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Measuring the occupational segregation of males and females in Pakistan in a multigroup context

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This study measures the occupational segregation of male and female workers in Pakistan using the microdata obtained from the labour force survey of Pakistan for the period 2013–18. The local segregation method is used to study occupational segregation by gender and for several subgroups based on individual and labour market characteristics. Results show that female segregation explains a substantially large proportion of the overall gender segregation, even though the demographic weight of the female labour force is low compared to the male labour force. The analysis of different age groups shows that occupational segregation is significantly higher among elderly males than males in other age groups. Similarly, for females, occupational segregation is significantly higher among elderly females compared to females in other age groups and males in any age group. Furthermore, it is also found that human capital characteristics such as higher education do not contribute to reducing occupational segregation in the labour market, as both males and females with higher levels of education are more segregated than those with low education. Finally, the study concludes that the devaluation and compensating differentials theories partially explain gender segregation in Pakistan.

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Introduction

Differences in the distribution of demographic groups (e.g., male and female) across the units of establishments, such as industrial or occupational groups, are defined as occupational segregation (Reskin, 1993; James and Taeuber, 1985; Blackburn et al., 1995; Charles and Bradley, 2002).

The segregation of men and women across and within jobs is often attributed as a major cause of gender disparities in labour market outcomes. It has been identified as a significant contributor to the gender pay 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). Male and female enters the labour market with different expectations. However, the segregation of different demographic groups in a few occupations affects their labour market expectations and reinforces gender-role norms in society; it may also undermine the returns from labour market participation (Sinclair and Carlsson, 2013). Over the years, occupational segregation by gender has received considerable importance from both economists and sociologists (Reskin, 1993; Anker, 1998; Blau et al., 1998; Chang, 2004; Charles and Bradley, 2002; Del Río and Alonso-Villar, 2010; England, 2010; Rapoport and Thibout, 2018).

Economic theories offer two main explanations for gender segregation in different occupations. The compensating differentials theory suggests that if women prefer jobs with comfortable and less hazardous working conditions, such as the mother-friendly work environment, fewer working hours, or low physical danger, they will compromise earnings for other non-pecuniary compensation. However, many studies indicate that 'compensating differentials does not entirely explain the pay gap between male and female jobs (England, 1992). However, the crowding hypothesis suggests that women receive lower wages because they are crowded in a limited number of occupations, which results in excess (female) labour supply and suppresses wages (Bergmann, 1974).

Alternatively, the devaluation theory presents a sociological perspective to explain the lower earnings of females. This theory suggests that these wage differences occur because of the institutional norms and social values of women's work and occupations. The gendered cultural norms assign high value to work performed by men, and the work performed by women is mainly considered worthless (England et al., 2007; Reskin and Maroto, 2011; Levanon et al., 2009). The first theory assumes that female workers choose between pecuniary and non-pecuniary benefits. The latter suggests that the workers are subjected to constraints that limit their ability to earn and receive benefits.

Pakistan is a patriarchal society, and women are subject to severe economic and social vulnerabilities (Sarfraz et al., 2022). The prevailing social norms expect men to be the primary breadwinners. Women are generally expected to remain at home and take care of household responsibilities, limiting the power, access and opportunities for women. The participation of females (22%) in the labour market is substantially lower than that of men (84%). Even though female labour force participation as a percentage of male labour force participation has increased from 13.32% in 1990 to 27.18% in 2018, it is still the lowest in the region.

Despite the improvement in the female labour force participation rate during the last two decades, gender differences are visible across industrial sectors and occupations. According to recent labour market statistics, the largest proportion of women workers is engaged in agriculture, forestry and fishing sector (67%), while there are almost no women in sectors such as mining and Quarrying. Regarding occupational distribution, most of the women work as skilled agriculture, elementary, craft and related trade workers. The global gender gap index (2020) has ranked Pakistan at 153 out of 156 countries. Several empirical studies have also shown the existence of a substantial gender wage gap in the labour market, and women who do work earn disproportionately lower wages and have less social protection (Nazli, 2004; Ahmed and Hyder, 2008; Mahmood et al., 2020).

Gender segregation can have significant policy implications in the case of Pakistan as it shapes the skill composition of the future workforce and thus may represent a hurdle for labour market productivity gains and economic development. Therefore, this study aims to provide a detailed analysis of the occupational segregation of male and female workers in the labour market of Pakistan.

To obtain more in-depth estimates of the trend and pattern of occupational segregation, as opposed to previous studies that analyse the overall gender segregation in Pakistan (see Ahmed and Hyder, 2008; and Irfan et al., 2013), this study contributes to the existing literature by measuring not only the overall segregation (in a binary context) but also the segregation of several populations' subgroups.

In this regard, it first demonstrates the occupational segregation of women and men. Additionally, incorporating occupational segregation in a multigroup context, its studies, whether age, education, nature of the job (part-time/full-time), or the type of organisation (private/public), affect the occupational distributions of men and women in the same way. In doing so, to analyse occupational segregation with respect to gender and age group, both men and women are partitioned into young-aged, middle-aged, and elderly workers, resulting in three subgroups for each gender (a total of six target groups); next, to determine the occupational segregation with respect to gender and education, four target groups by gender and education (low education and high education) are obtained. Similarly, multiple subgroups for male and female workers are obtained to determine the level of occupational segregation with respect to hours of work and organisation type. This paper has used the local segregation measures proposed by Alonso-Villar and Del Río (2010) to determine the occupational segregation of male and female workers in a multigroup context.

This study is structured as follows: Section "Literature review" presents the literature review of the relevant studies. The section "Data and methodology" describes the data and methodology used. Section "Results and discussion" presents the results and discussion. Finally, the section "Conclusion" presents the conclusion of the study.

Literature review

The literature generally agrees on what defines the lack of segregation or equality: These are situations where the groups are spread uniformly across the classes of realisations. This notion of dissimilarity dates back to Gini (1914), who stated that two (or more) groups are similarly distributed if "the populations of the two groups assume the same values with the same frequency. Segregation measures the degree to which women and men are separated in the labour market, usually represented as a proportion of men and women (in binary case) or a specific subgroup, e.g., women having a university degree (Blackburn et al., 2001).

There are several methods for measuring overall occupational segregation, including the index of dissimilarity (Duncan and Duncan, 1955); the Karmel MacLachlan (IP) index (Karmel and Maclachlan, 1988); the WE index (OECD, 1980, 1985); sex-ratio index of occupational segregation (Hakim, 1979, 1981); marginal matching (MM) measure (Blackburn and Marsh, 1991) and Gini index (Silber, 1989, 1992).

