

On the Conceptualisation and Measurement of Horizontal and Vertical Occupational Gender Segregation

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In a series of papers, Blackburn *et al.* claim to solve the conceptual and measurement issues associated with vertical gender segregation by occupation. In this paper it is argued that the authors misinterpret the conventional index measures of segregation, which leads them to a misspecification of their vertical and horizontal components of segregation which are alleged to be orthogonal. As a consequence, the two components are conflated, so that neither component of segregation is correctly calculated. There are also conceptual and measurement difficulties with the cross-national empirical work of Charles (2003). The absence of hierarchical employment data by occupation from the typical Labour Force Survey precludes the estimation of country wide vertical segregation. Data from sources such as the Australian Workplace Industrial Relations Survey will enable the calculation of vertical gender segregation, in addition to the generation of insights about the factors contributing to vertical gender segregation. Case studies too will enable a greater understanding of the extent and causes of vertical gender segregation.

In recent papers, Blackburn, Jarman and Brooks (2000), hereafter BJB (2000); Blackburn, Brooks, Jarman (2001), (BBJ, 2001); and Brooks, Jarman and Blackburn (2003), (BJB, 2003) claim to identify and resolve the enduring conceptual and measurement issues associated with the interpretation of horizontal and vertical occupational gender segregation. Their interest in vertical segregation was promoted by their search for an explanation of the results of their cross-national study (BJB, 2000) in which high levels of gender segregation in countries, including Sweden, Finland and Canada, did not appear to necessarily signify high gender inequality in those countries (BJB, 2001: 511; see also Charles, 2003: 268).

In this comment, I argue that, while it is important to highlight this apparent empirical anomaly, the approach

of the three authors to the conceptualization and measurement of vertical and horizontal segregation is fundamentally flawed, which reflects both a limited definition of vertical segregation and a misunderstanding about what typical indexes of occupation gender segregation actually measure. Charles' cross-national study (2003) also fails to clearly differentiate horizontal and vertical components of segregation.

The Measurement of Segregation

BJB (2000: 124–127) find a consistent non-negative, cross-national correlation between their measure of

occupational segregation based on marginal matching and United Nations development measures of gender equality, even after a normalisation procedure to correct for unequal numbers of occupations across the countries.

BJB (2000: 127–130) assert that traditional segregation indexes measure overall segregation, which, in turn, is the product of two orthogonal components, namely horizontal and vertical segregation (see also BBJ, 2001: 513). These two concepts have important methodological significance, in that vertical segregation is the direct measure of gender inequality in the distribution of men and women across occupations. This gender inequality is manifested in differences in pay, prestige, skill, social stratification, etc. which are associated with better and worse occupations (BJB, 2000: 129). The authors eschew any reference to the underlying power relations in the workplace and hence the notion of hierarchy.^{1,2} They argue that, by contrast, horizontal segregation measures difference without inequality. Traditional measures of segregation are alleged to incorporate a component of inequality, but it is not measured directly, because the measure is also comprised of elements of difference, that is horizontal segregation.³

BJB (2000) resolve the apparent contradiction of the non-negative cross-national correlation by arguing that the significance of the vertical (gender inequality) component of overall segregation varies across countries. In particular, a higher level of overall segregation tends to be associated with a smaller vertical component, since women have a higher probability of attaining the top positions in a particular occupation the greater their share of employment in that occupation (BJB, 2000: 131). In most countries the female share of employment has exhibited a monotonic increase.

The authors measure vertical segregation by Somers D which can be written as:

$$D = (1/FM) \left[\sum_{i=2}^n M_i \sum_{j=1}^{i-1} F_j - \sum_{i=2}^n F_i \sum_{j=1}^{i-1} M_j \right] \quad (1)$$

where the occupations are ordered according to a particular criterion, such as pay, prestige, skill, social stratification, etc. (BJB, 2000: 129) and F_i (M_i) is the number of females (males) in the i th occupation. This measure is also the Lieberman's Index of Net Difference (Lieberman, 1975), which is employed in a study of racial inequality by Fossett *et al.* (1986: 423).

