OCCUPATIONAL GENDER SEGREGATION: INDEX MEASUREMENT AND ECONOMETRIC MODELING*

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Empirical studies of gender segregation by occupation must be founded on rigorous measurement procedures. There appears to be a consensus that any index used in the analysis of time-series or international cross-section employment data must be either margin-free or decomposable to yield a margin-free component. On the other hand, Charles and Grusky (1995) advocate the use of multiplicative log models from which a margin-free odds ratio can be derived. In this paper, I contrast the construction and interpretation of the index of dissimilarity and the Karmel-MacLachlan index with the multiplicative modeling of gender segregation and the associated log index.

Occupational gender segregation remains a serious area of inquiry for social scientists (see the special issues of the *Review of Radical Political Economics*, vol. 25(3), and the *Journal of Econometrics*, vol. 61(1); Charles 1992; Charles and Grusky 1995; King 1992; Nermo 1996; Watts 1995a; Watts and Rich 1991, 1992a, 1992b, 1993). The preeminence since 1955 of the index of dissimilarity in the study of occupational and residential segregation has been challenged in recent years. Elsewhere (Watts 1992), I advocate the use of Karmel and MacLachlan's I_p index (Karmel and MacLachlan 1988).[1] By contrast, Charles (1992) and Charles and Grusky (1995) adopt a structural approach in their cross-country studies in which their index of segregation is based on a log-multiplicative model.

Researchers appear to agree that, along with other properties, a measure of segregation should be margin-free to enable rigorous cross-section and time-series comparisons. I argue that the I_p index has a number of desirable properties that make it a more appropriate index for use in studies of gender segregation by occupation than either the index of dissimilarity or Charles and Grusky's log (A) index. Despite the emergence of model-based approaches, index measurement remains an integral component of national and, to a lesser extent, cross-national studies of gender segregation. The use of an appropriate index to measure quantitative changes in segregation over time informs and provides focus for complementary forms of analysis, including case studies, other descriptive statistics, and possibly econometric analysis.[2]

THE MEASUREMENT OF OCCUPATIONAL GENDER SEGREGATION

The type of empirical investigation of gender occupational segregation being undertaken will influence the choice of methodology. Most empirical studies of occupational gender segregation are time-series analyses of individual countries (see Beller 1985; Karmel and MacLachlan 1988; King 1992; OECD 1985; Rubery 1988; Watts 1995a; Watts and Rich 1991, 1992a, 1992b, 1993), but cross-country studies have also been conducted (see Charles 1992; Charles and Grusky 1995; Jacobs and Lim 1992). Index measurement has characterized the time-series studies and the combination of regression analysis and index computation in the work of Charles and Grusky (1995) and Jacobs and Lim (1992).

Occupational gender segregation is said to exist when women and men are differently distributed across occupations than they are in employment overall, regardless of the nature of job allocation (Jonung 1984:45). That is, an occupation is said to be (fe)male dominated if its (fe)male share of employment is higher than the overall (fe)male share of employment. An index of gender segregation can be viewed as measuring the extent to which men and women are unevenly distributed across occupations (see Massey and Denton 1988). Explicit in the calculation of an index is the specification of a counterfactual, integrated distribution of employment by occupation and gender. Denote the employment distribution by gender and occupation by the $n \times 2$ matrix N, where

$$N = \begin{bmatrix} F_1 & M_1 \\ F_2 & M_2 \\ \mathrm{K} & \mathrm{K} \\ F_n & M_n \end{bmatrix}. \tag{1}$$

F_j (M_j) denotes the number of females (males) in occupation j ($j = 1,\ldots,n$). Denote an index of segregation as $S(N)$.

A gross index of occupational gender segregation should satisfy four criteria: organizational equivalence, size invari-

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1. Butler (1987), Hutchens (1991), Silber (1989), and Deutsch, Fluckiger, and Silber (1994) advocate the use of the Gini coefficient. Unlike the I_p index, however, the Gini coefficient cannot be decomposed to reveal the contribution of different groups of occupations to the overall level and rate of change of segregation (see James and Taeuber 1985 for a discussion of its properties). Blackburn, Jarman, and Siltanen (1993, 1997; Blackburn, Siltanen, and Jarman 1995) advocate the use of the marginal-matching technique (but see Watts 1994, 1995c, 1997a).

