Industrial and Occupational Sex Segregation Measurement Methodology: A Discussion

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Abstract

During the past few decades, several indices were developed to search for the best measure of the complex phenomenon of gender segregation, for example Duncan and Duncan index of dissimilarity. Karmel MacLachlan (IP) index; Employment standardized index of dissimilarity, Size standardized Dissimilarity index, Association index under Structured Log Linear model, Total occupational concentration, Male or female-dominated occupations and Gender labelling of Industries etc. The objective of this paper is to present and discuss the methodologies used to measure occupational sex segregation. I have made attention to the question, of how the degree of segregation should be measured. It is concluded that the measurement of the level of segregation by sex is still a matter of great controversy. No index is right for all proposes and the appropriate index can be chosen according to the study's objective.

Differences in the distribution of workers (male and female) across and within the units of establishments, such as industrial or occupational groups, are defined as sex segregation *(RESKIN, 1993; JAMES AND TAEUBER, 1985; BLACKBURN ET AL., 1995; CHARLES AND BRADLEY, 2002).* This segregation has been identified as a significant contributor to the gender wage gap, job quality, and employment disparities *(AMUEDO DORANTES AND DE LA RICA, 2006; ISMAIL ET AL., 2017; BRYNIN AND PERALES, 2016; STRAWINSKI ET AL., 2018).*

During the past few decades, several indices were developed to search for the best measure of the complex phenomenon of gender segregation. Many researchers have stated that no single summary index can capture all relevant aspects of levels of segregation in the labour market or that no index is right for all proposes *(HAKIM 1993a; 1993B; 1992; JACOBS 1993; JACOBS 1989; WATTS 1993, 1998; CHARLES AND GRUSKY 1998; 1995; ABRAHAMSON AND SIGELMAN 1987)*

The objective of this paper is to present and discuss the methodologies used to measure occupational or industrial sex segregation. I have made attention to the question, of how the degree of segregation should be measured. Different researchers used several different methods. I have included the Duncan and Duncan index of dissimilarity. Karmel MacLachlan (IP) index; Employment standardized index of dissimilarity, Size standardized Dissimilarity index, Association

index under Structured Log Linear model, Total occupational concentration, Male or female dominated occupations and Gender labelling of Industries in my analysis and tried to find out the advantages and disadvantages of different measurement methods.

DUNCAN AND DUNCAN DISSIMILARITY INDEX (D)

Most research on occupational sex segregation has used index of dissimilarity (D), proposed by *DUNCAN & DUNCAN (1955).* It compares male and female along all occupations. This index (D) measures the main dimensions of segregation: the degree to which two groups are dissimilarly distributed over a set of categories i.e. it represents the proportion of women who would have to change occupations if women were to be distributed in the same manner as men. The dissimilarity index is based on comparing the distribution of women and men across all occupations. This index is half a sum of the absolute differences between the proportion of female labour force in a certain occupation and the male labour force in that occupation. D is symmetrical, which means that the same proportion of men would have to change occupations if men were to be distributed in the same manner as women. The value assumed by D varies from 0 to 100. The value 0 means no differences between occupational distribution of men and women and the value 100 means there is no overlap between the occupational distributions of the two groups. This index can be expressed through equation (i):

$$D_{ik} = \tfrac{1}{2} \sum_{j=1}^{N} | P_{ij} - P_{kj} |\text{------------(i)}$$

Where P_{ij} is the percentage of group i in the occupation j and P_{kj} is the percentage of group k in occupation j, N is total number of occupations.

There has been a lot of debate on the suitability of this index *(e. g. HAKIM 1992; 1993b; CHARLES AND GRUSKY 1995)*. However, there are some potential limitations in using the dissimilarity index (D) to measure segregation within occupations.