While these methods are well-established, they are mostly limited to binary groups (e.g., male and female). However, as societies become increasingly diverse concerning race, gender, and social classes, the binary group analysis becomes increasingly inefficient in characterising complex segregation and integration patterns. Over the years, several indexes have been introduced to determine the level of occupational segregation in the labour market in a multigroup context. For instance, Reardon and Firebaugh (2002) presented six indexes to measure multigroup segregation; these include the Gini index (*G*), the squared coefficient of variation index (*C*), the information theory index (*H*), the normalised exposure index (*P*) and the relative diversity index (*R*). Each of these indexes captures the differential distribution of mutually exclusive groups distributed across occupations (i.e., the Evenness dimension of segregation (Massey and Denton, 1988)). Contributing to the debate on multigroup segregation indexes, Del Río and Alonso-Villar (2010) highlighted that most multigroup segregation indexes are only useful in measuring the overall segregation and presented the local segregation indexes to measure the multigroup segregation in more detail.

Most of the existing segregation indexes used to measure the degree of labour market segregation range between 0 and 1 in explaining the extent of labour market segregation among different groups or for specific proportions of an individual group (e.g., segregation among women with different levels of education). 1 represents total segregation, and 0 represents absolutely no segregation; a value closer to 1 indicates a high level of segregation in the labour market and vice versa. Several studies have discussed the gender disparities in employment regarding gender segregation (Hakim, 1992; Charles and Bradley, 2002). Bettio and Verashchagina (2009) used the IP index to measure the level of segregation and found 25.3% occupational segregation and 18.3% sectoral segregation, which shows that high segregation is prevalent. The findings also show a difference of around 10 percentage points among countries with the most to least segregation. In another study, Jarman et al. (2012) found that, in general, many men and women work in different occupations. Occupational segregation appears to be damaging for women because, based on occupational distribution, men have an advantage over women in several developed countries. Burchell et al. (2014) determined that occupational segregation does not solely depend on the share of a male and female distribution; it also depends upon occupational characteristics such as feminised occupations, male-dominated occupations, or blue or white-collar occupations. The study found that the level and patterns of occupational segregation by gender differ significantly across and within countries. Hesmondhalgh and Baker (2015) also found high occupational segregation among males and females. On the one hand, they found a higher concentration of women in marketing and public relations and similar roles, such as coordination-related activities. Man, on the other hand, concentrated on more technical jobs.

Blackburn et al. (2016) used the Gini index to show that women are primarily found in low-pay and low-level occupations. However, on vertical dimensions, many men are at the bottom of the hierarchy, and many females are at a high level. In another study, Campos-Soria and Ropero-García (2016) used data from 61 occupations in 51 industries to determine that most women work in low-paying jobs. They also found that individual characteristics do not contribute to reducing occupational gender segregation. Education level only helps in reducing the wage gap in some specific industries. Yunisvita and Muhyiddin (2020) used the *D*-index of dissimilarity to find a significantly high level of segregation in rural areas of Indonesia. The results from the Pearson correlation show that occupational segregation by gender has a significant relationship with rurality and other demographic characteristics such as education and age.

Tomaskovic-Devey et al. (2006) used the multigroup index of dissimilarity (*D*) to determine occupational segregation by race, ethnicity, and gender during 1966–2003 in the USA. The findings show an overall decline in segregation during 1960–1980; however, the decline was observed only in gender-based segregation in the later years. Del Río and Alonso-Villar (2010) used the local segregation index to analyse occupational gender segregation in the multigroup context in Spain. The estimates show high occupational segregation among female workers compared to male workers across several subgroups.

Agrawal (2016) used the occupational segregation indexes proposed by Alonso-Villar and Del Río (2010) to determine occupational segregation by gender and social groups in India. Results of the study show a high level of occupational segregation by gender and social groups in the urban sector compared to the rural sector. In Comparision to male workers, female workers are more segregated in rural and urban sectors across all subgroups. Moreover, in the context of subgroups based on age groups and occupational characteristics, local segregation indexes show that elderly workers with permanent jobs have a higher degree of segregation than their counterparts in the same subgroup. Alonso-Villar and Del Río (2017) used the local segregation indices to measure occupational segregation by the level of education to reveal that African-American women with multiple universities or college degrees have low occupational segregation compared to those with less educational qualifications. Using the same methodology, Gradín (2020) measured the level of occupational segregation among low-wage workers. The study shows a very high level of segregation for female workers employed in low-paid occupations.

The problem of occupational segregation by gender has received very little attention in Pakistan. Occupational gender segregation in the country. Ahmed and Hyder (2008) used data from the labour force survey of 2005–2006 to determine the extent of occupational gender segregation and gender wage gap using the standard mincer wage function. The Duncan index of dissimilarity revealed a high degree of occupational gender segregation across nine major occupations in Pakistan. Similarly, Irfan et al. (2013) used the data obtained from the labour force survey 2009–10 to show a high level of gender segregation based on the Duncan index of dissimilarity.

From the above discussion, it can be seen that the literature on occupational gender segregation in Pakistan is very limited. Therefore, this study contributes to the existing literature by accounting for occupational segregation separately for male and female workers while considering several subgroups at the three-digit occupational level to provide a more detailed insight into occupational segregation by gender in the country.

Data and methodology

Measuring segregation. A large amount of existing literature on occupational segregation primarily looks at the overall or aggregate level of segregation. The dissimilarity index proposed by Duncan and Duncan (1955) is the most used despite its well-known limitations; among others, the Karmel and MacLachlan (1988) I_p index has also gained popularity due to its better normative properties (Bettio and Verashchagina, 2009). However, the dissimilarity index in a multigroup setting necessitates pairwise comparisons between all groups, complicating the interpretation of the results because the comparisons are confined to examining how the groups relate to one another. To overcome these constraints, Silber (1992) expanded the binary segregation index created by Karmel and MacLachlan (1988) to the multidimensional case. Reardon and Firebaugh (2002) and Frankel and Volij (2011) also suggested different multigroup segregation

indices that account for disparities among all groups simultaneously while measuring the overall segregation. These measures of overall segregation help provide a summary statistic of the simultaneous distributional discrepancies that exist among the demographic groups into which society is partitioned (Watts, 2013; Gradín et al., 2015; Kramer and Kramer, 2019). However, since these indexes only quantify overall segregation rather than the segregation of each group, they prevent us from learning about their specific predicament.

However, when we are interested in a specific group, separately measuring its segregation becomes indispensable. Moir and Selby Smith (1979) addressed this concern for the binary case. Alonso-Villar and Del Río (2010) presented a new framework to study segregation for any subgroup of the population (referred to as local segregation) in a multigroup context. Local segregation refers to determining the segregation of a particular demographic group (target group) and comparing its distribution to the total employment distribution. By doing so, the measure of local segregation permits an in-depth analysis of segregation in the labour market by determining the extent to which each subgroup contributes to overall segregation. These local segregation measures appear particularly useful for highlighting the situations of small subgroups, whose unequal distributions across units may have a minimal impact on overall segregation (Del Río and Alonso-Villar, 2015; Agrawal, 2016; Azpitarte et al., 2019; Palencia-Esteban, 2021).

Measures of local segregation. Consider an economy with many occupations $j > 1$, and where $T =$ total population distributed as $t = (t_1, t_2, t_3, \ldots\ldots, t_j)$, where $t_j > 0$ is the number of individuals in jth occupation with distribution: j = (1, 2, 3, ….., J) and T can be written as $T = \sum_j t_j$; and g denotes the target groups (1 2,3…..,G) distributed as $c^g = \left(c_1^g, c_2^g, c_3^g \ldots c_j^g\right)$, where $c^g =$ could denote the occupation distribution of groups (e.g., male and female in this study).