2. I do not address vertical segregation in this paper. Typically economy-wide employment data are based on a classification of occupations by skill rather than hierarchy. Thus, the exploration of vertical segregation is more suited to case studies.

ance, gender symmetry, and the principle of transfers in its weak form (Watts 1992:476–77). If an index is unaffected either by the combination of two occupations that have an identical pattern of segregation or by the division of a single group of occupations into units with identical segregation patterns, then it exhibits *organizational equivalence*. *Size invariance* refers to the invariance of the index when the populations are changed proportionately, so that $S(\lambda N) = S(N)$ where λ is a positive scalar.

The magnitude of a *gender-symmetric* index is unaffected by replacing data on female employment or share by corresponding numbers for males, and vice versa, in the index definition (see Siltanen 1990:12). Otherwise there are two values for the index, and movements in the values may be contradictory (Karmel and MacLachlan 1988:188).

The *principle of transfers* in its strong form requires that segregation decline when, for example, a female worker moves from a female-dominated occupation to a less female-dominated occupation and is replaced by a male worker from the latter occupation, *ceteris paribus*, so that the occupational structure and overall gender composition of employment are unchanged (Siltanen 1990:8–9; Watts 1992). The principle of transfers in its weak form requires that the transfer of a female employee from a female-dominated to a male-dominated occupation and her replacement by a male employee from the male-dominated occupation lead to a decline in the index, because both occupations have become less gender dominated. The weak form of the principle of transfers is satisfied by many linear indices, including the index of dissimilarity and the I_p index.

The evaluation of different indices based solely on these four criteria is inadequate for tracking trends in the pattern of occupational gender segregation in a time-series analysis: Over time, the overall shares of employment by gender change, and this change is generally accompanied by a change in the distribution of employment across occupations. Likewise, simple cross-country comparisons of gender segregation would be biased by differences in the overall shares of employment by gender and the overall shares of employment by occupation.

Accordingly, many economists and sociologists argue that the gross index of gender segregation employed in empirical studies should be margin-free, so that changes in its magnitude over time are independent of the interrelated changes in the overall shares of employment by gender and the occupational structure (e.g., Blackburn et al. 1993, 1995; Charles 1992). This requires that the gross index be characterized by both composition invariance and occupations invariance. *Composition invariance* 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. Thus,

$$S(N\Lambda) = S(N), \tag{2}$$

where Λ denotes a diagonal matrix, whose elements $\lambda_i > 0$ $(i = 1,2)$.

Occupations invariance requires that the measure of segregation be invariant to changes in the relative size of occupations if the gender composition of these occupations remains constant. Consider the $n \times n$ diagonal matrix, Γ, whose jth diagonal element is written $\gamma_j > 0$, $(j = 1,2,\ldots n)$. The condition of occupations invariance can be written as

$$S(\Gamma N) = S(N). \tag{3}$$

An alternative view is that temporal changes in the chosen gross index of segregation satisfying the first four criteria should be decomposed to reveal a margin-free component (composition effect)[3] (Beller 1985; Blau and Hendricks 1979; Jonung 1984; OECD 1985; Rubery 1988; Watts 1992). Composition and occupations invariance, in addition to the other four criteria, are demanding requirements for a gross index of gender segregation. Thus, the adoption of a decomposition procedure warrants serious consideration.

Finally, rigorous comparisons of index magnitudes in time-series and cross-section studies require compatible occupational definitions and hence equal numbers of occupations. This problem is acute in time-series studies, which must confront the emergence of new occupations, as well as in cross-country studies, in which the need for compatible occupational definitions generally confines studies to a limited number of aggregated occupations. A consistent classification of occupations can be achieved, albeit with difficulty, by either excluding some occupations or combining them with compatible occupations.[4]

INDICES OF GENDER SEGREGATION

Index of Dissimilarity

Despite the emergence of new methods of analysis, the index of dissimilarity remains an important form of measurement, particularly in the United States (e.g., Albelda 1986:405; Cherry and Mobilia 1993; Jacobs 1993; King 1992:31). The index of dissimilarity can be written as

$$D = (1/2)\sum_j \left|(F_j/F) - (M_j/M)\right|, \tag{4}$$

where F_j and M_j denote the number of female and male employees in the jth occupation, and F and M are total female and male employment, respectively. The index satisfies four criteria: organization equivalence, size invariance, gender symmetry, and the principle of transfers in its weak form.