CORTESE, FALK, AND COHEN (1976) explores the mathematical properties of Duncan and Duncan's index which lead to difficulties of interpretation. The major objections of the index of dissimilarity follow:

1. The expectation of 'evenness' as the opposite of segregation is not as useful in most cases as the concept of 'randomness'
2. D is affected by the difference in the proportion of the minority in the population, thus preventing intercity comparisons.
3. D is affected by the size of the area unit of analysis.
4. The present interpretation of D is misleading, since it does not include the concept of replacement.

CORTESE, FALK, AND COHEN (1976) feel that the objections to D, which have been voiced, are not minor in their effect on the use of the index.

One another well-documented shortcoming of the index of dissimilarity is that it does not produce a consistent level and trend of segregation among different regions during the same period. It is not entirely margin free, which is of interest when we want to measure differences in segregation between different regions. The

same is true for comparison over time. Through the dissimilarity index is invariant for multiplicative shifts in the sex composition of the labour markets, but not for similar shifts in the occupational structure *(NERMO 2000)*. For instance, if many workers are in the occupations containing relatively few individuals, may be biased upward simply because of the small numbers involved *(CORTESE, FRANK, & COHEN 1976).* Many studies of sex segregation try to overcome this weakness by using a size-standardized version of the dissimilarity index (Ds) as a complement *(JACOBS AND LIM 1992; JACOBS 1989; CHARLES AND GRUSKY 1995).*

EMPLOYMENT STANDARDIZED INDEX OF DISSIMILARITY

The index of segregation has two components, labeled the "mix effect" and the "composition effect" by *BLAU AND HENDRICKS (1979).* The value of the index depends upon both the relative size of the various occupations and the sex composition within occupations. The value of the index may also depend upon the degree of aggregation of the occupation. Typically, the greater the degree of aggregation, the lower the level of measured segregation. Thus, changes in the index derive from changes in the occupational distribution, changes in the entry mix of men and women into various occupations, and the interaction between changes in composition and mix. These changes may be in reinforcing or opposing directions. A standardization procedure can be employed to determine the influence of each of the effects. To determine the effect of changes in sex composition within occupations on change in segregation index from year t-1 to year t, the index of segregation of year t can be computed by standardizing the

size of occupations to year t-1. Thus, the employment –standardized index of segregation holds constant the distribution of employment across occupations (occupational mix) and enables us to observe the effects of change in the sex composition within specific occupations *(BELLER 1985)*. The employment-standardized index of segregation is defined as follows (equation (ii)):

$$Ds=\frac{1}{2}\sum_{J=1}^{N}\left(\left[\frac{(F_j/P_{tj})(P_{jt-1})}{\sum (F_j/P_{tj})(P_{jt-1})} - \frac{(M_j/P_{jt})(P_{jt-1})}{\sum (M_j/P_{jt})(P_{jt-1})}\right]*100\right)----(ii)$$

Where P_{tj} refers to the total number of males and females in the jth occupation at time t, P_{jt-1} refers to the total number of males and females in the jth occupation at time t-1 (i.e. $P_j = F_j + M_j$), F_j is the total number of females in the occupation j, M_j is the total number of males in the occupation j and N refers to total number of occupations.

SIZE STANDARD DISSIMILARITY INDEX

The size standardized dissimilarity index is the absolute measure of segregation that controls the effect of the occupational structure treating all occupations as if they have the same size, calculated over a fixed number of comparable occupational categories *(CHARLES, GRUSKY, 1995).* The difference between D and Ds is that the latter is not sensitive to the structural changes; that is changes over time in a large occupation are of the same importance for the level of segregation as changes in a smaller one. This allow us to determine what the level of segregation would have been if the relative size of different occupations had remained constant

over time *(JACOBS AND LIM 1992; JACOBS 1989;)*. As D, 0 represents perfect integration and 100 represents perfect segregation. This index can be expressed through equation (iii): -

$$Ds = \frac{1}{2} \sum_{J=1}^{N} \left(\left[(Fj/Pj) / \sum (Fj/Pj) - (Mj/Pj) / \sum (Mj/Pj) \right] * 100 \right) \text{------(iii)}$$

Where Pj refers to the total number of males and females in the jth occupation (i.e. Pj = Fj + Mj), Fj is the total number of females in the occupation j, Mj is the total number of males in the occupation j and N refers to total number of occupations.