BBJ (2001: 533–34) show that the Gini coefficient is the maximum value of Somers D, when occupations are ranked from the most female dominated to the least, and

where female dominance in occupation i can be measured by F_i/M_i . The Gini coefficient is used to measure overall segregation (the hypotenuse). These measures are argued to be comparable with both using the same statistic on the same set of occupations, albeit ordered differently. BBJ (2001: 517–18) use pay data from the UK New Earnings Survey and scores from the Cambridge Scale of Social Stratification across 371 occupational categories which were converted to scale values and added together with equal weighting. These values were the basis for the ordering of occupations in (1).

Male pay data were employed, along with the male values of the Cambridge Scale in the calculations, both because male data were superior, and since they claimed that inter-occupational differences, reflecting the tendency for men and women to be located in different occupations, were of interest, rather than intra-occupational gender differences.⁴ A positive value for the measure of vertical segregation (1) signifies male advantage, whereas a negative value signifies female advantage. After using the Gini coefficient to compute overall segregation, BBJ (2001) were then able to compute the horizontal component of segregation by using Pythagoras' Theorem.

A Critique

Segregation Measurement

My major point of departure from BBJ in their conceptualization of vertical and horizontal segregation in these papers is in their assertion that *overall* segregation can be measured by one of the traditional measures of segregation employed in the literature. Measures of segregation, which include Marginal Matching, the Index of Dissimilarity, the Karmel-Maclachlan Index and the Gini coefficient, utilize occupational employment data by gender and do not measure *inequality*, but rather the extent of the difference between the occupational distributions of employment for women and men. The metric that is utilized in the calculations is the number of employees by gender and occupation. Thus, these are measures of *horizontal* segregation because they place no formal significance on the gender composition of any particular occupation(s), and hence do not recognize any detailed ranking of the occupations according to hierarchy, status or pay, even though such a ranking based on the occupational classification may have been constructed in other studies (see, for example, the international work of Ganzeboom and Treiman, 1996 and the Australian study by Jones and McMillan, 2001).

Fossett *et al.* (1986: 423) are critical of the Index of Dissimilarity for measuring 'nominal differentiation not inequality', but this criticism is equally applicable to other segregation indexes. Thus there is no justification for arguing that the Gini index is conceptually different from other indexes and actually measures overall rather than horizontal segregation.⁵ Consequently it is incorrect to deduce the extent of horizontal segregation through the calculation of the Gini coefficient (hypotenuse), a measure of vertical segregation based on Somers D and the use of Pythagoras' Theorem. We return to the conceptualization of vertical segregation below.

This curious interpretation of overall segregation and its components by the authors is shown in sharp relief when they consider in turn the use of male pay and the Cambridge Scale by occupation and a combined measure as the metric for the computation of vertical segregation for the British labour force in 1991 and 1996 (BBJ, 2001: 518–521).⁶ First, since horizontal segregation is a residual, its magnitude depends on the choice of the measure actually employed. As a consequence the measure of horizontal segregation exhibits some variation in the three calculations undertaken for each of the two years. Second, the authors impose a convention, whereby a negative magnitude for vertical segregation signifies that overall segregation, which is depicted in the second quadrant of Cartesian space, is also negative. Thus, even though they measure overall segregation to some degree independently of vertical segregation (but see below), the sign of the measure of the former is determined by vertical segregation, that is one of its components, and the sign can change when a different metric is used in the computation of vertical segregation. Third, the simplest, yet most damning criticism is that if the ranking of occupations by status or pay coincides with the ordering by occupation of either the male shares or female shares of employment, then the absolute magnitude of vertical segregation coincides with 'overall' segregation. Then, applying Pythagoras' Theorem yields a zero horizontal component of segregation, irrespective of the variation in the (fe)male shares of employment across the occupations, which is the source of non-zero gender (horizontal) segregation, as typically understood in the literature. The authors would no doubt argue that this example, given the existence of a complete ordering of occupations by status, signifies that vertical segregation, based on these status differences, represents segregation in its entirety, so that necessarily horizontal segregation is zero. If the rankings of occupations by (fe)male employment shares and status do not coincide, then the algebra indicates that horizontal

segregation is non-zero, but this requires a conceptual, not merely an algebraic, justification. There remains a complete ordering of occupations in the vertical plane by status, so why is the independent horizontal component non-zero?

