position of women and indifferent to changing it.

In 1991 the Committee of Vice Chancellors and Principals of the Universities of the United Kingdom (CVCP) issued a document, 'Guidance for Good Practice for Equal Opportunities in Employment in Universities'. This complies with recommendations from both the Equal Opportunities Commission and the Commission for Racial Equality that employers develop appropriate equal opportunities in their own sectors on an entirely voluntary basis. The CVCP's suggested framework for implementing equal employment opportunities policy includes the establishment of an Equal Opportunities Committee (EOC), fully funded, with adequate staff, centrally located within the university's administration and regularly reporting to the highest authority in the university that is in a position to act on policy.

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The CVCP Guidance, importantly, suggests that the universities should consider adopting even more active steps, such as setting targets, in their implementation of equal employment opportunity policy. The Hansard *Report* also recommended the introduction of voluntary targets (Hansard Society 1990, p. 67). However, some of the recommendations of the CVCP have not been warmly embraced by all participants in the university sector (Acker 1992). It should be noted also that equal employment policy in the United Kingdom is not complemented by any affirmative action legislation, as is the case in the United States and Australia.

Heward and Taylor (1992) compared equal employment opportunity programmes operating in the universities and polytechnics and found little evidence of successful implementation or progress in equal opportunity policies in British higher education. The policies had not progressed much beyond identifying imbalances through monitoring and assessing recruitment and promotion. They concluded that 'managements believe the criterion of academic merit is a guarantee against discrimination and are resistant to the idea of effective equal opportunities policies' (Heward and Taylor 1992, p. 111).

Some further insights on equal employment opportunity programmes in the universities in Great Britain can be gained by comparing them with those operating in universities in the United States (where segregation was found to have declined to a much greater extent).

Webb (1988) provides case studies of the implementation of equal opportunity programmes in North American and British universities. She found also that, even when the North American university was committed to implementing affirmative action (beyond the letter of the law) and had a programme that was well funded and run efficiently, only slow change was achieved in increasing numbers of women (and ethnic minorities) in higher levels. She found also that continued monitoring by an Equal Opportunity officer was necessary to ensure that hard-won changes were not dissipated in the future. The British attempt at equal opportunity was deemed unsuccessful and succeeded only in raising awareness of the issues involved in achieving equality.

The North Americans concentrated on the need to standardize employment practices as well as the statistical monitoring of employment processes. This was complemented by a legally required programme with numerical goals, centrally located within and financed by the university. The British model, based in a technological university, only partly emphasized the need for a more accountable and standardized approach to employment practices. Greater emphasis was placed on the discussion and breaking down of the stratified nature of employment in academia, such as the division between full-time continuous and part-time discontinuous work and the lack of women in high-ranking positions. This was complemented by an equal opportunity programme that had limited funding, was not located centrally within, or openly encouraged by the university, and sought to achieve qualitative guidelines as appropriate equal opportunity targets.

A comparison with Australian institutes of higher education is also pertinent. First, a study of segregation in Australian HE institutes for the period 1989–94 found a decline in segregation for full-time staff at each level of academic appointment (composition effect of –16.5%) comparable to that of the

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United States (Rich 1997). Second, there are similarities between the two sectors over the last decade, such as amalgamations and mergers, funding cuts and quality assessment and review (as well as social similarities between the two countries). The underdeveloped state of equal opportunity policy in Great Britain's universities contrasts sharply with those in Australia (and the United States). In 1986, Australian universities were required to implement affirmative action programmes. These programmes are monitored and evaluated by the Affirmative Action Agency.

Studies of academia in Australian institutes of higher education have found a complexity of management interests. 'Universities are, in the main, well established structures which do not readily adapt to change' (Glass and McInnes 1989, p. 40). Studies of the implementation of affirmative action in universities has shown some diversity, but most are conservative in their approach. They tend more to follow the model outlined in the case study by Webb (1988) of the North American university, and are by no means without their critics.

The lack of women in senior ranks does not on the face of it seem to be a sex-based difference in academic merit. However, concern has been expressed that, in the university sector, certain procedures in recruitment and promotion that may appear neutral (based on merit) actually act to maintain differential treatment of females and to limit severely the opportunity of women to reach higher levels. A survey of recruitment and promotion by the Association of University Teachers in the UK found that promotion prospects varied across cost centres. They reported that for 1984 in science only 3.5% of promotions at the lecturer level were female, even though female representation at this level was 12.5% (Aziz 1990). Aziz found that by 1986 little had changed: women had achieved 10% of a total of 536 promotions in academic employment from lecturer to senior lecturer/reader level. Female promotions as a proportion of total promotions in all cost centres were far less than their proportions in academic employment, except for the cost centre that included nursing (Aziz 1990, pp. 36–7).

Recently, Kennedy (1995) raised again the issue of objective measurement of merit. 'This fiction that the tests of excellence are neutral and that merit is an objective assessment are perpetually fostered' (Kennedy 1995, p. 15). Certainly, the strongest argument made against equal employment opportunity and affirmative action programmes is that less qualified individuals will get jobs; that is, the programmes will violate the principle of merit in job hiring. The proper appraisal of the hiring process requires more quantitative analysis to investigate the reasons for lower female representation at the higher levels of academia. If it is due in part to some systematic bias in hiring processes, then it is pertinent to consider the Carnegie Council comment: 'in broadening their recruitment nets and more effectively documenting their selection and promotion decisions . . . Universities are likely to raise the overall quality of their appointments, on the reasonable assumption that highly qualified persons have been overlooked under past exclusive and more confidential procedures' (Carnegie Council 1975, p. 96).

