Additively decomposable segregation indexes. The case of gender segregation by occupations and human capital levels in Spain

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Abstract. Building upon the ideas first exposed by Theil and Finizza (1971) and Fuchs (1975), this paper presents an additively decomposable segregation index based on the entropy concept used in information theory. For any pair of classification variables in a given year, the index is decomposed into a *between-group* and a *within-group* term. To analyze intertemporal changes in gender segregation for a given partition, the index is decomposed into two terms that capture, respectively, gender composition effects, and changes in the groups' demographic importance. These decompositions are illustrated with Spanish data on occupations and human capital levels for 1977 and 1992. It is found that, in both years, the higher the educational level, the smaller is gender segregation for most age groups. Moreover, gender segregation decreases with age in all educational categories. However, most gender segregation takes place within, rather than between, age/education categories. Lastly, changes in gender composition across occupations, nearly offset by occupational mix changes, account for a decline of 2% in total gender segregation over this period.

Key words: additively decomposable indexes, entropy measures, gender segregation.

1. Introduction

Gender segregation in the employed population is an important aspect of the way the labor market works. In a few instances, some authors have classified all existing jobs according to two dimensions in order to study different structural aspects of gender segregation in a given moment of time.¹ More often, gender segregation has been studied along a single dimension, usually occupation.²

Presumably, the distribution of people across occupations is the result of the demand for and the supply of labor. But the interplay between the forces of demand and supply at this stage is conditional on certain productive characteristics of the individuals from both genders. In this paper, individual data on occupations are combined with human capital characteristics for which information is readily available: age and attainment levels of broad educational categories. Thus, the main empirical objective of the paper is to investigate the links between occupational gender segregation and certain human capital features. First, if education widens career opportunities and occupational choices for females workers, then occupa-

tional segregation should differ across human capital categories: the higher the educational level for a given age group, the smaller should be gender segregation and segregated male occupations would not necessarily require more education than female occupations. Second, from a human capital perspective, women will choose those occupations where their skills depreciate less if they leave for periods of time because of family obligations. Thus, those females who remain employed in the later part of their life cycle might be expected to be less segregated by occupation than the group of younger female workers. Finally, the role of human capital factors in gender segregation, that is, by how much is gender segregation reduced when human capital differences are controlled for, have been investigated in a number of countries. However, in Spain, the country covered in this paper, as well as in other Southern European countries, this topic is an open question worth investigating.³

To examine these issues, which involve a pair of classification variables, a segregation index with the property of additive decomposability is needed. Building upon the ideas first exposed by Theil and Finizza [44] and Fuchs [18], this paper develops an additively decomposable segregation index that is based on the entropy concept used in information theory. In the two-dimensional context of this paper, the overall measure of gender segregation is decomposed into two components: a *between-group* term, which captures the direct gender segregation induced by the first variable, say human capital; plus a weighted sum of *within-group* terms, where each of them captures the gender segregation induced by the second variable, say the occupation, within the corresponding human capital category.⁴ The index also has a convenient commutative property, according to which the role of the two variables in the above decomposition can be interchanged. In addition, there are other aspects of gender segregation which can be conceivably investigated with this index. For instance, the study of gender segregation induced by pairs of variables such as type of contract versus part-time/full-time status, occupation versus the position within the firm's hierarchical structure, or occupation versus sector. While not denying their importance, we limit our empirical illustration to the relation between human capital characteristics and occupational segregation.

It has been forcefully argued that, for rigorous cross-section and time-series comparisons, the effect of changes in the overall female share of employment and in the occupational structure should be removed. Efforts to address this issue are founded on two different methodological approaches. On one side, Charles [10], Charles and Grusky [12] and Grusky and Charles [21] adopt a structural approach to sex segregation measurement. They propose a segregation index that is consistent with a log-multiplicative model that allows for variation in the segregation profiles, and which is composition and occupational invariant. A second line of research, which is closest to this paper's strategy, is based on the idea that changes in the indices might be decomposed to isolate changes in the gender composition of specific occupations from changes in the gender composition of the population as a whole and changes in the occupational structure. In our case, for any given

partition, the structure of the index facilitates the decomposition of the intertemporal change in gender segregation into two terms.⁵ The first one accounts for the effect of changes in gender composition across the partition's subgroups, while the second term captures the impact of changes in the subgroups' relative demographic importance.