White (1985:202) argues that the index, when applied to residential segregation, "is easily interpreted as the per-

3. The composition effect would be zero if either the gender composition of each occupation remained unchanged while their relative sizes changed, or the number of females and/or males changed uniformly across occupations.

4. Massey and Denton (1988) identify five dimensions of residential segregation: evenness, exposure, concentration, centralization, and clustering. The exposure measure has no obvious relevance to occupational segregation, unless intra-firm employment data are available, and concentration, centralization, and clustering appear irrelevant to occupational segregation because they embrace a spatial dimension. But many researchers use a socioeconomic or prestige scale as a means of calculating the social distance between male and female employment distributions (see Charles and Grusky 1995:956–60 and references therein).

centage of one group which would have to change residences in order to produce an even distribution" (see also Albelda 1986:405; Charles and Grusky 1995:933; King 1992:31; Massey and Denton 1988:284; Nermo 1996:322; Rubery and Fagan 1995:239). Cortese, Frank, and Cohen (1976:634–35) demonstrate that the D index represents the share of either group that must be removed, *without replacement*, to achieve zero segregation. All excess (fe)males in (fe)male-dominated occupations are culled, so that the distribution of employment associated with gender integration, explicit in the D measure, differs in its occupational structure from the actual employment distribution. Hence, the D index is an inappropriate measure of trends in gender segregation (see also Watts 1992).

The D index fails to exhibit occupations invariance, but exhibits composition invariance. The standardized D index is occupations invariant, but is not composition invariant (Charles and Grusky 1995:935). Several researchers have decomposed the index of dissimilarity to counter the absence of occupations invariance (see Beller 1985:238; Blau and Hendricks 1979; OECD 1985:68; Rubery 1988:13), but I argue that these approaches are flawed (Watts 1992:481–82).

Recent innovations with respect to the analysis of gender segregation can be seen as a response to these problems. Two solutions to the problems of index definition can be identified in the literature: (1) the construction of a margin-free index, and (2) the development of a procedure to decompose a satisfactory index of segregation.

Charles' Structural Index

In a cross-national study, Charles and Grusky (1995) adopt log-multiplicative specifications to identify gender-specific, occupation-specific, and national factors. They use the logarithmic A index, which takes the form

$$A = \exp\left\{\frac{1}{n}\sum_{j=1}^{n}\left[\ln\left(\frac{F_j}{M_j}\right) - \left\{\frac{1}{n}\sum_{j=1}^{n}\ln\left(\frac{F_j}{M_j}\right)\right\}\right]^2\right\}^{\frac{1}{2}}. \tag{5}$$

The index is gender symmetric, but the (geometric) mean female-to-male ratio is highly sensitive to the degree of occupational disaggregation because the approach entails standardizing the occupations to equal size. Consider dividing an occupation into m equal-sized occupations ($m > 1$) with the same gender composition. Each of these m (equal) female-to-male ratios would have a weight equal to the gender ratios of the other $n - 1$ occupations in the mean ratio computation. In addition, they would increase the number of occupations in the calculation by $m - 1$, thereby biasing the computation. Hence, this index does not exhibit organizational equivalence. However, the index exhibits occupations invariance, because of the standardization of the occupations, and composition invariance.

All index computations are sensitive to the extent of occupational disaggregation, because the aggregation of occupations tends to hide outlying gender ratios (aggregation bias). In a time-series study with compatible occupation definitions, the logarithmic index tends to exhibit significant fluctuations because of the sensitivity of its magnitude to the gender ratio. Indeed, if an occupation is completely segregated, with no (fe)male employees, the logarithm of the gender ratio is not defined. This makes intertemporal comparisons of index magnitudes difficult, unless these occupations are combined with others or removed from the calculations.

On the other hand, in cross-national studies this problem is less acute because the number of occupations under study is usually small, due to the difficulties of reconciling the different classifications across countries. However, the variance of employment, even across the major occupations, is significant (see Charles and Grusky 1995: table A1). Further, the suppression of cross-national differences in the disaggregated occupational structure inhibits researchers from gaining insight into differences in the pattern of gender segregation.