Segregation curves. Alonso-Villar and Del Río (2010) proposed a variation of the conventional segregation curve to understand the segregation of any subgroup in a multigroup context, referred to as the local segregation curve. On the horizontal axis, the local segregation curve represents the cumulative employment proportion, while the vertical axis represents the cumulative proportion of individuals in the target group.

Alonso-Villar and Del Río (2010) presented the following measures in other to quantify the segregation of each target group.

$$G^g = \frac{\sum_{ij} \frac{t_i}{T}\frac{t_j}{T}\left|\frac{c_i^g}{t_i} - \frac{c_j^g}{t_j}\right|}{2\frac{C^g}{T}} \tag{1}$$

The first measure G^g used to study local segregation, is a variant of the conventional Gini index. The second measure represents the index based on the generalised entropy family, where: α can be interpreted as a segregation aversion parameter. Third, the multi-groups index D^g is a variant of the dissimilarity index proposed by Moir and Selby (1979).

$$\Phi_a^g = \sum_j \frac{c_j^g}{C^g} \ln\left(\frac{c_j^g/C^g}{t_j/T}\right) \tag{2}$$

$$D^g = \frac{1}{2}\sum_j \left|\frac{c_j^g}{C^g} - \frac{t_j}{T}\right| \tag{3}$$

As discussed by Alonso-Villar and Del Río (2010), G^g and Φ_a^g show better normative properties, but D^g has a more straightforward interpretation. Both G^g and D^g range between 0 and 1, while Φ_a^g, can still be transformed to the interval (0, 1).

These indices are also consistent with several overall measures. The latter are weighted means of the local segregation indices applied to each mutually exclusive group, with weights equal to their shares of the total workforce. The Ip^g index is consistent with the Multigroup Index of Dissimilarity I_p proposed by Karmel and MacLachlan (1988) and later extended by Silber (1992) in a multigroup context.

$$I_p = \sum_g \frac{C^g}{T} D^g \tag{4}$$

The Gini index G^g proposed by Alonso-Villar and Del Río (2010) is the weighted mean of the conventional Gini index and coincides with the unbounded version of the multigroup Gini index developed by Reardon and Firebaugh (2002):

$$G = \sum_g \frac{C^g}{T} G^g \tag{5}$$

Finally, the mutual information index proposed by Theil and Finizza (1971) and characterised by (Frankel and Volij, 2011) can be expressed as the mean of one of the local indexes proposed by Alonso-Villar and Del Río (2010) by weighing each target group by its demographic weight, which allows one to determine the contribution of each group to the overall segregation.

$$M = \sum_g \frac{C^g}{T} \Phi_I(C^g; t) \tag{6}$$

The way the local segregation is measured does not require pairwise comparisons among groups; because the procedure by which a group's segregation is quantified does not necessitate pairwise comparisons among groups and is compliant with the procedure by which overall segregation is measured in a multigroup case because aggregating the mutually exclusive population subgroups (using the weighted demographic shares of each group) is equal to the overall segregation.

Data description. This study is based on three waves of the labour force survey of Pakistan for the period 2013–2018. The labour force survey conducted by the statistical bureau of Pakistan is a cross-sectional survey that provides microdata incorporating annual estimates of detailed labour market characteristics. The sample for this study consists of the civilian labour force aged between 15–65, working full-time in different sectors of the economy. The information about the earning distribution of the employed labour force by industry division and occupation is particularly important for this study. The sample is limited to the paid employees only; own account workers and contributing family workers are excluded from the sample. After excluding the observations with missing values, the total sample was 64,946. A large majority of the labour force consists of the males labour force (86.46%). The dataset available for researchers includes occupation on a three-digit level of ISCO-08.

Table 1 presents general labour market statistics related to male and female workers. It can be seen that females have a significantly low labour force participation rate and higher unemployment rate than male workers. The employment-to-population ratio for female workers also remained around 20%, which is significantly lower than that of male workers. The share of female waged and salaried workers in total employment showed a slight improvement in 2017–18, but it remained around 40% less than the male workers.

Table 2 presents the summary statistics related to the occupational composition of the labour force (based on ISCO 3-digit occupational classification). A large proportion of the

Table 1 Selected labour market statistics.

	2013–14	2014–15	2017–18
Employment to population ratio (%)			
Male	77.3	77.5	77.2
Female	22.8	22.7	20.9
Total	50.1	50.2	48.9
Labour force participation rate (%)			
Male	81.0	81.4	81.1
Female	25.0	25.0	22.8
Total	53.1	53.3	51.9
Unemployment rate (%)			
Male	4.6	4.7	4.9
Female	8.9	9.2	8.5
Total	5.6	5.8	5.7
Share of wage and Salaried Workers in total EMP (%)			
Male	43.5	43.5	46.8
Female	27.0	25.3	29.0
Total	39.8	39.4	42.9

female labour force is associated with street and related sales and service workers, business and administration professionals, drivers and mobile plant operators, while the male workers are more proportionally distributed across occupations. Table 3 presents the gender composition of the labour force in different occupations based on a 3-digit occupational classification. It can be seen that almost all occupations are male-dominated. The occupational group' market-oriented skilled forestry, fishery, and hunting workers' have the largest share of the female labour force (68%), followed by street and related sales and service workers (40%), food preparation assistants (37%) and Business and administration professionals (36%). It is also worth noting that many occupations have 0% female workers.

Results and discussion

To begin, this study quantifies occupational segregation between men and women. Each point on the segregation curve represents the proportion of males (females) employed in each cumulative decile of total employment. The first cumulative decile encompasses the occupations where the male (female) has the smallest

Table 2 Composition of labour force across occupations.

