# How Should Occupational Sex Segregation be Measured?

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*Work Employment Society* 1992 6: 475
DOI: 10.1177/095001709263009

*Work, Employment & Society*, Vol. 6, No. 3, pp. 475–487 September 1992

# NOTES AND ISSUES
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## Introduction

In recent years numerous studies have uncritically employed the Index of Dissimilarity in the analysis of occupational sex segregation (e.g., the international studies in Rubery 1988; the Swedish work of Jonung 1984; Beller's U.S. study 1985; and the Australian work of Lewis 1982, 1985). On the other hand a consensus appears to have emerged that the Sex Ratio Index, utilised by Hakim (1979, 1981) is fundamentally flawed in that it fails to exhibit either Composition Invariance or Gender Symmetry (Siltanen 1990a) and exhibits inconsistent movements, following a change in the degree of segregation (Tzannatos 1990: 106; Siltanen 1990a,b).[1] Accordingly, this paper examines the adequacy of the Index of Dissimilarity (ID) as a measure of occupational segregation. There is some confusion about the interpretation of ID, however (Tzannatos 1990: 107), although the mathematical properties of the index have been explored within the extensive sociology literature on racial segregation in housing (Duncan and Duncan 1955; Cortese *et al.* 1976, 1977; Taeuber and Taeuber 1976; Massey 1977) and in schools (Zoloth 1976; James and Taeuber 1985).

The ID can be shown to be the ratio of a linear loss function to its maximum value, where the latter is based on complete segregation of the sexes (Zoloth 1976: 276). Karmel and Maclachlan (1988) examine the properties of an index, IP which measures the fraction of the work force which must relocate to achieve zero segregation of the sexes. It can be shown that IP is this linear loss function.

Movements of an index of segregation will normally reflect changing sexual and occupational shares of employment, in addition to changes in the sexual composition of individual occupations. Thus an appropriate temporal decomposition of an index of occupational segregation by sex

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must purge both the impact of the changing sexual shares of total employment and also the impact of changes in the occupational structure, thereby identifying the Composition Effect (Karmel and Maclachlan 1988: 189–190). Their decomposition procedure also identifies the Mix Effect which can be subdivided into Gender, Occupation and Interaction Effects.

By contrast, the Gender Effect, which picks up changes in the sexual shares of total employment, is purged in the Index of Dissimilarity. The temporal decomposition of changes in this index over time, proposed by Rubery (1988: 13) and also the OECD decomposition (OECD 1985: 68) are both flawed and do not permit the isolation of the Composition Effect. It is shown that, utilising the decomposition procedure devised by Karmel and Maclachlan (1988), the Composition Effects based on the IP index and the Index of Dissimilarity are approximately equal.

A time series analysis of the changing pattern of occupational segregation by sex should not be necessarily confined just to the documentation of movements in the Composition Effect. The overall pattern of employment, differentiated by part-time and full-time, which reflects the labour force participation behaviour of males and females and the hiring practices of employers, also contributes to the explanation of sex segregation and is of interest to the labour market researcher. Hence, in an analysis of occupational employment by sex, the breakdown of the overall change in IP into its constituent components, namely the Composition Effect and the Mix Effect, where the latter is subdivided into Gender, Occupation and Interaction components should be examined (Karmel and Maclachlan 1988; Watts and Rich 1991a). By contrast, decomposition of the ID index using this procedure, yields a Mix Effect which is distorted by the suppression of the Gender Effect.

## Criteria for the Evaluation of Indexes

James and Taeuber (1985) propose four criteria by which to judge segregation indexes.[2] Composition Invariance (a zero Gender Effect) refers to the invariance of the index following uniform, percentage changes in the number of males and females in each occupation reflecting the overall, but typically unequal, percentage changes in male and female employment. If the index is unaffected either by the combination of two units (occupational groups) which have an identical pattern of segregation or by the division of a single occupational group into units with identical segregation patterns, then it is said to exhibit Organisation Equivalence. Size Invariance refers to the invariance of the index when the populations are increased proportionately, whereas the Principle of Transfers requires that segregation declines when (fe)male workers move from occupations of high to low concentration of their sex, *ceteris paribus* (Siltanen 1990a: 8–9).

The evaluation of different indexes based solely on these four criteria, is inappropriate in respect of a time series analysis of occupational sex segregation because temporal changes in the index can be decomposed into separate components. It is argued in this paper that a suitable index of gross occupational sex segregation must satisfy the second and third criteria and normally the fourth (see below) but that the requirement of a zero Gender Effect is unnecessarily restrictive and inhibits the detailed analysis of occupational employment data by sex.