Charles and Grusky (1995) analyze six major occupations in their cross-country study, but are able to examine compatible data for 45 occupations for Japan and the United States. They justify the minimal disaggregation of occupations for all countries by showing that, for Japan and the United States, disaggregation has little influence on the results. This test, however, provides no guidance as to whether the limited disaggregation matters for other countries in their study for which detailed, compatible occupational data are not available.

The Karmel and MacLachlan Index

Karmel and MacLachlan (1988:188) define their index as

$$I_P = \left(\frac{1}{T}\right)\sum_{j=1}^{n}\left|F_j - a\left(M_j + F_j\right)\right|, \tag{6}$$

where T and a are total employment and the female share of total employment, respectively, and F_j and M_j are as defined earlier. The number of females in occupation j under occupational integration is $a(M_j + F_j)$. Thus, the index denotes the total level of employment that would have to relocate with replacement to achieve zero segregation by gender, but maintains the occupational structure and the overall gender shares of employment. Underpinning the index calculation is a counterfactual distribution of employment with an integrated structure of employment and the same overall gender and occupational shares.

The index has a simple interpretation, in contrast to the index of dissimilarity. The I_P index exhibits organizational equivalence, size invariance, and gender symmetry. The I_P computation is also linear and is based on the distinction between female- and male-dominated occupations. Thus, the weak form of the principle of transfers holds. The I_P and D indices are simply related:

$$I_P = 2a(1 - a)D. \tag{7}$$

The I_P index is neither composition invariant nor occupations invariant.[5] Karmel and MacLachlan (1988:190–91)

5. For example, the upper bound of the index is $2MF/T^2$, which is twice the product of the overall male and female shares of employment. This characteristic has been a source of criticism (Blackburn et al. 1993:355; Jones

show that a temporal change in their index can be decomposed into composition and mix effects, where the latter can be divided into occupation, gender, and interaction effects (see Appendix). Caution must be exercised in drawing inferences from the occupation and gender effects, however, because of the interaction effect.

The composition effect is based on the difference between the I_p index magnitudes of a transformed Period 1 distribution of employment and the Period 2 distribution; it identifies the impact of the change in the gender composition of individual occupations and excludes the impact of the change in the occupational structure and the related change in the overall gender shares between the two periods (Watts 1993:317). Thus, the composition effect is composition and occupations invariant, and hence margin-free. It is expressed as a percentage of the average index values, thereby revealing the rate of change of the index magnitude.[6]

The I_p index and its decomposition are less well suited to cross-national studies. If researchers can construct a coherent and reasonably detailed classification of occupations common to all countries, insights can be gained by cross-section comparisons of countries through the calculation of pairwise I_p composition effects. By definition, these rankings are independent of the differences in the overall gender shares of employment and the associated occupational structures, but are not necessarily transitive across countries.[7] Thus, establishing a unique and consistent ordering of countries at a point in time may not be possible.

SEGREGATION WITHIN OCCUPATIONAL GROUPS

The Karmel and MacLachlan approach can been extended to analyze groups of occupations within the overall structure of employment (Watts 1995a; Watts and Rich 1992a, 1993). These calculations are straightforward using the *KM* index because the index can be written as a weighted sum of the normalized contributions of the individual occupational groups:

$$I_P = \left(\frac{1}{T}\right)\sum_{j=1}^{n}\left|F_j - a\left(F_j + M_j\right)\right|$$

$$= \sum_{I}\left(\frac{T_{OI}}{T}\right)\sum_{i\in I}\left|F_i - a\left(F_i + M_i\right)\right| \Big/ T_{OI}\,, \qquad (8)$$

where T_i and T_{OI} denote total employment in the *i*th occupation and *I*th occupational group, respectively.

Further, for each occupational group, one can calculate composition effects, which measure the speed of change in segregation within each occupational group in the context of the overall gender shares and occupational structure of employment (Watts 1995a; Watts and Rich 1992a, 1993). This decomposition enables the identification of the source of change in the overall pattern of segregation[8] and provides insights to assist in policy prescription. By distinguishing between more and less prestigious and highly paid groups of occupations, the approach helps to overcome the criticism that the index of dissimilarity (and other indices of segregation) measures "nominal differentiation not inequality" (Fossett, Galle, and Kelly 1986:423).