Occupation	Male	Female	Total
Chief executives, senior officials and legislators	0.41	0.17	0.38
Administrative and commercial managers	0.43	0.14	0.39
Production and specialised services managers	0.66	0.35	0.62
Hospitality, retail and other services managers	0.14	0.00	0.12
Science and engineering professionals	0.38	0.03	0.33
Teaching professionals	0.33	0.96	0.42
Business and administration professionals	4.57	16.95	6.24
Science and engineering associate professionals	0.87	0.09	0.76
Health associate professionals	0.10	0.05	0.09
Business and administration associate professionals	1.08	0.17	0.96
Legal, social, cultural and related associate professionals	1.19	0.10	1.05
Information and communications technicians	0.96	3.16	1.26
General and keyboard clerks	1.83	0.17	1.61
Customer services clerks	0.47	0.10	0.42
Numerical and material recording clerks	0.31	0.03	0.27
Other clerical support workers	2.38	0.27	2.10
Personal services	0.43	0.15	0.40
Sales workers	0.66	0.09	0.58
Personal care workers	0.31	0.02	0.27
Protective services workers	4.05	0.91	3.62
Market-oriented skilled agricultural workers	5.18	0.40	4.53
Market-oriented skilled forestry, fishery and hunting workers	0.03	0.42	0.08
Subsistence farmers, fishers, hunters and gatherers	3.79	0.15	3.30
Building and related trades workers, excluding electricians	0.50	0.06	0.44
Metal, machinery and related trades workers	0.19	0.00	0.16
Handicraft and printing workers	0.01	0.00	0.01
Electrical and electronic trades workers	8.28	0.65	7.25
Food processing, wood working, garment and other craft and related trades workers	3.34	0.16	2.91
Stationary plant and machine operators	0.97	1.90	1.10
Assemblers	1.50	0.05	1.30
Drivers and mobile plant operators	5.53	17.08	7.10
Cleaners and helpers	4.15	0.72	3.68
Agricultural, forestry and fishery labourer	0.04	0.00	0.03
Labourer in mining, construction, manufacturing and transport	6.59	0.15	5.71
Food preparation assistants	2.32	9.01	3.23
Street and related sales and service workers	9.33	40.76	13.58
Refuse workers and other elementary workers	24.55	3.35	21.68
Chief executives, senior officials and legislators	0.02	0.00	0.02
Administrative and commercial managers	0.03	0.01	0.03
Production and specialised services managers	2.08	1.23	1.96
Total	100.00	100.00	100.00

Source: Author's own Calculation based on data used in the study.

Table 3 Gender composition of labour force in different occupations.

Occupations	Male	Female
Chief executives, senior officials and legislators	93.85	6.15
Administrative and commercial managers	95.26	4.74
Production and specialised services managers	92.33	7.67
Hospitality, retail and other services managers	100	0.0
Science and engineering professionals	98.60	0.74
Teaching professionals	68.89	31.11
Business and administration professionals	63.89	36.77
Science and engineering associate professionals	98.39	1.61
Health associate professionals	93.33	6.67
Business and administration associate professionals	97.60	2.40
Legal, social, cultural and related associate professionals	98.68	1.32
Information and communications technicians	66.01	33.99
General and keyboard clerks	98.56	1.44
Customer services clerks	96.72	3.28
Numerical and material recording clerks	98.30	1.70
Other clerical support workers	98.24	1.76
Personal services	94.94	5.06
Sales workers	97.88	2.12
Personal care workers	98.87	1.13
Protective services workers	96.60	3.40
Market-oriented skilled agricultural workers	98.81	1.19
Market-oriented skilled forestry, fishery and hunting workers	31.48	68.52
Subsistence farmers, fishers, hunters and gatherers	99.39	0.61
Building and related trades workers, excluding electricians	98.26	1.74
Metal, machinery and related trades workers	100	0.0
Handicraft and printing workers	100	0.0
Electrical and electronic trades workers	98.79	1.21
Food processing, wood working, garment and other craft and related trades workers	99.26	0.74
Stationary plant and machine operators	76.58	23.42
Assemblers	99.53	0.47
Drivers and mobile plant operators	67.41	32.59
Cleaners and helpers	97.37	2.63
Agricultural, forestry and fishery labourer	100	0.0
Labourers in mining, construction, manufacturing and transport	99.65	0.35
Food preparation assistants	62.20	37.80
Street and related sales and service workers	59.37	40.63
Refuse workers and other elementary workers	97.90	2.10
Chief executives, senior officials and legislators	100	0.0
Administrative and commercial managers	94.74	5.26
Production and specialised services managers	91.54	8.46

Source: Author's own Calculation based on data used in the study.

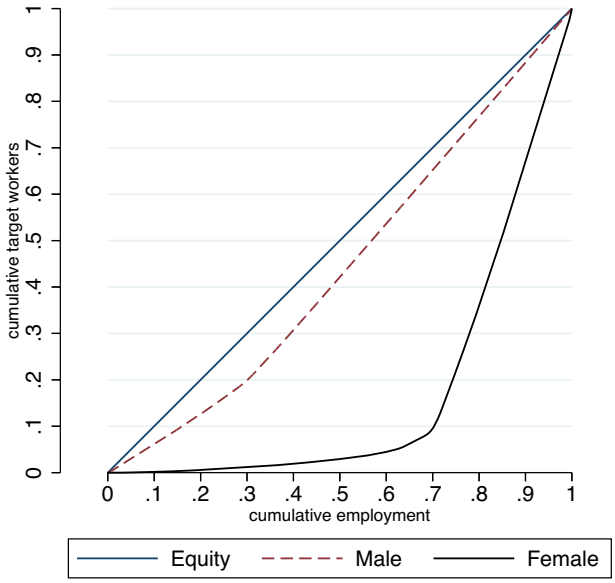

Fig. 1 Occupational segregation curve by gender. The figure shows the occupational segregation of male and female workers.

Table 4 presents: (1) the overall segregation based on the mutual information index (M), the multigroup index of dissimilarity (Ip), and the multigroup Gini index (G) by occupation and gender for both female and male labour force; (2) the contributions of each group (male and female) to overall segregation for three indexes; and (3) the local segregation indexes discussed earlier. In line with the results of overall segregation, all the local indexes: Φ_a^g (that is related to the M index of overall segregation) and where $a = 0.1$, 05, 1, and 2; G^g (that is related to the G index of overall segregation); and D^g (that is related to the Ip index of overall segregation) also show remarkably higher values for females compared to males. Consequently, even though the female employment share represents only 14% of total employment, the contribution of females in the overall segregation is 83% based on (the mutual information index). The multigroup index of dissimilarity (Ip) and the multigroup Gini index (G) show that females contribute 50% to overall segregation (the difference in values of indexes is because Φ emphasises the degree of occupational feminisation and masculinisation). There is a substantial degree of occupational segregation between male and female workers in Pakistan, and as shown in Fig. 1, female workers face higher segregation in the labour market.

relative presence; it accounts for 10% of the total employment distribution. Similarly, the second cumulative decile accounts for 20% of the total employment distribution, with the lowest relative presence of male (female) workers across occupations. Thus, decile by decile, the local segregation curve, as a result, demonstrates that the target group is underrepresented in the labour force relative to the economy's overall employment structure. If the occupational distribution of the target group appears the same as the distribution of total employment, no segregation would exist for the (demographic) groups, and the local segregation curve would be equal to the bisector.

The local segregation curves (Fig. 1) indicate that males outnumber female workers, as the curve associated with the former is above the curve associated with the latter. Therefore, consistent with these curves, the local segregation index also validates higher occupational segregation for female workers.

Gender and region. Figure 2 plots the segregation curve for males and females in the rural and urban regions. The cumulative proportion of total employment is presented on the horizontal axis, while the cumulative proportion of each gender group is presented on the vertical. The curve corresponding to male workers in rural and urban regions is above that of female workers. This implies that women occupy a more constrained position in the labour market. The comparison of males in rural and urban regions shows the high segregation of males in urban areas compared with rural areas.