This type of standardization has been applied by *PRESSER AND KISHOR 1991; JACOBS 1989; AND JACOBS AND LIM 1992).* However, the use of Ds2 is far from cost-free since it lacks one quality that the original dissimilarity index possesses, that is, the index of dissimilarity is invariant under multiplicative transformations of the sex ratio but not under multiplicative transforms of the occupational margins. At the same time, the size-standardized index successfully eliminates the latter dependence, but only at the cost of losing the scale invariance that characterized the original index *(CHARLES AND GRUSKY 1995; GRUSKY AND CHARLES 1998; HAKIM 1993; JACOBS 1993; WATTS 1993, 1998; WEEDEN 1998; CHANG 2000).*

HAKIM (1992) discovered that values of indices vary with the degree of detail in the occupational classification, the greater the number of occupational classifications, and the higher the level of segregation and vice versa. The value of index may also vary according to the base of population selected and the fact weather the

index takes into account changes in labour force and occupational structure. Despite the fact that two different regions share the same level of segregation in same specific time, the patterns, content and meaning of segregation might vary strongly between these two regions.

Such summery measures provide convenient snap shots of the distribution of men and women across occupations, at best they leave many interesting issues unanswered, and at worst they provide misleading portrayals of women's economic status across societies. *(CHANG 2000)*. The choice among various segregation indices has become the subject of much debate

KARMAL AND MACLACHLAN INDEX (KM INDEX)

Watts himself explained that the analysis of sex-segregation in any occupation would not be complete until the respective shares of both males and females in total labour force participation are not taken into account *(WATTS, 2013)*. So, he favours **Karmal and Maclachlan Index (KM Index)** which is given as follows:

$$I = \frac{1}{T} \sum_{j=1}^{n} \left| f_j - a \left(m_j + f_j \right) \right|$$
$$= \frac{1}{T} \sum_{j=1}^{n} \left| (1-a) f_j - am_j \right|$$

where T, a, f_j, m_j are defined as total employment, the overall female shares of employment and female and male employment in the jth occupation, respectively. The index denotes the fraction of total employment that would have to be relocated between occupations to achieve zero gender segregation. This index is a measure of difference between the integrated and actual distribution of employment by gender. Over time, both the occupational shares and overall

gender shares of employment typically change. KM index being sensitive to these interrelated changes, is considered a better measure than the simple ID.

ASSOCIATION INDEX UNDER STRUCTURED LOG-LINEAR MODEL (A)

In recent years the full potential of log-linear modeling has been put forward as an alternative to more traditional ways of studying sex segregation *(CHARLES 1992; CHARLES AND GRUSKY 1995, 1998)* the advantage of using log-linear models instead of various versions of dissimilarity index is that it provides a margin free study of net of variations in the association between sex and occupational structure. The association index is an indicator of occupational sex segregation that intends to control the effects of sex composition and occupation structure of the labour force. The index is derived from saturated log-linear models and the interaction terms are used to generate a segregation index not affected by variation of the sex ratio and of the occupational distribution. Three indexes are derived to compute the Association index (A) Rj, Vj, and R.