Even if BBJ accepted that the traditional index based measure of occupational gender segregation measured horizontal rather than overall segregation, the measurement of overall segregation based on the two components of horizontal and vertical segregation and the use of Pythagoras' Theorem would still be flawed. It would combine two measures of segregation which were underpinned by the same inter-occupational distribution of employment by gender. It is unclear how it could be argued that these two inter-related measures of segregation were orthogonal, thereby justifying the use of Pythagoras' Theorem to compute the overall level of segregation.

Charles (2003: 269) also appears to be critical of BJB (2000) for not conceptualizing and measuring horizontal segregation independently. She notes that horizontal segregation is the residual association between occupation and sex once gender differences in occupational income (or other vertical indices) have been taken into account. She points out that this approach is likely to lead to an underestimation of the vertical component of segregation, because the horizontal component will be measured as the sum of segregation across the divide between manual and non-manual occupations, but also the unmeasured vertical and horizontal inequalities. In other words, the occupational classification used in the computation of the overall level of segregation contains vertical inequalities which should be added to the pre-existing vertical component. Again it should be emphasized that standard index measures of horizontal segregation do not formally recognize any vertical differentiation between occupations.

Gender Inequality

The authors are correct in arguing that researchers tend to identify traditional measures of segregation with gender inequality, so that the imperative to reduce the index measure to improve women's labour market fortunes is accepted uncritically (Watts, 2003b; Watts and Macphail, 2005). For example, in a recent study, Bettio (2002, S68) reports a positive cross-section relationship between the annual Index of Dissimilarity (ID), based on 110 occupations under the three-digit ISCO 88 classification and the female employment rate across 15 European countries. She concludes that a

rising female share of employment can have a detrimental effect on segregation.

Some high ID countries, including Sweden, Denmark and Finland, promote the employment of women, yet Emerek *et al.* (2003: 4) report that the European Council of Ministers recommended that the Scandinavian countries design employment policies in 2000 to reduce segregation.

Indexes of segregation measure the extent to which men and women are unequally represented across occupations. Most measures are symmetric, so that whether women are under- or over-represented in higher and lower status occupations makes no difference to the measure of segregation.⁷ Further the interpretation of annual observations of a single aggregate measure of occupational segregation tends to be based on the dubious premise that ‘universal segregative and integrative forces dwarf occupation specific forces’ (Weeden, 1998: 4; see also Charles, 1998: 109) so that changes in the summary measure adequately capture the complexity of changes across groups of occupations. Also, by failing to recognize the symmetry of the measure, the researcher may incorrectly conclude that women are systematically enjoying improved (worse) occupational attainment according to whether the index is falling (rising).

Controversy continues as to the appropriate measure of horizontal measure of segregation (see the recent work of Watts, 1998a,b; Grusky and Charles, 1998; and Mora and Ruiz-Castillo, 2003, for an indication of the state of the index war). Watts (1992, 1998a) argues in favour of the KM index, which has a number of desirable properties, including one which is particularly relevant to the interpretation of movements over time of horizontal segregation. First, a margin free Composition Effect can be constructed, which overcomes one of the deficiencies associated with simple index calculations. Second, the KM index can be disaggregated to reveal the contributions of different occupational groups (OGs). Then some form of qualitative judgment can be made about women’s progress in the labour market, according to rates of segregation or integration of the different OGs, and the relative status or earnings of the OGs. For example, in recent time series studies of Australia and Canada (Watts, 2003b; Watts and MacPhail, 2005), the rate of integration was found to have stagnated, yet a closer examination of the data revealed that women now predominated in the higher status professional occupations, which contributed positively to the level of segregation.⁸