In addition, a satisfactory measure of occupational segregation should be Gender Symmetric, so that its magnitude is unaffected by replacing male emloyment or share data by corresponding female numbers and *vice versa* in the index definition (Siltanen 1990a: 12). Otherwise there are two values for the index and there is the possibility that movements in the values may be contradictory (Karmel and Maclachlan 1988: 188). The Concentration Index $IC = \sum | F_i/F - T_i/T |$ which is used in the OECD study (1985) and Moir and Selby Smith (1979) is not Gender Symmetric.

## Indexes of Segregation

### *Index of Dissimilarity*

Cortese *et al.* (1976: 634–35) demonstrate that the Duncan index represents the share of either group which must be removed *without replacement* to achieve zero segregation. For example, in male dominated occupation i,[3] $R_i$ males must be removed to achieve the overall male share, $\bar{a}$, where:

$$(M_i - R_i)/(T_i - R_i) = \bar{a}$$

thus

$$R_i = (M_i - \bar{a}T_i)/(1 - \bar{a}) \tag{1}$$

Then aggregating over all male dominated occupations, m, yields:

$$R^m = \sum_m R_i = \sum_m (M_i - \bar{a}T_i)/(1 - \bar{a}) \tag{2}$$

$$\text{but } \sum_i (M_i - \bar{a}T_i)/(1 - \bar{a}) = 0 = R^m + \sum_f (M_i - \bar{a}T_i)/(1 - \bar{a})$$

$$\text{hence } R^m = \sum | M_i - \bar{a}T_i | /2(1 - \bar{a}) \tag{3}$$

and the share of males who must be removed, namely:

$$R^m/M = R^m/\bar{a}T = \sum_i | M_i - \bar{a}T_i | /(2(1 - \bar{a})\bar{a}T)$$

$$= \sum_i | M_i/M - F_i/F | /2 \tag{4}$$

which is the Dissimilarity Index, ID.[4]

This notional removal of 'excess' male employees necessarily upsets the overall occupational composition of employment (Moir and Selby Smith 1979). On the other hand, from (4), ID clearly exhibits Gender Symmetry, so that it also represents the share of female employees who must be removed from female dominated occupations.[5] There is a zero Gender Effect (Composition Invariance), because uniform percentage increases in the number of (fe)males in each occupation leaves each ratio in (4) unchanged for each occupation.

In addition, there is Size Invariance and Organisation Invariance but the index fails on the criterion of Transfers, when a transfer of (fe)males between 2 (fe)male dominated occupations is considered (James and Taeuber 1985: 13). All linear indexes, which entail the separation of occupations between those which are male and female dominated, fail the criterion of Transfers in this respect, because the values of these indexes do not reflect the actual distribution of employment within (fe)male dominated occupations. For example, the Dissimilarity Index can be written as:

$$ID = (F_f/F - M_f/M) \tag{5}$$

where $F_f$, $M_f$ are the total numbers of females and males, respectively, in female dominated occupations, which is unaffected by changes in the employment distribution of females *within* these female dominated occupations.

Zoloth (1976: 276) provides an insightful interpretation of Dissimilarity Index (see also the oblique reference in Duncan and Duncan 1955: 211). Consider the magnitude $D_N$ where:

$$D_N = \sum_i (T_i/T) \mid a_i - \bar{a} \mid \tag{6}[6]$$

where $a_i$ denotes the male share of total employment in occupation i. This linear loss function measures the mean absolute deviation of the (fe)male share from its average value, where the weights are the occupational shares of total employment. The magnitude of $D_N$ is not constrained to lie between 0 and 1. Its maximum value, $2\bar{a}(1-\bar{a})$, which is associated with complete segregation between the sexes, is a function of the overall female share of total employment, assuming the original employment distribution can be achieved. Division of $D_N$ by its maximum value yields:

$$D = \sum_i (T_i/T) \mid a_i - \bar{a} \mid /(2\bar{a}(1-\bar{a})) \tag{7}$$

It is readily sown that this index D equals the Index of Dissimilarity. Evidently the numerator, a linear loss function, is normalised by division by its maximum value, so that its magnitude can be identified as the relative level of occupational sex segregation, given the overall sexual shares of employment.