The index Rj is the average of the logarithms of the sex ratios among the occupational categories and is expressed through equation (iv):

$$Rj = 1/n \sum \log (Fj/Mj) \text{---------(iv)}$$

The Vj index is the deviation of the ratio of women on men in occupational group j in relation to the mean ratio of all groups, that is the deviation of the group in relation to the female representation. It can be expressed through equation (v): -

$$Vi = \{ \log (Fi/Mi) - 1/n \sum \log (Fi/Mi) \}\text{----------(v)}$$

R is the average of the sum of the deviations of each group in relation to the representation of the sexes. Integration requires R=0 and exp®=1. R can be expressed through equation (vi): -

$$R = 1/n \sum | \{ \log (Fi/Mi) - 1/n \sum \log (Fi/Mi) \} | \text{-------------(vi)}$$

The index A is a derived from R, when the square root of this indicator is exponentialized. A=1 in a perfectly integrated labour market. A can be expressed through equation (vii):

$$A = e^{[1/n \sum \{ \log (Fj/Mj) - 1/n \sum \log (Fj/Mj) \}^2]^{1/2}} \text{----------------(vii)}$$

Where Fj is the total number of females in the occupation j, Mj is the total number of males in the occupation j and n refers to total number of occupations.

However, log-linear modeling presents only half of the sex segregation story, since it controls for differences important for variations in the absolute level of sex segregation. For example, a margin measure suggests that a small occupational category has the same weight as larger ones *(NERMO 2000)*.

TOTAL OCCUPATIONAL CONCENTRATION

As a complement to the dissimilarity index, Concentration index is used to study the distribution of women and men in different occupations in the labour market *(LEINIO 1988)*. The concentration index C is calculated

separately for women (FC) and men (MC). It measures the extent, for instance, women's work is concentrated in certain occupations in the labour market. Thus, the index (FC) gives the proportion of women who would have to change the occupation in order for all women to be equally distributed in all occupational categories in the labour market. It can be represented through following equations (viii) and (ix):

$$MC = \sum (Mi/M)^2 \text{-------------(viii)}$$
$$FC = \sum (Fi/F)^2 \text{---------------(ix)}$$

Where Fj is the total number of females in the occupation j, Mj is the total number of males in the occupation j and M and F are total number of male and female workers respectively,

MALE OR FEMALE DOMINATED OCCUPATION:

The single segregation index implicitly entails a sharp male-female dichotomy by expecting that absence of segregation should mean an absolutely uniform sex ratio in every occupation. The reality however shows that there do not exist only male or female occupations in the labour market. Most of the occupations employ both women and men, and the gender composition in some occupations might be becoming more balances, while other might be becoming more segregated.

Other measurement used is the gender composition of the occupational structure. This is the measurement that can be referring to segregation measure. Concept of segregation should be used in the context of aggregated occupational structure based on gender compositions in individual occupations. Attentiveness, instead, shows the share of the workforce in an occupation. Men's share of a male-dominated occupation may be rising; yet

their concentration in the occupation may falling because of the decreased demand in that occupation but greater employment growth in other occupations. Especially during the 1990s, an analytical framework, which distinguishes integrated and segregated occupations, was used in many international studies *(HAKIM 1992; 1993b; MELKAS AND ANKER 1997)*. This method allows for a more informative and more flexible analytical framework for historical, comparative and longitudinal gender segregation. *HAKIM (1993b)* pointed out that, the definition of integrated and segregated occupations usually varies between different studies and that different studies are not inevitably comparable. Quite often the definition of the integrated and the segregated occupations are related around the women's share in the labour market *(HAKIM 1993b)*.

BELLER (1984, 1985); JUSENIUS (1977) define the sex label according to deviations from the sex composition of the labour force as a whole in the given year. *BELLER (1984, 1985)* Allowing for some random deviations of up to +- .05, he denote PMt as the male proportion of employment in the experienced civilian labour force in year t, and PMit as the corresponding male proportion in occupation i in year t. than the occupation shall be "male" if PMt + .05 < = PMit and "female" if PMit < = PMt -.05. If neither of above holds, and PMt-.05< PMit< PMt +.05 the occupation is labeled integrated.

It is clear that this criterion is not suitable for comparison of data of various census and various districts because sex ratio differs between different districts and census and over time, and the criterion will change as sex composition of labour market changes during the period. A base year has to be defined. Moreover, the choice of 5% is arbitrary.