The interest of the approach is illustrated with an empirical application using Labor Force Survey data for Spain for 1977 and 1992. During this period, the Spanish labor market underwent three important transformations. First, as a consequence of an increase in the female labor force participation rate and a slight decrease in the male one, the proportion of females in the employed population grows from 28.6% to 32.9%. Second, there is a major improvement in educational standards over the period for both male and female workers. Finally, the shares of agricultural and public employment at the beginning of the period were, respectively, well above and below the OECD averages. By 1992, the share of agricultural employment had halved whilst the percentage of workers in the public sector had raised over the OECD average. Thus, the period under study is ideally suited to explore the influence of supply (increasing female labor participation, improvements in education standards), and demand (decreasing agricultural employment coupled with increasing public employment) factors on the evolution of gender segregation.

The rest of the paper contains four sections and an Appendix. Section 2 is devoted to the measurement of segregation. Section 3 studies the pattern of gender segregation in 1977. Section 4 deals with the evolution of gender segregation during the 1977–1992 period, while Section 5 offers some concluding comments. The descriptions of the data as well as the list of 29 occupational categories that are used in the empirical sections are relegated to the Appendix.

2. The measurement of segregation

To explain our measurement approach, we proceed in two steps. We begin with situations in which workers with a given characteristic, say a three-digit occupation, can be classified in terms of a second characteristic, a two-digit occupation, but not vice versa. This case is referred to as “a pair of one-way classification variables”. In the next step, we confront situations in which individuals can be classified in terms of a first characteristic, say human capital attainment, and/or in terms of a second characteristic, say occupation. This case is referred to as “a pair of two-way classification variables”.

2.1. THE CASE OF A PAIR OF ONE-WAY CLASSIFICATION VARIABLES

2.1.1. *Within-group Segregation*

Theil and Finizza [44] – or TF for short – study racial integration in a city where students of both genders can be classified in J schools and I school districts with $I < J$. In our context, let there be J three-digit occupations, indexed by

$j = 1, \dots, J$, classified into I two-digit occupational groups, indexed by G_i , $i = 1, \dots, I$. There are a number of procedures for measuring segregation along a single dimension,⁶ but not all of them are equally well-suited when one wants to consider two classification variables.

Let F_{ij} and T_{ij} be the number of females and workers of both genders, respectively, in three-digit occupation j within two-digit group i . Let $F_i = \sum_{j \in G_i} F_{ij}$ and $T_i = \sum_{j \in G_i} T_{ij}$ be the number of females and workers in group i , and let $T = \sum_i T_i$ be the total number of workers in the employed population. Let $W_i = F_i/T_i$ be the proportion of females in group i , and let $w_{ij} = F_{ij}/T_{ij}$ be the proportion of females in group i and occupation j . TF say that the population in group i is segregated in occupation j whenever w_{ij} differs from W_i . In information theory, the expression

$$I^{ij} = w_{ij} \log(w_{ij}/W_i) + (1 - w_{ij}) \log((1 - w_{ij})/(1 - W_i)) \quad (1)$$

is known as the expected information of the message that transforms the proportions $(W_i, (1 - W_i))$ to a second set of proportions $(w_{ij}, (1 - w_{ij}))$. The value of this expected information is zero when the two sets of proportions are identical; it takes larger and larger positive values when the two sets are more different. For $w_{ij} = 1$ the value of expression (1) is $\log(1/W_i)$, and for $w_{ij} = 0$ it is $\log(1/(1 - W_i))$. Thus, for example, when a two-digit group is predominantly male (W_i small), the presence of an all female occupation j ($w_{ij} = 1$) implies a large value of I^{ij} . This is intuitively reasonable for a measure of segregation.

TF define the occupational segregation within group i as a whole by

$$I^i = \sum_{j \in G_i} (T_{ij}/T_i) I^{ij}. \quad (2)$$

That is to say, I^i is the weighted average of the information expectations in (1), with weights proportional to the number of workers in the occupations within group i .