Cortese *et al.* (1976: 632) also argue that the comparison of measures of segregation over time should not be distorted by changes in the sexual shares, a non-zero Gender Effect. They claim that the appropriate yardstick for the observed pattern of segregation is a random (sex blind) distribution of individuals across occupations rather than either complete segregation or zero segregation. The mean value of the index reflects the sexual shares of employment in each occupation. Thus the Dissimilarity Index should be redefined as its 'standard score' namely the deviation of the index from its mean value, $\mu_D$ divided by its standard deviation $\sigma_\Delta$:

$$ZD = (ID - \mu_\Delta)/\sigma_\Delta \tag{8}$$

The computation of the mean value of the index is based on the utilisation of the hypergeometric probability distribution, since the random distribution of individuals across occupations represents sampling without replacement. There does not appear to be an adequate approximation of this distribution, however, to enable a computationally efficient calculation (Cortese *et al.* 1978: 591). In addition, since the ID is already normalised, which purges the Gender Effect, the further refinement of this index, as proposed by Cortese *et al.* is incorrect.[7]

In summary, the Index of Dissimilarity can be interpreted as either the share of (fe)males who must be removed from (fe)male dominated occupations to achieve occupational integration or the ratio of a linear loss function to its maximum value. The Index exhibits Gender Symmetry and the properties desired by James and Taeuber (1985), except for the Principle of Transfers, but it is argued that Composition Invariance (a zero Gender Effect) is not necessarily an appropriate property of an index of sex segregation.

### *The IP Index*

Karmel and Maclachlan (1988) propose a new index, IP, where:

$$IP = \sum_i |M_i - \bar{a}T_i| / T \tag{9}$$

It measures the fraction of total employment which must relocate, *with replacement*, to achieve zero segregation, because the 'correct' number of males in occupation i is $\bar{a}T_i$. Hence the original occupational structure is maintained by this notional redistribution of employees between occupations.

Like the Dissimilarity Index, IP is Gender Symmetric and transfers reduce its magnitude, except in the case cited with respect to ID. Unlike ID, however, IP does not exhibit Composition Invariance (a zero Gender Effect). It is readily shown that $IP = D_N$ in equation (6), which is the linear loss function, so that:

$$IP = 2\bar{a}(1-\bar{a})ID \qquad (10)^{8,9}$$

Using UK data over the period 1901–79 the movement of the 2 indexes, IP, ID are broadly similar (Tzannatos 1990: 109). However, in studies performed for other countries the 2 indexes have moved in opposite directions, which reflects the pervasive influence of the positive Gender Effect in the movement of IP.[10]

## Index Decomposition

In her examination of the Sex Ratio Index, Siltanen (1990a: 8–9) presumes that the 4 criteria for an adequate index of racial segregation in housing, documented in James and Taeuber (1985), are equally relevant to the examination of occupational sex segregation and consequently she ignores the possibility of decomposing temporal changes in an index.

### *The IP Index*

Karmel and Maclachlan (1988: 189–90) reveal that changes in their index over time can readily be decomposed into Composition and Mix Effects with the latter subdivided into Gender, Occupation and Interaction Effects.[11]

Two new indexes can be defined, namely:

$$IP_A = (1/T_2)\sum |(1-a^*)M_{i1} - a^*F_{i1}|(T_{i2}/T_{i1}) \qquad (11)$$

$$\text{where } a^* = \sum M_{i1}(T_{i2}/T_{i1})/T_2 \text{ and}$$

$$IP_B = (1/T_2)\sum |(1-a_2)(\bar{M}_2/\bar{M}_1)M_{i1} - a_2(\bar{F}_2/\bar{F}_1)F_{i1}| = Z_{21}IP_1$$

$$\text{where } Z_{21} = a_2(1-a_2)/a_1(1-a_1). \qquad (12)$$

and the subscripts 1,2 refer to time periods 1,2. The index $IP_A$ is obtained by proportionately adjusting the number of males and females in each occupation by the change in the employment level in that occupation from period 1 to period 2, $(T_{i2}/T_{i1})$. The resulting male share of total employment is denoted by $a^*$. Thus the initial sexual composition of each occupation is retained but the share of total employment in each occupation is adjusted to that prevailing in period 2. Thus the comparison of $IP_A$ with the value of the index in period 1 yields the 'forwards' OCCUPATION effect.[12] 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, but the size of occupations will differ from those of period 2. Comparison of $IP_B$ with the value of the index in period 1 yields the 'forwards' GENDER effect.

