Employment Segregation: Can We Measure It and What Does the Measure Mean?

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1. INTRODUCTION

Measuring qualitative aspects of the labour force has always been a difficult task. One solution is to resort to various *ad hoc* indices whose construction is at times arbitrary and interpretation ambiguous. This short note examines the properties and possible (mis)interpretations of two commonly cited indices of employment segregation and offers new insight to understanding them. I draw my examples from employment segregation between women and men in Britain.

2. THE HAKIM INDEX

A measure proposed by Hakim (1981) is based on the observation that some sectors (occupations, industries, regions and so on) employ proportionately more women (or men) than the overall ratio of the two sexes in the total labour force. Thus, the 'expected' sex ratios in each and every sector, which should be equal to the overall ratio if men and women were identical in all respects, are usually different from the actual ratios in these sectors. If the actual ratio of women to men in a given sector is higher than the expected ratio, then the sector is said to be over-represented; if the contrary, the sector is said to be under-represented (always with respect to female employment). From this observation, Hakim argues that the difference between the ratios of women actually employed and women expected to be in the over- and under-represented sectors can be utilized to show the extent of sex segregation in the labour market; i.e.,

$$(1) \qquad H = (F_i^a / F_i^e) - (F_j^a / F_j^e)$$

where H stands for the index, F is the number of women workers, superscripts a and e indicate actual and expected values, and subscripts i and j are, respectively, the female over-represented and under-represented sectors.

   This index takes the value of 0 if the actual sex ratio in each and every

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sector is equal to the overall sex ratio in the labour force (no segregation). Apart from this corner value, the usefulness of the index is limited: the index is unbounded (to the right), and its upper limit depends on the size of the labour force. In addition, the index does not satisfy one of the basic properties, that is that an increase in segregation should result in an increase in the value of (any uni-dimensional) index (Hall and Tideman 1967). An example is given in Table 1. In case 1, *H* has the value of 1.07. In case 2, the number of women in the under-represented sector increased four-fold and the index was (correctly) reduced. However, a similar (four-fold) increase in the number of women in the over-represented sector also resulted in an (improper) decrease of the index (case 3). It is instructive to estimate the upper bound of the index in these three cases. This is done in the figures in the brackets in Table 1. Notice that the ratio of the actual value of the index to its maximum value has the desired property of decreasing when more women enter the under-represented sector, *ceteris paribus* (case 2), and of increasing when more women work in the over-represented sector, *ceteris paribus* (case 3).[1]

TABLE I

Hypothethical Employment Distributions and Segregation Indices

		Women (1)	Men (2)	All (3)	H-index (4)		D-index (5)
Case 1	Occupation 1	10	60	70			
	Occupation 2	40	40	80			
	All	50	100	150	1.07	(3.00)*	0.40
Case 2	Occupation 1	40	60	100			
	Occupation 2	40	40	80			
	All	80	100	180	0.23	(2.25)*	0.10
Case 3	Occupation 1	10	60	70			
	Occupation 2	160	40	200			
	All	170	100	270	1.04	(1.59)*	0.54

*Figures in brackets indicate the maximum value of the Hakim index, that is if there were complete segregation.

In conclusion, the Hakim index has a number of desired properties such as uni-dimensionality and zero value for no segregation. However, the fact that the index is not dependent only on relative values results in the undesirable properties of unboundness and ambiguous movements when segregation and the size of the labour force change. This is clearly inappropriate for study on segregation.

3. THE DUNCAN INDEX

This index was proposed by Duncan and Duncan in 1955 and has the form
(2) $D = \frac{1}{2}\Sigma |f_i - m_i|,$ $i = 1, 2, \ldots, k$

where D stands for the index and f_i (m_i) is the proportion of women (men) in sector i as a percentage of the total female (male) labour force, k is the number of sectors and the summation refers to the absolute difference between f_i and m_i. The index can take any value between 0 and 1 and has all the desired properties cited earlier. For example, in the cases presented in Table 1, the index registers a decrease when the number of women in the female under-represented sector increased, while it moved upwards when the number of women in the female over-represented sector increased (column (5)). An additional advantage of the index is that it can be decomposed to structural and compositional effects for its changes over time. Structural effects to relate the changes in the index because the importance of the sectors i have changed, even if the proportions of women and men within sectors remained the same. Compositional effects come from the change in the sex ratios within sectors (Rubery 1988: 13, Humphries 1988 34–7).