A quantitative approach to measuring the evolution of occupational gender inequality could draw on the Somers D index as utilized by Blackburn *et al.* in their

measure of vertical segregation and by Fossett *et al.* (1986: 423) in their study of racial inequality. The relative status of different occupations is reflected in their ranking. Alternatively a traditional measure of segregation can be employed weighted by the corresponding socio-economic index which captures the absolute measures of status across occupations (see Watts, 2003a).⁹ In Australia, Jones and Macmillan (2001) have constructed an index for 300 occupations under the ASCO 2nd division classification which reflects the approach of Ganzeboom *et al.* (1992). Such measures must be viewed as complementary to the traditional measures of (horizontal) segregation. They cannot be construed as measuring an orthogonal, vertical component of segregation, because they draw on the same inter-occupational distribution of employment by gender.

The Concept of Vertical Segregation

Concepts in the social or physical sciences should be defined in such a way as to inform the processes of theory development and empirical investigation. Necessarily the concept of vertical segregation must define a distinct dimension of gender segregation which is not conflated with horizontal segregation.

Thus, as noted above, a measure which draws on the distribution of employment by occupation and gender, albeit complemented by a measure of status or earnings, cannot be viewed as independent of the measurement of horizontal segregation. Charles (2003: 271) also conflates the two dimensions of segregation in her empirical work. She identifies vertical segregation with men’s domination of the highest status occupations within the manual and non-manual sectors, as measured by the major occupational category values of the internationally standardized socio-economic index (SEI), published by Ganzeboom and Treiman (1996). On the other hand, she identifies horizontal segregation by the differentiation of male-dominated manual from female dominated non-manual groups of occupations. Thus, the measures of the two dimensions of segregation are underpinned by the same classification of occupations, and the associated gender distribution of employment.

Anker (1997) acknowledges the hierarchical dimension of vertical segregation in the context of the distribution of men and women employed in the same occupation ‘but with one sex more likely to be at a higher grade or level—for example, men are more likely to be production supervisors and women production

workers, men more likely to be senior managers and women junior managers'. A measure which recognized that there were intra-occupational gender differences in status and/or earnings would address to some degree the complaint about the absence of an independent measure of vertical segregation. However, Jones and MacMillan (2001: 548) argue that there is minimal empirical pay-off from the construction of gender-specific quantitative scales (levels of status), so that a measure collapses to one based on inter-occupational status differences with its attendant problems. On the other hand, if earnings by occupation are utilized, then the measure picks up gender wage inequality, based on both inter- and intra-occupational gender wage differences. Hakim (1996: 150–151) and Fortin and Huberman (2002: S26–S27), amongst other researchers, argue that intra-occupational wage inequality is a major source of gender wage inequality in the UK and Canada, respectively, rather than inter-occupational wage differentials compounded by horizontal gender segregation.¹⁰

If the concept of vertical segregation is to have independent meaning and inform the process of gender segregation, then each occupational category would need to incorporate a hierarchy of job classifications for which employment data by gender were available. Each set of hierarchically differentiated occupations¹¹ would contribute to the computation of vertical segregation within each occupational category. Thus, by construction, no occupational category would be comparable from a hierarchical perspective,¹² and each would contribute to the measure of horizontal segregation. While the computation of the vertical component of segregation indirectly draws on aggregate employment by gender in each occupational category, the independence of this computation from the horizontal component would arise because separate employment figures by gender were available for each position on the job ladder for each occupational category.¹³

However, this hierarchical differentiation within occupations tends to be suppressed in the occupational classification, even at high levels of disaggregation. For example, the two digit level of the Australian Standard Classification of Occupations (Second Edition) includes 24: Education Professionals, which in turn is broken down into 241: School Teachers; 242: University and Vocational Education Teachers; and 249: Miscellaneous Education Professionals. At the 4 digit level, both 241 and 242 identify different types of School and University teachers, respectively, such as Primary School Teachers and Secondary School Teachers, and University Lecturers and Tutors, and Vocational Education Teachers,

rather than Junior, Senior and Head Teachers, and Lecturers, Senior Lecturers and Professors.