Table 5 provides various measures of local segregation. All the indexes indicate that females suffer higher segregation in both regions than males. A comparison of female workers in both regions shows higher segregation for women in rural areas, while the comparison of the male group shows that men in urban areas suffer relatively higher segregation than those in

Table 4 Occupational segregation by gender.

Overall Segregation	M	G	Ip		Employment share
Gender Segregation	0.15	0.19	0.17		
Male Contribution	0.16	0.50	0.50		0.85
Female Contribution	0.83	0.50	0.50		0.14
Local Segregation	$\Phi_{0.1}$	$\Phi_{0.5}$	Φ_1	$\Phi 2$	D^g	G^g
Male	0.03	0.03	0.029	0.027	0.10	0.11
Female	1.39	1.01	0.85	0.87	0.60	0.64

Source: Author's own Calculation based on data used in the study.

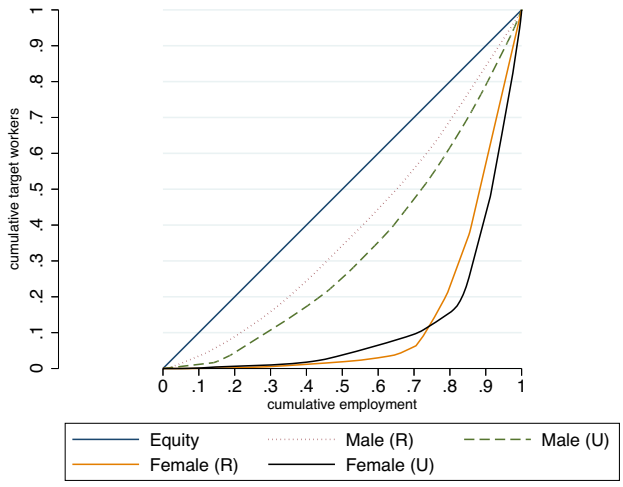

Fig. 2 Occupational segregation curve by gender and region. The figure shows the occupational segregation of male and female workers in rural and urban regions.

rural areas. 67% of the female labour force resides in rural areas, while 59.91% of the male labour force also belongs to rural areas. Agrawal (2016) found similar results for India using the same methodology.

To further analyse occupational gender segregation in a multigroup context, this study considers appropriate subgroups of individuals: by gender and age; gender and education level; gender and type of organisation (public/private); and gender and hours of work (full-time/part-time).

Gender and age. According to the statistics, Pakistan is among the top five countries with respect to the population of young people as a percentage of the total population and is ranked second in South Asia. Improvements in educational attainment are expected to change the occupational composition of the labour force. Thus, studying occupational differences by sex and age is particularly interesting. For this purpose, the labour force is partitioned into three different age groups and by gender: 15–29 years of age (young), 30–44 years of age (middle-aged), and over 45 years of age (elderly). Thus, six target groups were considered in the analysis.

Figure 3 presents the local segregation curve by gender and age groups across occupations. For clarity, segregation curves are presented separately for both males and females. The Figure shows that the curves representing female workers are far from zero for all age groups compared to male workers. The highest

Table 5 Occupational gender segregation by region.

Local segregation	$\Phi_{0.1}$	$\Phi_{0.5}$	Φ_1	Φ_2	D^g	G^g	% Distribution of labour force
Male workers							100
Rural	0.09	0.09	0.08	0.07	0.16	0.22	59.91
Urban	0.26	0.22	0.19	0.18	0.24	0.34	40.09
Female workers							100
Rural	2.16	1.22	1.02	1.18	0.63	0.72	67.89
Urban	1.60	1.16	1.10	1.62	0.64	0.74	32.11

Source: Author's own calculation based on data used in the study.

level of segregation is evident among the elderly female workers, while the young female workers had the lowest segregation among females of all age groups. Since the curve corresponds to middle-aged male workers dominating the rest of the groups, middle-aged men have the lowest occupational segregation in the labour market.

The results of the local segregation indexes (Table 6) also confirm the above results. According to all indexes, the labour force is dominated by individuals between the ages 15–29 (with 42.27% of females and 43.05% of males); however, the share of the labour force within the middle-age group (41.85% female and 39.20% male) is only marginally small compare to young aged individual. The results indicate that female workers (in any age group) suffer relatively more segregation than male workers. Compared to female workers across different age groups, elderly female workers show a higher segregation level than middle-aged and young female workers. However, the segregation of the younger and middle-aged was relatively smaller for males than for elderly male workers. Therefore, the segregation is higher for those above 45 years of age, while the comparison of the same age group shows a significant difference between the two genders, with female workers suffering significantly higher segregation. However, since young workers are more likely to be employed in occupations with a more equal distribution of each gender, it can be anticipated that occupational segregation would diminish for the young aged labour force, Del Río and Alonso-Villar (2010) for Spain; and Agrawal (2016) for India also reported similar findings.

Gender and level of education. Education can play an essential role in creating better job opportunities for women (Sarfraz et al., 2021); Education can play an important role in explaining occupational segregation by gender (Rawlston and Spriggs, 2002). Andlib and Khan (2018) have shown that the education level helps increase Pakistan's female labour force participation rate. However, whether education plays a role in reducing occupational gender segregation remains questionable. To study occupational gender segregation by education level, female and male workers are classified into two groups: low-educated (including those with pre-primary schooling to those with secondary school certificates); and highly educated (those with an education level higher than the secondary school certificate). The local segregation curves of the target groups are presented for males and females in Fig. 4. When comparing male and female subgroups, the curves corresponding to low-educated men clearly show the lowest segregation compared to high-educated males and females in any educational subgroup. The segregation curve of low-educated female workers appears to dominate the highly educated women. Female workers with higher education suffer the highest level of segregation in the labour market. However, since the segregation curves of highly educated male workers and low-educated females cross, comparing the two curves may not provide accurate information.

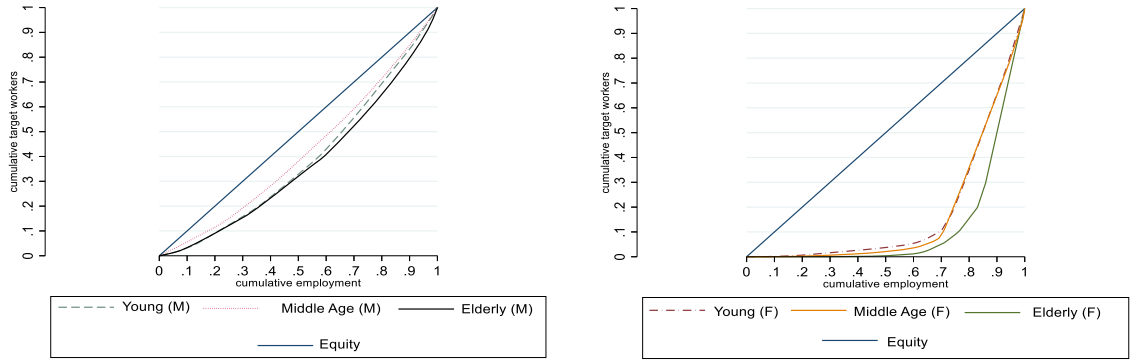

Fig. 3 Occupational segregation by gender and age. The figure shows the occupational segregation of male and female workers with respect to different age groups.