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 realised whereas, after the even iterations, the period 2 gender totals are achieved. The distribution is said to converge when the proportional error associated with the second period distribution of employment is less than 0.025%[13] with respect to either the gender totals after the occupational transformation or the employment levels by individual occupations after the gender transformation. This procedure appears to have been first used by Deming and Stephan (1940).[14]

Denoting the index associated with this employment distribution as $IP_{C2}$, then the (absolute) 'forwards' Composition Effect is defined as $IP_2 - IP_{C2}$ and it entails the comparison of the employment distribution in period 2 with that resulting from a series of linear transformations of the employment distribution in period 1 which generates the same occupational and overall sexual shares of total employment as in period 2. The 'forwards' Mix effect is $IP_{C2} - IP_1$ so that by subtraction, the residual Interaction Effect is $(IP_{C2} - IP_1) - (IP_A - IP_1) - (IP_B - IP_1)$. These 'forwards' and 'backwards' effects can be converted into percentages by multiplying by 100 and dividing by the mean of the index values, namely $(IP_1 + IP_2)/2$.[15]

*Index of Dissimilarity*

In her edited volume, Rubery (1988: 13) defines the decomposition of the Dissimilarity Index into the Structural (Occupational) Effect, Sex Composition Effect and the Residual Effect. Writing $ID_A$ as:

$$ID_A = \sum | (F_{i1}/T_{i1})(T_{i2}/F_2) - (M_{i1}/T_{i1})(T_{i2}/M_2) | /2 \qquad (13)$$

then the structural effect is written as $ID_A - ID_1$.

$$ID_B = \sum | (F_{i2}/T_{i2})(T_{i1}/F_1) - (M_{i2}/T_{i2})(T_{i1}/M_1) | /2 \qquad (14)$$

and the sex-composition effect is defined as $ID_B - ID_1$. The residual effect can be written as $(ID_2 - ID_1) - (ID_A - I_1) - (ID_B - ID_1)$.

There are two important shortcomings with this decomposition:

(a) In both $ID_A$ and $ID_B$ the denominators of the terms are inconsistent with the occupational transformation, so that removal of the modulus signs does not lead to zero values for the expressions (cf. 4). For example, in (13) the occupational transformation does not, in general, lead to total male and female employment of $M_2$ and $F_2$, respectively (cf. 11).

(b) The construction of $ID_B$ is the basis for computing the 'backwards'

Structural (Occupational) Effect, since the occupational employment levels are multiplied by $T_{i1}/T_{i2}$. To avoid problems of symmetry, computations both backwards and forwards are required, in short the percentage (Dissimilarity) Structural Effect should be written as:

$$SED = (ID_A - ID_1 + ID_2 - ID_B)*100/(ID_1 + ID_2) \quad (15)$$

where $ID_A$, $ID_B$ are redefined in the manner described in (a). The remaining effect compounds both Composition and Interaction Effects, however, and cannot be readily interpreted or decomposed. Similar criticisms can be made of other decompositions of the Dissimilarity Index (OECD 1985: 68; Beller 1985: 238).

The Composition Effect should be based on the employment distribution calculated via the successive linear transformations of the period 1 distribution through the procedure documented by Karmel and Maclachlan (1988), and again all calculations should be reversed to avoid asymmetry problems.

## An Evaluation of the Indexes

The calculation of the Index of Dissimilarity involves the normalisation of the IP computation by the maximum rate of segregation. The Gender Effect, as defined by Karmel and Maclachlan, is purged, wich may be a desirable property of indexes of racial segregation in housing and schooling, which are examined by sociologists. In a time series analysis of occupational segregation, however, the Occupational Effect, which picks up the effects of changes in the occupational structure should also be purged, because changes in the occupational structure do not reflect the differential treatment of the sexes in the labour market. Thus the Composition Effect is the appropriate measure of the change in the degree of occupational sex segregation over time. Karmel and Maclachlan (1988) argue that this effect should be defined in percentage terms as:

$$CEP = [(IP_2 - IP_{C2}) + (IP_{C1} - IP_1)]*100/(IP_1 + IP_2) \quad (16)$$

On the other hand, changes in the sexual shares of total employment over time are interrelated with changes in the occupational structure and reflect the hiring practices of employers and the labour force participation behaviour of the sexes. In both Britain and Australia the unequal sharing of non-market work between the sexes has been accompanied by a significant increase in the female rate of labour force participation over the last 10 years, particularly with respect to part-time work (e.g., the British work of Dex and Walters 1989; Watts and Rich 1991a,b). Only when paid and unpaid work is distributed more equally between the sexes will patterns of

employment with respect to part-time and full-time become more equal between the sexes, which is a precondition for a significant decrease in the overall index of occupational segregation.