The entropy of a distribution with proportions $(W_i, (1 - W_i))$ is defined as

$$E_i = W_i \log(1/W_i) + (1 - W_i) \log(1/(1 - W_i)). \quad (3)$$

Equation (3) is a measure of the gender mix in group i . Notice that E_i takes its minimum value, equal to 0, when $W_i = 0$. Otherwise, E_i is positive and reaches its maximum value, equal to $\log 2$, when $W_i = 1/2$. To normalize E_i between 0 and 1, from here on it is assumed that all logarithms are in base 2. Analogously, the entropy of a distribution characterized by the proportions $(w_{ij}, (1 - w_{ij}))$ is given by

$$E_{ij} = w_{ij} \log(1/w_{ij}) + (1 - w_{ij}) \log(1/(1 - w_{ij})). \quad (4)$$

The average occupational entropy, or the average gender mix of the three-digit occupations in group i , is the weighted mean of the E_{ij} s with weights proportional to the number of workers in the occupations within group i : $\mu_i = \sum_{j \in G_i} (T_{ij}/T_i) E_{ij}$.

TF establish the relationship between the segregation index in group i , I^i , on one hand, and the maximum entropy allowed by the gender composition in that group, E_i , and the average occupational entropy of the three-digit occupations in group i , μ_i , on the other. The result is the following:

$$I^i = E_i - \mu_i. \quad (5)$$

If $w_{ij} = W_i$ for all j , then $E_{ij} = E_i$ for all j , so that the sum $\mu_i = \sum_{j \in G_i} (T_{ij}/T_i) E_{ij} = E_i$, and as a consequence $I^i = 0$, indicating complete absence of segregation within group i . Given that μ_i is non-negative, I^i is bounded from above by E_i , which is itself bounded by 1.

2.1.2. The Decomposition of Overall Segregation

The contribution of TF concludes here. These authors never define a notion of overall segregation for the population as a whole. In this subsection, two such notions are suggested and are shown to be equivalent.

In the first place, let $F = \sum_i F_i$ and $W = F/T$ be the total number and the proportion of females in the employed population, respectively. Consider the expected information of the message that transforms the proportions $(W, (1 - W))$ directly into the proportions $(w_{ij}, (1 - w_{ij}))$:

$$I_{ij} = w_{ij} \log(w_{ij}/W) + (1 - w_{ij}) \log((1 - w_{ij})/(1 - W)). \quad (6)$$

The index I_{ij} provides what is called a *direct* measure of gender segregation in two-digit group i and three-digit occupation j in relation to the entire employed population. Naturally, the greater the discrepancy between the proportion of females in group i and occupation j , w_{ij} , and the proportion of females in the population, W , the greater is the segregation index I_{ij} . The ratio w_{ij}/W can also be expressed as the ratio between the female distribution over three-digit occupations to the distribution of the overall population, $(F_{ij}/F)/(T_{ij}/T)$. Therefore, the greater the discrepancy between the distribution of female and male workers over three-digit occupations, the greater is the segregation index I_{ij} . The weighted average of the I_{ij} s, with weights proportional to the number of workers in the three-digit occupation j within two-digit group i , provides a reasonable overall measure of occupational segregation:

$$I = \sum_i \sum_{j \in G_i} (T_{ij}/T) I_{ij}. \quad (7)$$

Applying the TF result in Equation (5), we have that $I = E - \mu$, where $E = W \log(1/W) + (1 - W) \log(1/(1 - W))$ is the entropy of the distribution characterized by the proportions $(W, (1 - W))$, and $\mu = \sum_i \sum_{j \in G_i} (T_{ij}/T) E_{ij}$ is the average occupational entropy in the entire population. Therefore, the index I can take values in the interval $[0, E]$, and E in turn is normalized in the unit interval.⁷

In the second place, the expected information of the message that transforms the entire population proportions $(W, (1 - W))$ into group proportions $(W_i, (1 - W_i))$ is given by

$$I_i = W_i \log(W_i/W) + (1 - W_i) \log((1 - W_i)/(1 - W)). \quad (8)$$

Consider the weighted average of the I_i s with weights proportional to the number of workers in each group, that is,

$$I^B = \sum_i (T_i/T) I_i. \quad (9)$$

Equation (9) can be interpreted as the *between-group* (direct) gender segregation induced at the two-digit occupational level. On the other hand, given that I^i is the gender segregation in two-digit group i induced by three-digit occupations (see Equation (2)), the overall *within-group* gender segregation in the partition by two-digit occupational groups can be defined as

$$I^W = \sum_i (T_i/T) I^i. \quad (10)$$

Hence, the sum of I^B and I^W provides a second reasonable measure of overall occupational segregation.