The construction of the index rests on inituitive but sound grounds. The sum of the differences between the percentage of female and male employment within sectors should give an indication of the extent of aggregate segregation. However, when it comes to the interpretation of the index, there seems to be no clear agreement or understanding of what its values stand for. Some have referred to it as a measure of association between sex and employment sectors, with a higher degree of association indicating more segregation by sex across sectors. (Obviously, this interpretation comes close to that of correlation, and the limitations of the latter are well established.) Other authors have attempted a more rigorous interpretation and claimed that the index 'represents the proportion of *either* men *or* women who would have to be transferred from one [sector] to [another] in order to obtain equal proportions across [sectors]' (Brown *et al.* 1980:515) or 'the index represents the percentage of men (or women) who have to change sectors for the distributions to become identical' (Joseph 1983:147). Clearly, this is wrong, as the index has a single value and the total numbers of men or women in the labour force can only by accident be the same. Thus, the usual escape has been to state that segregation has changed because the index has changed (see e.g. Chiplin and Sloane 1976: 22).

One can show that the index can be derived from an explicit formulation, and this enables a clear interpretation to emerge. The number of women and men who should change sector in order to equate their sectoral ratio to the total ratio in the labour force can be easily shown; it is given by the formula

(3) $\qquad N = \Sigma \, (f_i - m_i)FM \, / \, (F + M)$

where f_i and m_i are as before and F and M stand for the total number of female and male workers, respectively. N varies between 0 (no change required) and

(4) $\qquad N_{max} = 2FM \, / \, (F + M)$.

It can be easily shown that the Duncan index is the ratio of N over N_{max}. As such, it shows nothing about how many women or men should change sector for equality to be restored: it simply indicates how far from complete

segregation the actual employment distributions of the sexes are. In other words, the index is a standardized measure of segregation, which is standardized for the size of the labour force. This is captured by the changing value of N_{max} as the size of the labour force increases. Of course, if one wants to know the percentage of women (or men) who should change sector, all that is required is to divide N by 2 and the resulting number by the number of women (or men) in the labour force.[2]

4. TWO APPLICATIONS

An application of these considerations to the British labour force provides useful insights. Table 2 provides estimates for the Hakim and Duncan indices as well as for the proportion of the labour force that should change occupational sector in order to restore equality between the employment distributions of men and women. The Hakim index registers a one-third decline in occupational segregation in the first 80 years of the present century, while the Duncan index indicates a decline of only 10 per cent. The Hakim index is clearly overstating the decline in segregation because it is affected by the higher rates of female participation in the labour force in the more recent years. Concentrating from now on on the Duncan index, it is obvious that, despite the small decline in segregation, the percentage of the labour force who have to change occupational sector to restore equality has remained practically the same during the aforesaid period (last column in Table 2). This is explained by the fact that the size of the female labour force has increased (column (1)), and can be taken to indicate that, although the sexual division of the labour force is today less acute than before, the relative cost of

TABLE 2

Occupational Segregation by Sex, 1901–1979

Year	% of women in the labour force (1)	Hakim index (2)	Duncan index (3)	% of the labour force to change (4)
1901	29	2.49	0.77	32
1911	30	2.22	0.73	31
1921	30	2.13	0.71	30
1931	30	2.14	0.71	30
1941	—	—	—	—
1951	31	1.98	0.68	29
1961	32	1.83	0.64	28
1971	36	1.73	0.66	30
1973	37	1.72	0.67	31
1975	38	1.66	0.66	31
1977	39	1.57	0.64	30
1979	39	1.71	0.69	33

Note: Adapted figures from Hakim (1980): 525.
Sources: 1901–71, Census estimates; 1973–9, EEC Labour Force Survey.

reallocating women to male-dominated sectors is not less than before. For (wo)manpower policies this is an important finding: the welfare loss of *occupational* segregation and the cost of policies to enable women to improve their employment distribution may still be no less important than a century ago.