Old biases and traditional values can pervade any new structures in jobs and wages that are implemented. Publicly available reports from the EOC could identify any imbalances by analysing and monitoring recruitment and

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promotion within the university, on the basis of statistics collected by the university on job applicants, job appointees and promotions. Analysis conducted by Rosenbaum (1985) (also see Webb 1992, p. 110) indicates that continual monitoring and evaluation of equal employment opportunity programmes (sustained by adequate data on staff) creates more positive outcomes.

It should be recognized that requirements for achieving equal employment goals will differ across individual institutes. There is a need to allow flexibility in equal employment programmes while creating incentives to meet the objectives set by the CVCP.

VIII. Concluding Remarks

The paper finds an increasing level of segregation in academic employment in Great Britain as measured by the *IP* index and a low rate of change in improving the ratio of females to males in higher levels of academia (the composition effect). While there has been some growth in the sector over the period analysed, there has been no marked change in the distribution of females across the grades of appointment. Further, a much greater decline in segregation at each academic level was found in US academia. However, looking at students, there has been a distinct improvement since 1980 in female shares, both in new enrolments and in graduates at both the undergraduate and postgraduate level. There is less segregation within subjects of study for both students newly enrolled and those completing degrees (as measured by the composition effect).

The studies of equal employment opportunity programmes in the university sector in Britain indicate they have not been very successful and that attitudes seem sometimes not entirely sympathetic to moves for change.

Given all the financial and other changes in the university sector in Great Britain over the last decade, it is hard to see where the funding and the initiative will come from to bring about the change necessary to make a significant improvement to the position of women in universities.

APPENDIX A: COST CENTRE CLASSIFICATION

The Universities Statistical Record (USR) groups academic departments into cost centres which reflect similarities in academic and resource requirements.

Appendix 11C of *University Statistics 1993–94*, Vol. 1, *Students and Staff*, sets out the following classification.

01 Clinical medicine
02 Clinical dentistry
03 Pre-clinical studies (where organized as such and not taught in departments separately organized and recorded under anatomy, biochemistry, etc.)
04 Anatomy and physiology
05 Pharmacology
06 Pharmacy
07 Nursing
08 Other studies allied to medicine
09 Biochemistry
10 Psychology
11 Other biological sciences
12 Agriculture and forestry
13 Veterinary science
14 Chemistry

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15 Physics
16 Other physical sciences
17 Mathematics
18 Computing
19 General engineering (if not more explicitly specified below)
20 Chemical engineering
21 Civil engineering
22 Electrical and electronic engineering
23 Mechanical, aero and production engineering
24 Mineral engineering
25 Metallurgy and materials
26 Architecture
27 Other technologies
28 Planning
29 Geography
30 Law
31 Other social studies
32 Business and management studies
33 Accountancy
34 Language-based studies
35 Humanities
36 Creative arts
37 Education
45 Adult education

Cost centre groups

Education	37, 45
Medicine, dentistry and health	01–08
Engineering and technology	19–25, 27
Agriculture, forestry and veterinary science	12, 13
Biological, mathematical and physical sciences	09, 11, 14–18
Administrative, business and social studies	10, 29–33
Architecture and planning	26, 28
Language, literature and area studies	34
Other arts	35, 36

APPENDIX B: THE DECOMPOSITION PROCEDURE

Three interrelated indices can be identified.

The index IP_A is obtained by proportionately increasing the number of males and females in each occupation by the percentage increase in the employment level in that occupation from period 1 to period 2. The resulting male share of total employment is denoted by $\bar{a}$. The initial gender composition of each occupation is retained, but the share of total employment by occupation is adjusted to that prevailing in period 2:

$$\text{(A1)} \qquad IP_A = \left(\frac{I}{T_2}\right)\sum\left|(1-\bar{a})M_{i1} - \bar{a}F_{i1}\right|\left(\frac{T_{i2}}{T_{i1}}\right),$$

where $\bar{a} = \dfrac{\sum M_{i1}(T_{i2}/T_{i1})}{T_2}$.

The index IP_B is calculated by adjusting the numbers of females (males) in each occupation by the increase in total female (male) employment between the two time periods. Thus, the overall gender composition of employment corresponds to that of period 2:

$$\text{(A2)} \qquad IP_B = \left(\frac{1}{T_2}\right)\sum\left|(1-a_2)\left(\frac{\bar{M}_2}{\bar{M}_1}\right)M_{i1} - a_2\left(\frac{\bar{F}_2}{\bar{F}_1}\right)F_{i1}\right| = Z_{21}IP_1,$$

where $Z_{21} = a_2(1-a_2)/a_1(1-a_1)$.

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The index IP_C is obtained by a process of iteration.

A third distribution of employment by sex across occupations is generated by successive transformations of the original distribution by the occupation and gender calculations detailed above. Thus, after each iteration, total employment corresponding to period 2 is achieved, but, after the odd iterations individual occupation totals are realized, whereas after the even iterations the period 2 gender totals are achieved. The distribution is said to converge when the proportional error is less than 0.025% with respect to either the gender totals after the occupational transformation or the occupational totals after the gender transformation.

The *IP* for the first period is denoted IP_1 and that for the second period, IP_2. To avoid arbitrariness, the decomposition of the index from period 1 to period 2 is reversed and the average values are utilized in all calculations.

The composition effect is $IP_2 - IP_C$.
The mix effect is $IP_C - IP_1$.
The occupation effect is $IP_A - IP_1$.
The gender effect is $IP_B - IP_1$.
The interaction effect is $(IP_C - IP_1) - (IP_A - IP_1) - (IP_B - IP_1)$.

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