Notice, however, that applying the TF result in Equation (9), we obtain that $I^B = E - \sum_i (T_i/T) E_i$. Recall also that, according to Equation (5), $I^i = E_i - \mu_i$. Therefore, we have

$$\begin{aligned} I^B + I^W &= E - \sum_i (T_i/T) E_i + \sum_i (T_i/T) (E_i - \mu_i) \\ &= E - \sum_i (T_i/T) \mu_i = E - \mu = I. \end{aligned} \quad (11)$$

Thus, the two measures of overall segregation are equivalent. The direct measure of occupational segregation I is decomposable into a *between-group* term, I^B , which measures the gender segregation at the level of two-digit occupational groups, plus a *within-group* term, I^W , which measures the gender segregation induced by three-digit occupations within each of the two-digit groups.⁸

2.2. THE CASE OF A PAIR OF TWO-WAY CLASSIFICATION VARIABLES

So far we have only considered a situation in which workers with a given characteristic could be classified in terms of a second characteristic, but not *vice versa*. In this subsection, we study situations in which workers can be classified in terms of a first characteristic indexed by $i = 1, \dots, I$, say human capital, and/or in terms of a second characteristic indexed by $j = 1, \dots, J$, say occupation. Thus, F_{ij} is the number of females with human capital level i in occupation j .

Since in this case there are two possible decompositions, the terms in Equation (10) must now specify the partition sequence they refer to. For example, if the population is first partitioned according to human capital, then the *between-group* segregation measure is $I_{(i)}^B = \sum_i (T_i/T) I_i$, where I_i was defined in Equation (8). On the other hand, the term I^{ij} in Equation (1) now measures the gender segregation in the group consisting of individuals with human capital i in occupation j ; I^i in Equation (2) measures the segregation induced by the gender-specific distributions across occupations⁹ within the group of individuals with human capital i ; and the *within-group* measure of gender segregation in the partition by human capital, defined in Equation (10), must be also indexed: $I_{(i)}^{Wj}$. Therefore, the previous result on the decomposition of the overall segregation index will be written as follows: $I = I_{(i)}^B + I_{(i)}^{Wj}$.

Let $F_j = \sum_i F_{ij}$ and $T_j = \sum_i T_{ij}$ be the number of females and workers in occupation j , respectively, and let $W_j = F_j/T_j$ be the proportion of females in that occupation. The index of gender segregation induced by human capital within occupation j can be defined as: $I^j = \sum_i (T_{ij}/T_j) I^{ji}$, where $I^{ji} = w_{ij} \log(w_{ij}/W_j) + (1 - w_{ij}) \log((1 - w_{ij})/(1 - W_j))$ is the gender segregation index of workers with human capital i employed in occupation j . Similarly, let $I_j = W_j \log(W_j/W) + (1 - W_j) \log((1 - W_j)/(1 - W))$ be the index of direct segregation in occupation j relative to the employed population as a whole. Following the same argument as in the previous case, it can be shown that the overall index I can be decomposed into the sum of two terms: a *between-group* term, $I_{(j)}^B = \sum_j (T_j/T) I_j$, which measures the gender segregation induced directly by occupation, and a *within-group* term, $I_{(j)}^{Wi} = \sum_j (T_j/T) I^j$, which captures the gender segregation induced by human capital in the partition by occupation. Therefore,

$$I = I_{(i)}^B + I_{(i)}^{Wj} = I_{(j)}^B + I_{(j)}^{Wi}. \quad (12)$$

Thus, given a pair of two classification variables, the overall segregation index has a commutative property, i.e. admits two alternative decompositions. In the first one, the term $I_{(i)}^{Wj}$ measures the role of occupation on gender segregation, the impact of human capital being kept constant in $I_{(i)}^B$. Similarly, the term $I_{(j)}^{Wi}$ measures the contribution of human capital to overall gender segregation, the impact of occupation being kept constant in $I_{(j)}^B$.¹⁰

Finally, it can be seen that

$$I = \sum_i (T_i/T) I(i) = \sum_j (T_j/T) I(j), \quad (13)$$

where $I(i) = I_i + I^i$, and $I(j) = I_j + I^j$.

The properties of additive decomposibility and commutativity are pivotal to investigate the links between occupational gender segregation and certain human capital features. Nevertheless, as shown in Mora and Ruiz-Castillo [36]), the index I satisfies most axioms proposed in the literature, including all axioms discussed in Kakwani [32]. In addition, it is proved that this index can be interpreted

as a log-likelihood ratio test for the equality in the probabilities of being female across occupations, and also as the log-likelihood ratio test for the equality in the occupational distribution across gender in non-parametric discrete choice models.