Finally, Table 3 duplicates these results for the case of industrial *segregation*, and the story is similar to that in the case of occupational segregation: The Duncan index indicates a drop of again about 10 per cent during the postwar era, but the percentage of the labour force that has to change industry to restore equality in employment has remained constant at around 19 per cent; this is so because the importance of the female labour

TABLE 3

Industrial Segregation by Sex, 1950–1981

Year	Fraction of women in the labour force (1)	Duncan index (2)	Fraction of the labour force to change industry (3)
1950	0.34	0.43	0.19
1951	0.34	0.42	0.19
1952	0.34	0.42	0.19
1953	0.34	0.43	0.19
1954	0.35	0.43	0.19
1955	0.35	0.42	0.19
1956	0.35	0.42	0.19
1957	0.35	0.42	0.19
1958	0.35	0.42	0.19
1959	0.35	0.41	0.19
1960	0.36	0.41	0.19
1961	0.36	0.40	0.19
1962	0.36	0.40	0.19
1963	0.36	0.40	0.18
1964	0.36	0.40	0.18
1965	0.37	0.40	0.18
1966	0.37	0.40	0.18
1967	0.37	0.40	0.19
1968	0.37	0.39	0.18
1969	0.38	0.39	0.18
1970	0.39	0.38	0.18
1971	0.39	0.39	0.19
1972	0.39	0.41	0.18
1973	0.40	0.41	0.19
1974	0.41	0.40	0.19
1975	0.41	0.39	0.19
1976	0.41	0.39	0.19
1977	0.41	0.40	0.20
1978	0.42	0.40	0.19
1979	0.42	0.40	0.19
1980	0.42	0.39	0.19
1981	0.43	0.39	0.19

Source: 1950–68, *British Labour Statistics: Historical Abstract* (London: HMSO, 1968); 1968 and 1970–81, *New Earnings Survey* (London: HMSO).

force has increased. And the previous inferences about the social costs of segregation, and also the costs of policies to improve the womanpower of the country, are equally valid. It seems that the march of women towards equality has still a long way to go.

FOOTNOTES

[1]It is interesting to examine the upper bound of the Hakim index. Concentrating for reasons of shortness of space on Case 1 of Table 1, recall that the value of the index was found to be 1.07. Under conditions of complete segregation, the employment distributions of women and men would look as follows

		Women	Men	All
	Occupation 1	50	0	50
Case 4	Occupation 2	0	100	100
	All	50	100	150

and the value of the index would be 3.00. If this view is taken, then the upper bound of the Hakim index is simply the inverse of the ratio of female workers in the total labour force $(1/(50/150)=3.00)$. However, it is now obvious that the Hakim index suffers from an additional problem, that is that complete segregation is not definitionally clear. This is so because, in order to find the value of the index under complete segregation (Case 4), one had to assume further that female employment is just exhausted in the female over-represented sector. Thus the upper bound of the index in this example is valid only if there were initially 50 workers in occupation 1 and 100 workers in occupation 2 (instead of 70 and 80 respectively). If one wants to find the value of the index *when the total employment in the two occupations remains the same*, then one has to assume that either no women work in occupation 2, that is

		Women	Men	All
	Occupation 1	50	20	70
Case 5	Occupation 2	0	80	80
	All	50	100	150

or that no women work in occupation 1, that is

		Women	Men	All
	Occupation 1	0	70	70
Case 6	Occupation 2	50	30	80
	All	50	100	150

In the first case the value of the Hakim index is 2.14 while in the second case it is only 1.88. These two estimates of the upper bound of the index, as well as the one for case 4, are equally valid but under different assumptions. The need for some sort of standardisation of the index remains.

[2]In line with the estimates presented in footnote 1, one may add that the Duncan index also suggests different maximum values *if the original employment level within occupations is maintained* (although the theoretical limit of the index remains unaffected). In the 3 cases presented in the previous footnote the Duncan index takes the values of 1.00, 0.80 and 0.70 respectively.

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