The problems with the occupational classification are not confined to specific occupations such as Education Professionals. While the major occupation, Managers and Administrators, is sub-divided into such categories as Engineering, Production, Sales and Marketing and Health Services, a reclassification of these positions to specific groups of occupations, which, it could be argued they head, is problematic, in the absence of clearly defined and consistent job ladders within and across establishments. In addition, generic managerial occupations are also defined, such as Generalist and Specialist managers, which are even more difficult to reclassify.¹⁴

Fortin and Huberman (2002: S12) differentiate between two forms of vertical segregation with the first being intra-occupational, if it occurs in similar lines of work, and the second being inter-occupational if it is founded on the hierarchical comparison of jobs across occupations. They fail to note that the latter undermines an independent measure of horizontal segregation. In line with BJB (2000), Fortin and Huberman (2002: S12) argue that vertical segregation is likely to decline as women gain higher levels of educational attainment and experience over time, whereas horizontal segregation, which is often associated with stereotypical gender roles, is likely to persist.¹⁵

Measuring Vertical Segregation

Putting aside the constraints of the occupational classification on the availability of employment data for hierarchically differentiated jobs, how should vertical segregation be measured? If the metric for measurement is merely employment and a standard segregation measure is utilized, such as the Gini coefficient or the KM index, then such a measure will be silent as to whether men or women dominate in the most senior positions in each occupation. In the same way indexes designed to measure horizontal segregation would measure nominal differentiation, not (hierarchical) inequality. The most suitable measure of vertical segregation would be Somers D based on the hierarchical ranking of each set of jobs within each occupational category. If absolute measures were available for each set of hierarchical jobs then a simple computation would be available to compare the average status of men and women in each occupational category.

The final question is whether it is meaningful to identify total gender segregation as some form of addition of

the horizontal and vertical components, when the two components are likely to be defined across different metrics. While the adoption of Pythagoras' Theorem to combine the two components has some appeal and signifies that the two components are orthogonal, their summation has little meaning. To claim that one country or state is more segregated than another due to a higher value for the aggregated measure begs the question as to the sources of that higher level of segregation. Researchers would again have to address the sort of puzzles which BBJ claim to address in their measurement of horizontal and vertical segregation.

High levels of vertical segregation signify the need for stronger forms of affirmative action and family friendly policies to enable women to achieve more senior positions. On the other hand, the persistence of high levels of horizontal segregation can be explained by a number of theories, which include feminist theory (Anker, 1997), statistical discrimination and human capital theory, which provide clues as to appropriate policy development.¹⁶

Conclusion

Researchers into the sources of gender inequality in the labour market typically refer to patterns of horizontal and vertical segregation and intra-occupational wage inequality, but the concept and measurement of vertical segregation have remained undeveloped, in part due to the absence of adequate data. Blackburn, Brooks and Jarman deserve acknowledgement for trying to address this complex issue.

The prime objective of this paper has been to demonstrate that their conceptualization and measurement of these dimensions of segregation is confused and ultimately unconvincing. Blackburn *et al.*'s denial of the relevance of empowerment and hence their rebuttal of measures of workplace authority lead to a trivialization of the concept of vertical segregation. Their measure of overall segregation measures nominal differentiation. As a consequence it can be shown that their residual measure of horizontal segregation can be zero, despite the presence of significant nominal differentiation. If vertical segregation is to be conceptually distinct from horizontal segregation, then its measurement cannot draw on inter-occupational comparisons of employment by gender.

It is very unlikely that employment data will be collected in the Labour Force survey such that pairwise comparisons of all combinations of occupations are possible to identify the corresponding horizontal or vertical

relationships. Unless this is done, it is likely that economy wide measures of vertical segregation will be somewhat meaningless, because of being conflated with horizontal measures. Some insights about the extent of vertical segregation by gender may be gained by researchers through achieving a better understanding of hierarchical job structures within firms through case studies, although generalizing from specific case study data is problematic.