Table 6 Occupational gender segregation by age.

Local segregation	$\Phi_{0.1}$	$\Phi_{0.5}$	Φ_1	Φ_2	D^g	G^g	% Distribution of labour force by gender and Age
Female workers							100
<30 years of age	1.42	0.96	0.83	0.87	0.58	0.65	42.27
30–45 years of age	2.06	1.11	0.90	0.93	0.61	0.66	41.85
>45 years of age	3.36	1.31	1.01	1.11	0.62	0.71	15.89
Male workers							100
<30 years of age	0.10	0.09	0.09	0.08	0.17	0.23	43.05
30–45 years of age	0.05	0.04	0.04	0.04	0.12	0.17	39.20
>45 years of age	0.12	0.11	0.11	0.12	0.19	0.26	17.75

Source: Author's own calculation based on data used in the study.

Table 7 presents the values of different local segregation indexes. On the one hand, the results show that the occupational segregation level of female workers is higher for the highly educated. These findings are in contrast to (Alonso-Villar and Del Río, 2017), who used the local segregation indices to find that low-skilled (less educated) female workers face more segregation compared to high-skilled (highly educated) African–American female workers. Similar results were also obtained by Alonso-Villar et al. (2012), who showed that human capital characteristics do not play a significant role in controlling occupational segregation. However, all indexes show that low-educated male workers suffer from the lowest level of segregation. Most indexes show that highly educated male workers suffer less segregation than low-educated female workers. The distribution of workers among the two classes (Table 7, last column) suggests that the proportion of the labour force with high education (equal to or more than 16 years of education) is substantially small compared to those with low education.

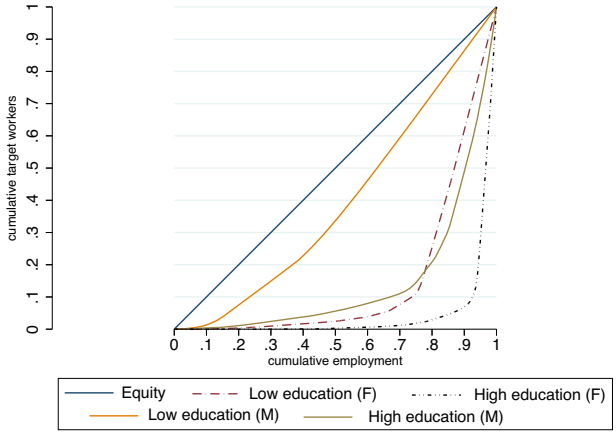

Fig. 4 Occupational segregation by gender and education. The figure shows the occupational segregation of male and female workers with respect to different education levels.

Gender and type of organisation. Figure 5 shows that the segregation curve of men working in the private sector organisations dominates those of women in all groups and the males working in the public sector organisations. Moreover, the segregation curve of males working in the public sector also appears to dominate females in both the public and private sectors. However, female workers in the public sector suffer relatively higher segregation than those in the private sector. Notably, 71.90% of males cluster in the private sector and only 28.10% in the public sector, while around 55% of females work in the public sector and 44.99% in the private sector. These findings are in contrast to the findings of (Villarrubia and Ucelay, 2003) for Spain, and Barón and Cobb-Clark (2010), who found high gender segregation in the private sector in Spain and Australia, respectively. Table 8 also shows that the indexes strongly increase for public sector female workers compared to any other group.

Gender and hours of work. Pakistani society is still subject to strict social norms and gender roles, where women are considered secondary earners, and the primary role assigned to them is to perform household activities and take care of children and the elderly. Most women, especially mothers, are less able to work long hours because their time is subject to family demands. Therefore, many females are expected to choose a part-time job compared to male workers. Thus, studying how work hours contribute to occupational gender segregation in the country may be interesting. About 77.36% of females work <48 h per week, while this ratio decreases to 30.52% for male workers, which means that a substantially higher proportion of women tend to concentrate on jobs that need fewer hours of work (Table 9, last

Table 7 Occupational gender segregation by level of education.

Local segregation	$\Phi_{0.1}$	$\Phi_{0.5}$	Φ_1	Φ_2	D^g	G^g	% Distribution of labour force
Male workers							100
Low education	0.18	0.13	0.10	0.08	0.17	0.21	83.21
High education	1.15	0.98	0.96	1.35	0.60	0.70	16.79
Female workers							100
Low education	1.82	1.14	0.98	1.10	0.63	0.69	81.95
High education	4.69	2.19	2.19	5.49	0.83	0.90	17.05

Source: Author's own Calculation based on data used in the study.

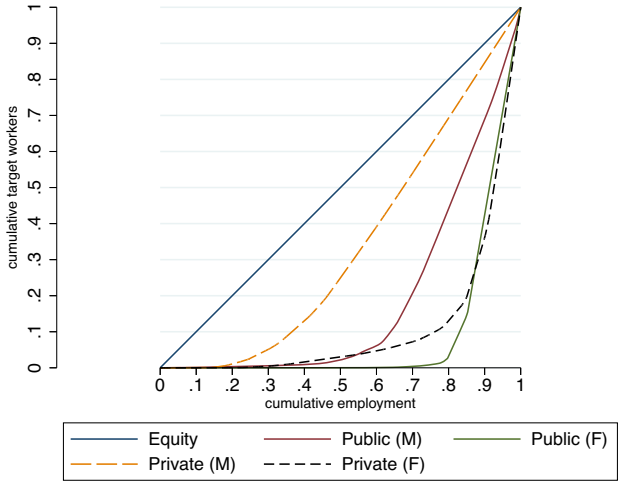

Fig. 5 Occupational segregation by gender and ownership. The figure shows the occupational segregation of male and female workers with respect to ownership of the organisation (public and private sector).

column). The local segregation curve (Fig. 6) depicts that almost all indexes show that women working <48 h a week face more segregation. These results align with those of Blackwell (2001) and Petrongolo (2004). It is also evident that even though female suffers more segregation than males, the direction of all indexes moves in a similar direction.

Conclusion

This paper has focused on investigating occupational gender segregation in Pakistan using local measures of segregation presented by Alonso-Villar and Del Río (2010). In doing so, the employment distribution of each target group is compared with the overall employment distribution across occupations. The selection of the local segregation method allowed us to quantify the segregation of different demographic groups separately (in this case, male and female), as well as the segregation of any specific subgroup (e.g., segregation of male and female workers by the level of education). All the indexes show that female segregation explains a substantially large proportion of the overall gender segregation, even though the demographic weight of the female labour force is low compared to the male labour force. Human capital characteristics such as education are not very useful in controlling occupational segregation by gender in Pakistan; the findings show that the increased human capital characteristics, such as education, do not necessarily increase labour market opportunities and reduce gender segregation. Based on the findings of this study, it can be concluded that both the economic and sociological theories can partially explain the extent and patterns of occupational gender segregation in Pakistan.