ECONOMETRIC MODELS

The small number of annual observations under a consistent occupational classification often rules out the use of time-series (single country) econometric analysis because of insufficient degrees of freedom. On the other hand, index computation can be viewed as measurement without theory: Explanations of the patterns of change identified by index measurement tend to be speculative. Through bootstrapping or jackknifing techniques, however, confidence intervals can be established for many indices of segregation to establish the statistical significance of changes over time (cf. OECD 1985:64).

The correct calculation of summary statistics across occupational groups yields more detailed insights into the source of the overall pattern of change, if not the cause. In calculating these summary statistics across occupational groups and in aggregate, one does not undermine the integrity of the data across the individual occupations through aggregation before numerical analysis, as in standard econometric time-series modeling (e.g., Rubery 1988).

Charles and Grusky (1995) adopt a log-multiplicative model to identify the dominant segregation profiles in a cross-country study of gender segregation.[9] In an earlier paper, Charles (1992) incorporates scalable contextual variables. This approach enables the identification of the causal factors influencing the pattern of gender segregation across countries through the examination of their statistical significance. In contrast to time-series studies, however, this approach is essentially static. Because gender segregation is a dynamic process, this approach neglects an important dimension.

OCCUPATIONAL SEGREGATION IN BRITAIN, 1979–1992

I use British employment data from the Labour Force Survey defined under the revised Warwick Occupational Categories to illustrate the properties of the different indices of segregation (see Institute for Employment Research 1989 for details of this occupational classification). British employ-

1992) that is only valid if a satisfactory margin-free index can be defined and/or the proposed decomposition procedure for this index is invalid.

6. The I_p index can also be applied to determine the contributions of full-time and part-time employment to the overall pattern and rate of change of segregation by total employment (Watts and Rich 1991, 1992b).

7. In an incomplete study of gender segregation in the armed forces (Watts 1998), following pairwise comparisons, I found a transitive ordering across the four branches of the serves across 38 common occupations. The ordering, however, was not transitive for groups of occupations.

8. For example, Blau (1989) resorts to descriptive statistics, rather than utilize a decomposition procedure, to explain why the rate of integration slowed in the 1980s in the United States, as measured by changes in a normalized dissimilarity index.

9. The particular year used for each country must be chosen carefully such that all countries are in the same phase of their respective business cycles. In time-series studies, the overall level of gender segregation has been shown to be sensitive to the state of the business cycle (Watts 1995a; Watts and Rich 1992a, 1993).

ment reached a local minimum in 1983 and a local peak in 1990. Thus, the complete sample period is divided into three subperiods—1979–1983, 1983–1990, and 1990–1992—to reflect the stages of the business cycle.

In Table 1, the index magnitudes, which are based on 76 occupations, are shown for 1979, 1983, 1990, and 1992. I divide the magnitude of the A index by 10 to make it comparable to the other indices. With the exception of the A measure during the 1979–1983 recession, the indices show similar trends.

The similarities of the trends across most of the indices do not provide a justification for being indifferent about the choice of index. Karmel and MacLachlan (1988) and others show that indices can exhibit inconsistent trends.

In Table 2, I decompose changes in the I_p indices to establish the composition effects. The composition effects for the A index for the four subperiods are calculated as the percentage growth rates of the index magnitudes: $CE_A = 100 \times (A_2 - A_1)/((A_2 + A_1)/2)$. The average value of the A index is used as the base of the calculation. The composition effect for the upturn, 1983–1990, reveals the volatility of the A index under a detailed occupational disaggregation.

Movements in the I_p index disaggregated into the four occupational groups are reported in Table 3. The clerical, service, and sales occupational group is the most segregated, followed by the skilled blue collar, the unskilled, and the professional and managerial groups (see Watts and Rich 1992b for a definition of these occupational groups). In 1992, for example, 33.3% of the clerical, service, and sales workforce needed to be relocated to achieve a structure of employment across these occupations consistent with the gender shares of overall employment, compared with only 19.6% of the professional and managerial group.