To beat this inadequacy an alternative definition of segregated and integrated occupation is used: Percent share of a group in an occupation could be 0 to 100. The best method for labeling occupations is dividing this interval (0-100) into three equal parts We can defined occupation labels as if more than or equal to 66.66 percent employed labour force are men than occupation is male dominated. If percentage of male labour force is between 33.33 to 66.66 than occupation is called integrated and if percentage of male labour force if less than 33.33 percent than occupation is labeled as non-male dominated occupation or female dominated occupation.

However, the gender labeling method is much more time-consuming, less economic and elegant, but by using it, one can identify which individual occupations are female, male or integrated as well as study the possible changes in the sex ratio of occupations during the time. Also, one can describe what kind of work, men and women do on the labour market. In addition to these, segregation classification shows how the workforce actually concentrates in the segregated and integrated occupations. According to **HAKIM (1993b)** it is use full tool for analyzing trends and patterns as well as causes and consequences of gender segregation. It allows for comparisons between different labour market sub-groups. It can be adapted to cross-national comparisons. It is not excessively sensitive to the degree of detail in occupational classification available, and it facilitates theoretical linkages between macro-level studies within industries, occupations, regions, and labour market sub-groups.

As revealed by the above discussion no single method can capture all relevant aspects of sex segregation in the labour market. All methods have some qualities and some limitations. To capture all features of sex segregation in Rajasthan all these methods are used by more-or-less.

Gender labeling of industries

The following two alternative criteria for sex labeling are used:

Domination criterion 1 (DC1): - In the literature of segregation labeling is done on the bases of the sex composition of total working population *(Beller 1985, Jusenius 1977).* Let the industry is labeled "female" if PFit >=PFt + .05 and "male" if PFit < = PFt -.05. If neither of above holds, and PFt-.05< = PFit< = PFt+.05 the industry is labeled integrated. Where PFit is the female proportion in industry i in year t. It is clear that this criterion of domination is not suitable for comparison over time because the criterion will change as sex composition of labour market changes during the period. A base year has to be defined. Moreover, the choice of 5% is arbitrary. In 1981, share of female in total labour force is 7.77 percent. Above definition tells that industries having greater than 12.77 percent (7.77+5) women share are female dominated and having less than 2.77 percent (7.77-5) women share are male dominated rest are integrated but it doesn't seems to be reasonable that a industry with 87.23 percent males or only 12.77 percent females is labeling as female dominated industry and if 5% is replaced with 10%, then according to the definition industries with greater than 102.23% male share are male dominated industries, which is absurd.

Domination criteria 2 (DC2): - percent share of a group in an industry could be 0 to 100. As already mentioned, the best method for labeling industries is dividing this interval (0-100) into three equal parts. This second criterion is independent of sex ratio. If more than or equal to 66.67 percent of workers in any industry are male the industry is designated as male

dominated. If percentage the of male workers is between 33.33 percent and 66.66 percent then that industry is called integrated and if percentage of male labour force is less than 33.33 percent then industry is labeled as female dominated industry. Use of this criterion in place of the former criterion will reduce the number of females dominated industries

Conclusion

The most significant theories applied to the question of gender inequality in the labour market are either action-oriented theories such as the human capital theory or theories with a more structural approach. These frameworks are mainly concerned with people's choice of occupation or with barriers, which limit women's opportunities to choose an occupation in a society *(NERMO 2000)*. Most attempts to measure relative segregation are based on a prior 'ideal' distribution. That is the complicated details of geographical distribution and clustering are ignored to get a simple overall index of segregation. Therefore, the idea of distribution has usually been taken to be an even distribution *(JAHN, SCHMIDT, AND SCHRAG 1947; CORTESE, FALK, AND COHEN 1976)*. Measurement of the level of segregation by sex is still a matter of great controversy. No index is right for all proposes and the appropriate index can be chosen according to the objective of the study.

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