Females are considered secondary earners in Pakistan, and the primary role assigned to them by the gendered social norms is to take care of household activities, childcare and elderly care. It is also evident that none of the occupations in Pakistan is considered feminised. Compared to male workers, a large majority of women workers are confined to occupations that receive low value in society irrespective of age and level of education. This might also force the women to opt for occupations that offer a relatively comfortable work environment and low working hours. Therefore, it is essential to emphasise more gender norm-centric policies. Government agencies and the media can play a crucial role in changing gender stereotypes at work and at home. The following are some policy recommendations to reduce occupational segregation by gender in Pakistan:

Increasing investment in education and promoting educational attainment among women to increase overall economic empowerment is also of utmost importance. Low levels of job-related skills or skill mismatch can also hinder the employment prospect of females; therefore, it is also important to provide women with the right skill set. Assuring a gender-friendly work environment can be instrumental in improving the involvement of females in the labour market. The government should provide different incentives, such as tax credits, to encourage employers to establish a female-friendly workplace. Alternatively, the government might promote secondary activities for women facing mobility issues due to socio-cultural norms, especially for rural women, to enhance economic activities.

Finally, it is worth mentioning that this study is limited to workers in the formal sector of the economy. Future studies can be extended to compare male and female workers employed in formal and informal sectors. Another limitation of this study is that it only considers horizontal segregation; vertical segregation can be considered in the future, subject to the availability of detailed data.

Data availability

This study is based on the PhD research work of the first author. Publicly available secondary data from the Labour force survey of Pakistan is used for the analysis. The data set and codes used in this paper are available from the corresponding authors at a reasonable request.

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Table 8 Occupational gender segregation by ownership.

Local segregation	$\Phi_{0.1}$	$\Phi_{0.5}$	Φ_1	$\Phi 2$	D^g	G^g	% Distribution of labour force
Male workers							100
Public	1.38	0.95	0.74	0.70	0.54	0.61	28.10
Private	0.64	0.37	0.25	0.18	0.27	0.32	71.90
Female workers							100
Public	5.31	1.94	1.52	2.01	0.76	0.81	55.01
Private	2.03	1.33	1.23	1.87	0.66	0.77	44.99

Source: Author's own calculation based on data used in the study.

Table 9 Occupational gender segregation by hours of work.

Local segregation	$\Phi_{0.1}$	$\Phi_{0.5}$	Φ_1	$\Phi 2$	D^g	G^g	% Distribution of labour force
Male workers							100
Full-time	0.13	0.10	0.09	0.07	0.16	0.21	69.48
Part-time	0.19	0.18	0.17	0.17	0.24	0.32	30.52
Female workers							100
Full-time	1.15	0.72	0.66	0.81	0.48	0.60	22.64
Part-time	2.34	1.25	0.98	0.99	0.63	0.67	77.36

Source: Author's own calculation based on data used in the study.

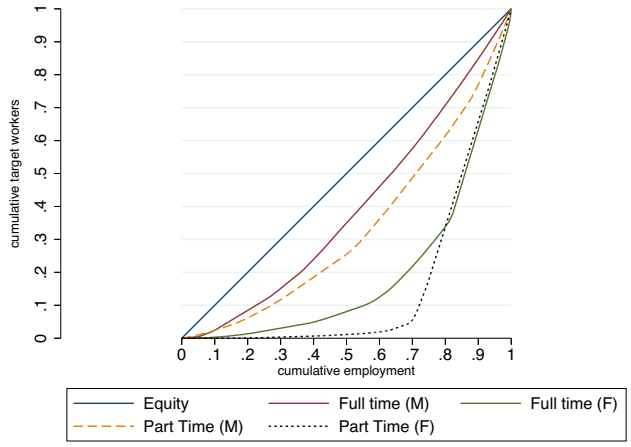

Fig. 6 Occupational segregation curve by gender and hours of work. The figure shows the occupational segregation of male and female workers with respect to hours of work.

References

Organisation for Economic Co-operation and Development (1985) The integration of women into the economy. OECD, Paris

Organisation for Economic Co-operation and Development (1980) Women in employment. OECD, Paris

Agrawal T (2016) Occupational segregation in the Indian labour market. Eur J Dev Res 28(2):330–351

Ahmed AM, Hyder A (2008) Sticky floors and occupational segregation: evidence from Pakistan. Pak Dev Rev 47(4):837–849

Alonso-Villar O, Del Río C (2010) Local versus overall segregation measures. Math Soc Sci 60(1):30–38

Alonso-Villar O, Del Río C (2017) The occupational segregation of African American women: its evolution from 1940 to 2010. Fem Econ 23(1):108–134

Alonso-Villar O, Del Río C, Gradín C (2012) The extent of occupational segregation in the United States: differences by race, ethnicity, and gender. Ind Relat 51(2):179–212

Amuedo-Dorantes C, De la Rica S (2006) The role of segregation and pay structure on the gender wage gap: evidence from matched employer–employee data for Spain. Cont in Eco Anal Policy 5:1

Andlib Z, Khan AH (2018) Low female labor force participation in Pakistan: causes and factors. Glob Soc Sci Rev 3(3):237–264

Anker R (1998) Gender and jobs: sex segregation of occupations in the world. International Labour Organisation

Azpitarte F, Alonso-Villar O, Hugo-Rojas F (2019) On the changing spatial distribution of human capital and occupation groups: an analysis of recent trends in Australia's Main Capital Cities. Universidade de Vigo, Departamento de Economía Aplicada Working Papers (No. 1903)

Barón JD, Cobb-Clark DA (2010) Occupational segregation and the gender wage gap in private-and public-sector employment: a distributional analysis. Econ Rec 86(273):227–246

Bergmann B R (1974) Occupational segregation, wages and profits when employers discriminate by race or sex. East Econ j 1(2):103–110

Bettio F, Verashchagina A (2009) Gender segregation in the labour market: root causes, implications and policy responses in the EU. European Commission

Blackburn RM, Marsh C (1991) Education and social class: revisiting the 1944 Education Act with fixed marginals. Br J Soc 42(4):507–536

Blackburn RM, Siltanen J, Jarman J (1995) The measurement of occupational gender segregation: current problems and a new approach. J R Stat Soc 158(2):319–331

Blackburn RM, Brooks B, Jarman J (2001) Occupational stratification the vertical dimension of occupational segregation. Work Emp Soc 15(3):511–538

Blackburn RM, Jarman J, Racko G (2016) Understanding gender inequality in employment and retirement. Contemp Soc Sci 11(2–3):238–252

Blackwell L (2001) Occupational sex segregation and part-time work in modern Britain. Gen Work Org 8(2):146–163

Blau FD, Simpson P, Anderson D (1998) Continuing progress? Trends in occupational segregation in the United States over the 1970s and 1980s. Fem Econ 4(3):29–71

Brynin M, Perales F (2016) Gender wage inequality: The de-gendering of the occupational structure. Euro Soc Rev 32(1):162–174

Burchell BJ, Hardy W, Rubery J, Smith M (2014) A new method to understand occupational gender segregation in European labor markets. European Union, p. 64