Over the period 1979–1992, occupations in the professional and managerial occupational group showed the fastest rate of decline in net segregation, as measured by the composition effect, followed by the unskilled occupations. On the other hand, the occupations that were highly segregated in 1979—clerical, service, and sales and skilled blue-collar occupations—integrated most slowly over the period. Net segregation declined only in the professional and managerial and unskilled occupations during the first downturn. By contrast, over the upswing of 1983–1989, integration occurred across all four groups, with the greatest reductions again in professional and managerial and unskilled occupations. The recession in the period 1990–1992 was qualitatively different, with modest declines in segregation across all the occupational groups. For a more detailed analysis of the pattern of change in gender segregation in the United Kingdom in the period 1979–1989, see Watts and Rich (1993).

CONCLUSION

The study of gender segregation remains an important area of academic research. The gender composition of employment by occupation and its evolution over time is the outcome of the complex interplay of economic, social, political, and institutional forces. These forces cannot be understood and articulated if there is not a coherent means of organizing and reporting the available evidence.

TABLE 1. MAGNITUDES FOR THE *D*, *I_p*, AND *A* INDICES FOR TOTAL EMPLOYMENT IN THE UNITED KINGDOM, BY GENDER: 1979–1992

	Year			
Index	1979	1983	1990	1992
D	0.657	0.648	0.599	0.580
I_p	0.313	0.313	0.295	0.287
A	0.910	0.982	0.539	0.519

Source: U.K. Labour Force Survey

Correctly calculated summary statistics can be a concise means of presenting the dominant trends. Most researchers agree that simple comparisons of index magnitudes either over time or across countries can be misleading unless the index is margin-free or can be decomposed to identify a margin-free element. Many index measures used in recent studies, including the index of dissimilarity and the A index, do not possess the appropriate characteristics for measuring the change in the extent of segregation. The A index is nonlinear and gives greater weight to more segregated occupations. Adoption of a particular measure cannot be justified by the observation that the particular data set under examination yields similar trends based on this and other measures.

The Karmel and MacLachlan index has desirable characteristics for a measure of segregation and has a simple interpretation. The decomposition procedure enables the computation of long-term trends in horizontal segregation in the form of (margin-free) composition effects, differentiated by occupational group, without sacrificing the integrity of the data through aggregation.[10]

The rigorous measurement of the extent of, and change in, the pattern of gender segregation is essential if inferences are to be drawn for policy prescription. The speed of women's entry into atypical occupations is of interest to many researchers (e.g., Figart and Mutari 1993; Reskin and Roos 1990). Although one may derive confidence intervals for the index through jackknifing and other techniques, index measurement does not identify the causal factors that explain the pattern of change over time.

When time-series econometric techniques are applied, problems may arise from the large number of occupations under consideration and the lack of degrees of freedom due to limited data based on a consistent occupational classification. The log-multiplicative models advocated by Charles and Grusky (1995) can be used in cross-country studies and

10. A multidimensional version of the I_p index can be used to explore trends in occupational segregation by gender and race (Silber 1992; Watts 1995b, 1997b).

TABLE 2. I_P INDEX DECOMPOSITION FOR TOTAL EMPLOYMENT IN THE UNITED KINGDOM, BY GENDER: 1979–1992

	Index Values		Index Decomposition (%)					
Period	Initial Value	Final Value	Total Percentage Change in Index Magnitude	Composition Effect	Mix Effect	Gender Effect	Occupation Effect	Gender/ Occupation Effect
I_P								
1979–1983	0.313	0.313	0.06	–0.89	0.95	0.03	1.51	–0.59
1983–1990	0.313	0.295	–6.08	–6.14	0.06	–0.87	1.69	–0.76
1990–1992	0.295	0.287	–2.72	–2.17	–0.55	–0.83	0.60	–0.32
1979–1992	0.313	0.287	–8.74	–9.25	0.51	–1.71	3.80	–1.58
A								
1979–1983	0.910	0.982		7.61				
1983–1990	0.982	0.539		–58.25				
1990–1992	0.539	0.519		–3.78				
1979–1992	0.910	0.519		–54.72				

Source: U.K. Labour Force Survey

can assist in identifying dominant segregation profiles, but the approach is static. Contextual factors can be introduced into the analysis and tested for statistical significance. A comprehensive cross-national study of segregation would embrace both the documentation of trends across countries through index measurement and the use of log-multiplicative models to identify the dominant segregation profiles and significant contextual factors.