Thus, while the Composition Effect is the appropriate metric for the measurement of occupational segregation by sex, an understanding of the forces operating on occupational employment requires the full decomposition of movements in the overall index.

## Results

In Table 1 decompositions of the two indexes for total (part-time and full-time) employment, based on the Karmel and Maclachlan (KM) procedure, are reported, using British data over 1979–88, under the new Warwick Occupational Classification (WOC) of 76 occupations and Australian data for the periods 1978–85, 1986–89. Data for 59 occupations, under the CCLO classification are available for the period 1978–85, whereas the ASCO classification of 52 occupations commenced in 1986.

The results reveal that the magnitude of the Composition Effect is relatively insensitive to whether it is defined by equation (16) or through (16) redefined in terms of ID. Secondly, the magnitude of the total percentage change of the IP index (or Mix Effect) minus the Gender Effect is approximately equal to the total percentage change of the ID index (or Mix Effect).[16] These results show that gross movements of the ID, IP indexes may differ markedly due to the role of the Gender Effect.

The breakdown of the Mix Effect, net of the Gender Effect, into the

***Table 1*** Minor Occupations:Index Decomposition

| | | I1 | I2 | Tch% | Comp% | Mix% | Occ% | Gen% | Int% |
|---|---|---|---|---|---|---|---|---|---|
| ID | U.K. | 0.657 | 0.611 | −7.29 | −5.39 | −1.90 | −1.91 | 0.00 | 0.01 |
| IP | 1979–88 | 0.313 | 0.299 | −4.46 | −5.39 | 0.93 | −0.38 | 2.83 | −1.52 |
| ID | AUS. | 0.617 | 0.600 | −2.87 | −1.48 | −1.39 | −1.83 | 0.00 | 0.44 |
| IP | 1978–85 | 0.284 | 0.284 | −0.05 | −1.47 | 1.42 | −1.06 | 2.81 | −0.33 |
| ID | | 0.532 | 0.528 | −0.79 | −0.39 | −0.41 | −0.11 | 0.00 | −0.29 |
| IP | 1986–89 | 0.254 | 0.255 | 0.52 | −0.38 | 0.90 | −0.01 | 1.31 | −0.40 |

*Source:*
U.K. Standard Occupational Classification revised according to Warwick Occupational Classification (76 occupations).
Australian Bureau of Statistics unpublished Labour Force Survey data (59 CCLO occupations 1978–85, 52 ASCO occupations, 1986–89).

Occupational Effect and the Interaction Effect differs across the two indexes so that there are marked differences in the Occupational Effects across ID and IP. The ID Occupation Effect makes little sense, however, because its measurement is distorted by the normalisation of the index, which purges it of a Gender Effect, so that the interpretation of the corresponding Interaction Effect is unclear. On the other hand, the presence of the Interaction Effect within the Mix Effect makes it difficult to definitively separate the Occupation and Gender Effects, although a small absolute Interaction Effect does permit limits to be imposed on Occupational and Gender Effects.

The decline in sex segregation as measured by the Composition Effect has been faster in the U.K. than in Australia. Indeed the decline in the Composition Effect in Australia was slower in the second than in the first period (Watts and Rich 1991a). The per annum Gender Effects are similar in Britain and Australia, being in the order of 0.30–0.40% per annum. In both countries the Occupational Effects differ markedly across the two indexes. In Britain the ID index reveals the emergence of a less segregated occupational structure, whereas the decomposition of the IP index implies a more segregated occupational structure, but a large Interaction Effect. Comparisons of different countries must be made with caution, however, because countries may be at different stages of economic and social development, as represented by different occupational and sexual shares of employment (Rubery 1988: 256).[17]. Marked differences exist between the two countries in respect of wage regulation and employment protection, as well as tax and social welfare legislation and the provision of child care. These institutional factors influence the labour supply behaviours of males and females. In addition, we argue that the state of the business cycle also impacts strongly on the magnitude of occupational segregation in Britain, in particular (Watts and Rich 1991b).

## Conclusion

Many recent contributions to the analysis of occupational segregation have tended to utilise the Index of Dissimilarity without a clear understanding of the interpretation of its movements through time. In this paper, it is argued that the KM decomposition of either the ID or the IP index yields an unambiguous calculation of the Composition Effect which is the appropriate metric for measuring temporal changes in occupational sex segregation in Western countries. Thus the Composition Effect based on this decomposition is based on rigorous foundations.