Campos-Soria JA, Ropero-García MA (2016) Occupational segregation and the female–male wage differentials: evidence for Spain. Gend Issues 33(3):183–217

Chang ML (2004) Growing pains: cross-national variation in sex segregation in sixteen developing countries. Am Soc Rev 69(1):114–137

Charles M, Bradley K (2002) Equal but separate? A cross-national study of sex segregation in higher education. Am Soc Rev 67(4):573–559

Del Río C, Alonso-Villar O (2015) The evolution of occupational segregation in the United States, 1940–2010: Gains and losses of gender–race/ethnicity groups. Demography 52(3):967–988

Duncan OD, Duncan B (1955) A methodological analysis of segregation indices. Am Soc Rev 20(2):210–217

England P (2010) The gender revolution: uneven and stalled. Gend Soc 24(2):149–166

England P, Allison P, Wu Y (2007) Does bad pay cause occupations to feminise, does feminisation reduce pay, and how can we tell with longitudinal data? Soc Sci Res 36(3):1237–1256

England P (1992) Comparable worth: theories and evidence. New Brunswick
Frankel DM, Volij O (2011) Measuring school segregation. J Econ 146(1):1–38
Gini C (1914) Sulla misura della concentrazione e della variabilità dei caratteri. Atti del Reale Istituto veneto di scienze, lettere ed arti 73:1203–1248
Gradín C (2020) Segregation of women into low-paying occupations in the United States. Appl Econ 52(17):1905–1920
Gradín C, Del R, Alonso-Villar CO (2015) Occupational segregation by race and ethnicity in the United States: differences across states. Reg Stud 49(10):1621–1638
Hakim C (1981) Job segregation: trends in the 1970s. Employ Gaz 89:521–529
Hakim C (1992) Explaining trends in occupational segregation: the measurement, causes, and consequences of the sexual division of labor. Eur Soc Rev 8(2):127–152
Hakim C (1979) Occupational segregation: a comparative study of the degree and pattern of the differentiation between men and women's work in Britain, the United States, and other countries. Department of Employment Research Paper No. 9
Hesmondhalgh D, Baker S (2015) Sex, gender and work segregation in the cultural industries. Soc Rev 63(S1):23–36
Irfan M, Anwar S, Akram W, Waqar I (2013) Occupational gender segregation and its determinants, an analysis of Pakistan labor force market. Am J Edu Res 1(7):221–224
Ismail R, Farhadi M, Wye CK (2017) Occupational segregation and gender wage differentials: evidence from Malaysia. Asian Econ J 31(4):381–401
James DR, Taeuber KE (1985) Measures of segregation. Sociol Methodol 15:1–32
Jarman J, Blackburn RM, Racko G (2012) The dimensions of occupational gender segregation in industrial countries. Sociology 46(6):1003–1019
Karmel T, Maclachlan M (1988) Occupational sex segregation—increasing or decreasing. Econ Rec 64:187–195
Karmel T, MacLachlan M (1988) Occupational sex segregation—increasing or decreasing? Econ Rec 64(3):187–195
Kramer R, Kramer P (2019) Diversifying but not integrating: entropic measures of local segregation. Tijdschr Econ Soc Geogr 110(3):251–270
Levanon A, England P, Allison P (2009) Occupational feminisation and pay: assessing causal dynamics using 1950–2000 US census data. Soc Forces 88(2):865–891
Mahmood F, Hashim S, Iram U, Chishti MZ (2020) Wage disparities between high and low wage cities with and without the cost of living within Punjab and Sindh: an application of Oaxaca–Blinder using PSLM with HIES. J Appl Econ Bus Stud 4(4):1–14
Massey DS, Nancy AD (1988) The dimensions of racial segregation. Soc Forces 67:281–315
Moir H, Smith JS (1979) Industrial segregation in the Australian labour market. J Ind Relat 21(3):281–291
Nazli H (2004) The effect of education, experience and occupation on earnings: evidence from Pakistan. Lahore J Econ 9(2):1–30
Palencia-Esteban A (2021) Occupational segregation of female and male immigrants in the European Union: accounting for cross-country differences. Int Lab Rev 161(3):341–373
Petrongolo B (2004) Gender segregation in employment contracts. J Eur Econ Assoc 2(2–3):331–345
Rapoport B, Thibout C (2018) Why do boys and girls make different educational choices? The influence of expected earnings and test scores. Econ Educ Rev 62:205–229
Rawlston V, Spriggs WE (2002) A logit decomposition analysis of occupational segregation: an update for the 1990s of Spriggs and Williams. Rev Black Pol Econ 29(4):91–96
Reardon SF, Firebaugh G (2002) Measures of multigroup segregation. Sociol Methodol 32(1):33–67
Reskin BF, Maroto ML (2011) What trends? Whose choices? Comment on England. Gen Soc 25(1):81–87
Reskin B (1993) Sex segregation in the workplace. Annu Rev Soc 19:241–270
Del Río C, Alonso-Villar O (2010) Gender segregation in the Spanish labor market: an alternative approach. Soc Indic Res 98(2):337–362
Sarfraz M, Andlib Z, Kamran M, Khan NU, Bazkiaei HA (2021) Pathways towards women empowerment and determinants of decent work deficit: a South Asian perspective. Adm Sci 11(3):80
Sarfraz M, Kamran M, Khan NU, Khalique M, Andlib Z (2022) Targeting Women's vulnerable employment through social protection: a quasi-experimental regression discontinuity design. Heliyon 8(2):e08964
Silber J (1992) Occupational segregation indices in the multidimensional case: a note. Econ Rec 68(202):276–277
Silber JG (1989) On the measurement of employment segregation. Econ Let 30:237–243
Sinclair S, Carlsson R (2013) What will I be when I grow up? The impact of gender identity threat on adolescents' occupational preferences. J Adolesc 36(3):465–474
Strawinski P, Majchrowska A, Broniatowska P (2018) Occupational segregation and wage differences: the case of Poland. Int J of Man 39(3):378–397
Theil H, Finizza AJ (1971) A note on the measurement of racial integration of schools by means of informational concepts. J Math Soc 1(2):187–193
Tomaskovic-Devey D, Zimmer C, Stainback K, Robinson C, Taylor T, McTague T (2006) Documenting desegregation: segregation in American workplaces by race, ethnicity, and sex, 1966–2003. Am Soc Rev 71(4):565–588
Villarrubia RM, Ucelay JR (2003) Gender segregation by occupation in the public and the private sector: the case of Spain. Documentos de trabajo. Economic series. Departamento de Economía, Universidad Carlos III
Watts M (2013) Socioeconomic segregation in UK (secondary) schools: are index measures still useful? Environ Plan A 45(7):1528–1535
Yunisvita Y, Muhyiddin NT (2020) Occupational gender segregation in rural urban economy. J Ekon Studi Pembang 12(2):93–107

Competing interests
The authors declare no competing interests.

Ethical approval
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Informed consent
This article does not contain any studies with human participants performed by any authors.

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