In a recent paper, Harrison (2004) draws on the Australian Workplace Industrial Relations Survey (AWIRS) and is able to provide a ranking of men and women by workplace responsibility, as well as one by wages. She employs a probit analysis to establish the determinants of women's attainment of managerial positions, drawing on individual and workplace characteristics. However, the occupational composition of employment by gender at each rank could be utilized to generate measures of horizontal measures of gender segregation to complement a vertical measure.

Notes

1. BJB (2000: 123) refer to the three components of the United Nations Gender Empowerment measure, which they note 'are not directly concerned with gender equality, but with women's involvement at the top of the stratification structure, their empowerment'.
2. Charles (2003: 270–271) pays lip service to male primacy, that is that men are more suited to positions of authority and domination, but in her empirical work utilizes the internationally standardized socioeconomic index for the major occupational categories developed by Ganzeboom and Treiman (1996).
3. BJB (2000: 128) are critical of Hakim (1979, 1981) for referring to the overall measure of segregation as horizontal, when the former has vertical and horizontal components. Consequently horizontal segregation is then often used as a measure of (vertical) inequality, so that the horizontal is treated as the same as the vertical.
4. Charles (2003: 267) also interprets vertical segregation as synonymous with status differences across occupations in her study of nine groups of occupations.
5. The index measures have different properties of course with the Gini index giving 'disproportionate weight to occupations with extreme gender concentration' (BBJ, 2001: 514).
6. The identification of vertical segregation with gender differences in workplace authority (Wright *et al.*, 1995) is rejected by BBJ (2001: 517), who argue that

their two measures (pay data and a score from the Cambridge Scale of Social Stratification) are highly correlated and 'cover the relevant possibilities well'. The high correlation of two job characteristics across occupations does not justify using these measures of nominal differentiation between occupations as the basis for computing vertical segregation, without more substantive justification.

7. Of course, this is not strictly true because representation has to be understood in the context of overall gender shares of employment which are determined by gender shares across occupations and shares of total employment across the occupations.
8. The index calculations were based on five occupational groups, namely Managers and Administrators; Professional; Clerical, Sales and Service; Tradespersons and Less Skilled.
9. The index can take positive and negative values, according to whether males or females predominate in the higher status occupations.
10. Hakim (1996: 151–152) also highlights the importance of job segregation at the establishment level, which limited the impact of equal pay legislation until equal pay for work of equal value was introduced at the request of the European Union. This allowed comparisons of the different jobs undertaken by men and women which were of equal value to the employer.
11. A simple example would be University teachers being divided hierarchically into Professors, Associate Professors, Senior Lecturers and Lecturers, although even here the line of command can be unclear if an Associate Professor is Head of the academic unit.
12. For example, an engineer and a shop manager can be compared by reference to status and pay, but are not located on the same hierarchical job ladder.
13. There is an analogy here with the standard analysis of variance in which the overall variance of a sample is divided into inter-group and intra-group variances, but we will argue that this summation has little meaning in the context of segregation.
14. Both Hakim (1996) and Anker (1997) also note that the vagaries of the occupational classification can influence the interpretation of the measure of gender segregation. For example, when men work as doctors and women as nurses, this would be horizontal segregation in a three-digit ISCO classification where these two occupations are classified separately; but this same phenomenon would be vertical segregation in a two-digit ISCO classification where medical, dental and veterinary workers are combined into one occupational group (Anker, 1997), but it would be suppressed. Hakim (1996: 155–157) examines women's shares of employment in the top jobs for 1971, 1981 and 1990, based on census and labour force data, but again notes the deficiencies of the occupational classification, even at its most detailed level, in identifying the extent of vertical segregation.
15. Fortin and Huberman (2002: S12) identify horizontal segregation with gender segregation into jobs with equivalent educational and other requirements, but the reference to educational qualifications seems to be redundant, since gender segregation is measured with respect to the unequal distribution of men and women across occupations with no linking of occupations requiring similar levels of educational attainment. Indeed an important feature of gender segregation within a number of countries, including Canada and Australia, is that the relationship between educational attainment and occupational status differs markedly between men and women.
16. For a recent review of theories of occupational gender segregation, see Watts (2003b).

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Manuscript received: February 2005.