The IP index measures gross occupational sex segregation, whereas the Index of Dissimilarity represents the IP index normalised by its maximum value. Examination of the full decomposition of the index, however,

contributes to the understanding of the forces determining the pattern of employment by sex, but caution must be exercised in drawing conclusions about Gender and Occupation Effects as part of the Mix Effect because of the contribution of the Interaction Effect. By contrast, the Gender Effect is suppressed in time series comparisons of the Index of Dissimilarity.

## Notes

1. Siltanen underpins her criticisms of the Sex Ratio Index by comparing it to the Standardised Sex Ratio Index, which is characterised by Gender Symmetry, in computations based on British data for the period 1901–79. There are also problems of interpretation of this index (Watts 1990), which she concedes (Siltanen 1990b).
2. For consistency, a number of arguments in the sociology literature, relating to the mathematical properties of indexes, are respecified in terms of occupational sex segregation.
3. An occupation is deemed to be (fe)male dominated if its (fe)male share of employment exceeds the overall (fe)male share.
4. Tzannatos (1990: 108) correctly argues that the number of women and men who should change sector to achieve zero segregation is given by:

$$N = \sum (f_i - m_i)\, FM/(F+M)$$
$$= \sum | M_i - \bar{a} T_i |$$

   where $f_i$, $m_i$ are the shares of total male and female employment in occupation i; $F_i$, $M_i$ are the corresponding employment levels; F, M are total female and male employment levels and $\bar{a}$ is the male share of total employment. He is unable to give a convincing rationale for the standardising factor $N_{max} = 2FM/(F+M)$.
5. Tzannatos (1990: 107) denies this claim because, like a number of other writers, including Brown *et al.* (1980: 515) and Joseph (1983: 147), he fails to realise that the removal of (fe)males from (fe)male dominated occupations occurs *without replacement*.
6. Zoloth defines the numerator as $T.D_N$ but, for comparison purposes, our definition is preferred.
7. Zoloth (1976: 282) defines a variance ratio (segregation) index which is a quadratic loss function, namely:

$$IV' = \sum_i T_i (a_i - \bar{a})^2 / T\bar{a}(1-\bar{a})$$

   where the denominator denotes the maximum of the numerator, the Mean Square Deviation. Highly segregated occupations have a disproportionate influence on the index. The index is Gender Symmetric and satisfies 3 of the 4 criteria devised by James and Taeuber, but it typically exhibits a non-zero Gender Effect, despite the normalisation (James and Taeuber 1985: 6).
8. The calculation of IP involves double counting, since the *total* fraction of the employed workforce who must relocate is computed.
9. Tzannatos (1990: 108) correctly points out that the percentage of the workforce who are required to move can be obtained by dividing N by 2T (table 2, p. 108) which is evidently IP/2.

10. Using employment data for 3 digit occupations in Sweden over the period 1960–75, Jonung (1984: 52) finds a monotronic decline in the Dissimilarity Index, whereas recalculation using IP reveals a net increase over this period. This phenomenon also occurred in Australia (Karmel and Maclachlan 1988).
11. The decomposition requires a constant pattern of occupational disaggregation and is therefore suited to a time series rather than a cross section analysis.
12. To avoid arbitrariness, the 'backwards' decomposition of the index from period 2 to period 1 is also calculated and average values are utilised.
13. The tolerance level was found after some experimentation. For a tolerance level of 0.025% the percentage Composition Effect varies with respect to the second figure after the decimal point, as compared to a tolerance level of 0.05%.
14. For a numerical example of this procedure see Karmel and Maclachlan (1988: 194).
15. The derivation of the decomposition procedure to break down gross movements in the IP index means that the redefinition of IP as its standard score, proposed by Cortese *et al.* (1976) (in respect of ID) is redundant.
16. The difference can be written as

$$100^{*}(Z_2 - Z_1)(Z_1IP_2 - Z_2IP1)^{2}/[Z_1Z_2(IP_1 + IP_2)(Z_2IP_1 + Z_1IP_2)]$$

where $Z_i = \bar{a}_i(1 - \bar{a}_i)$. This cannot be readily approximated but would appear to be small in magnitude.
17. The measure of occupational segregation also reflects both the degree and the nature of the occupational disaggregation, *ceteris paribus*.

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