The study of gender segregation should not be confined to complex numerical techniques, however. Where appropriate, reference should be made to longitudinal surveys, case studies, and simple descriptive statistics. Researchers should be cautious, however, in using these techniques in order to understand gender segregation processes and to explore other dimensions of segregation. For example, dominant trends may be hidden in a detailed occupation-by-occupation study drawing on descriptive statistics.

APPENDIX

To decompose changes in their index, Karmel and MacLachlan (1988:190–91) define two new indices based on the I_P index:

TABLE 3. I_P INDEX MAGNITUDES AND COMPOSITION EFFECTS, BY OCCUPATIONAL GROUP

	Professional and Managerial		Clerical, Service, and Sales		Skilled Blue Collar		Unskilled	
	Share	I_{P_1}	Share	I_{P_1}	Share	I_{P_1}	Share	I_{P_1}
Index Magnitudes								
1979	0.239	0.226	0.305	0.358	0.193	0.344	0.262	0.317
1983	0.283	0.222	0.309	0.359	0.175	0.364	0.233	0.326
1990	0.321	0.196	0.320	0.344	0.154	0.377	0.205	0.311
1992	0.344	0.196	0.331	0.333	0.139	0.377	0.186	0.306
Composition Effects								
1979–1983	–4.88		1.01		1.69		–2.72	
1983–1990	–11.37		–4.07		–2.93		–7.48	
1990–1992	–2.03		–3.00		–1.19		–1.66	
1979–1992	–18.74		–6.08		–2.54		–11.26	

Source: U.K. Labour Force Survey

Note: The numbers of occupations in each occupational group are 28 for professional and managerial; 21 for clerical, service, and sales; 10 for skilled blue collar; and 17 for unskilled.

$$I_{P_A} = \left(\frac{1}{T_2}\right)\sum_{j=1}^{n}\left|F_{j1} - \bar{a}\left(F_{j1} + M_{j1}\right)\right|\left(\frac{T_{j2}}{T_{j1}}\right), \tag{A1}$$

where $\bar{a} = \sum_{j=1}^{n} F_{j1}\left(\frac{T_{j2}}{T_{j1}}\right)T_2$,

and $I_{P_B} = \left(\frac{1}{T_2}\right)\sum_{j=1}^{n}\left|(1-a_2)\left(\frac{F_2}{F_1}\right)F_{j1} - a_2\left(\frac{M_2}{M_1}\right)M_{j1}\right|. \quad (A2)$

The index I_{P_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 female 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. The percentage (forward) occupation effect is written as $100 \times (I_{P_A} - I_{P_1})/((I_{P_1} + I_{P_2})/2)$.

The index I_{P_B} is calculated by adjusting the numbers of females (males) in each occupation by the increase in total female (male) employment. Thus the overall gender composition of employment corresponds to that of Period 2. The percentage (forward) gender effect is written as $100 \times (I_{P_B} - I_{P_1})/((I_{P_1} + I_{P_2})/2)$.

A third distribution of employment by gender across occupations is generated by successive transformations of the original distribution by the occupation and gender calculations detailed above (Deming and Stephan 1940). On the first and subsequent odd iterations, the levels of female and male employment in each occupation are uniformly adjusted to bring total employment in each occupation equal to that prevailing in Period 2. On the even iterations, the total levels of male and female employment are matched with those corresponding to Period 2 by the uniform adjustment of male and female employment in each occupation. The numerical adjustments continue until the gender and occupational structure of the transformed (Period 1) gender distribution of employment across occupations converges over consecutive iterations. The proportional error must be less than 0.025% with respect to either the gender totals after the occupational transformation or the occupational totals after the gender transformation. Thus, the transformed structure of employment has the same occupational shares of total employment and overall gender shares as the Period 2 distribution, but differs in its gender shares of employment across individual occupations. (For an example of this procedure, see Karmel and MacLachlan 1988:194.)

The index associated with this transformed distribution is denoted as I_{P_C}, and the forward percentage mix effect is $100 \times (I_{P_C} - I_{P_1})/((I_{P_1} + I_{P_2})/2)$. The forward residual interaction effect is $((I_{P_C} - I_{P_1}) - (I_{P_A} - I_{P_1}) - (I_{P_B} - I_{P_1}))/((I_{P_1} + I_{P_2})/2)$. The percentage forward composition effect is $100 \times (I_{P_2} - I_{P_C})/((I_{P_1} + I_{P_2})/2)$.

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