Finally, as pointed out by James and Taeuber [31] and Hutchens [24, 25] in relation to the TF index of segregation, a potential shortcoming of the index advocated in this paper is that it violates a *Composition Invariance* property, i.e. the requirement that proportional changes in the numbers of either female or male individuals should not affect the measure of segregation.

3. The gender segregation of the employed population in 1977

3.1. DESCRIPTIVE STATISTICS

As explained in the Appendix, the data used comes from the Spanish *Encuesta de Población Activa* (EPA), a labor force survey representative of the household population living in residential housing. The first year of study is 1977, the first time for which microeconomic data is available in electronic support. The target population in 1977 consists of 71,864 individuals, representative of 12,148,346 employed people, of which only 28.6% are females. Individuals are classified according to two variables. On one hand, human capital categories result from the combination of readily available variables, namely, age and education. This combination gives rise to 11 age/education categories. On the other hand, Herranz et al.[23] explores how far it is possible to aggregate an initial list of occupations without reducing too much the gender segregation value. Using an algorithm based on the bootstrap, that paper shows that an original list of 106 occupations for 1977 and 1992 can be aggregated into a common list of 29 occupational categories.¹¹

We begin by considering the usual case studied in the literature, namely, the partition of the employed population by occupation. For clarity of presentation, the 29 available occupations can be classified into three main categories. *Integrated* occupations are those where the proportion of females is within 10 percentage points of the proportion of females in the population in 1977, 28.6%, while in *male* and *female* occupations the proportion of females is below 18.6% or above 38.6% respectively. There are 14 male occupations, where the female proportion rate goes from 0 – in the *Armed forces* – to 17.8%; 11 female occupations, where the proportion of females goes from 45.9% to 93.9%; and 4 integrated occupations, where the proportion of females goes from 22% to 38.9%. In turn, each of these categories can be further divided into a maximum of four groups, depending on whether they contain agricultural, blue collar, white collar, or professional and managerial occupations.

The first 4 columns in Table I contain some descriptive statistics for the 29 occupations in 1977. Approximately, 48.8%, 22.8% and 29.5% of the population is employed in male, integrated and female occupations, respectively (see column 3). From another perspective, 20.7% of the population has a job in the agricultural sector, 39.1%, 27.1%, and 12.3% in blue collar, white collar, and professional and

Table I. Descriptive statistics and gender segregation indices in the partition by occupations, 1977

OCCUPATION	Labor force distribution across occupations			Female shares by occupation ^d	Gender segregation indices			Contribution to total segregation ^h
	Female ^a	Male ^b	Total ^c		Between ^e	Within ^f	Total ^g	
MALE	10.17	62.91	47.81	6.09				
Agriculture	4.26	10.75	8.89	13.72				
1.	4.24	9.40	7.92	15,32	7.06	1.03	8.10	26.94
2.	0.02	1.36	0.98	0,71	43.48	0.52	44.01	146.47
Blue Collar	2.20	35.28	25.81	2,44				
3.	0.21	15.98	11.47	0,51	44.68	0.12	44.80	149.11
4.	1.74	13.13	9.87	5,05	26.46	1.77	28.23	93.95
5.	0.23	4.15	3.03	2,16	36.48	1.21	37.69	125.44
6.	0.03	2.02	1.45	0,57	44.36	0.76	45.11	150.15
White Collar	1.46	7.04	5.45	7,69				
7.	0.26	3.05	2.25	3,32	32.02	1.87	33.89	112.79
8.	1.12	2.47	2.08	15,43	6.94	4.18	11.12	37.01
9.	0.08	1.53	1.12	2,08	36.82	1.28	38.10	126.82
Prof. & Manag.	2.24	8.70	6.85	9,38				
10.	0.26	3.38	2.49	3,02	33.07	0.76	33.84	112.62
11.	1.09	2.02	1.75	17,82	4.53	3.60	8.13	27.07
12.	0.74	1.61	1.36	15,52	6.84	2.80	9.64	32.10
13.	0.15	1.69	1.25	3,51	31.33	2.67	34.00	113.17
Armed Forces: 14.	0	1.13	0.81	0	48.65	0	48.65	161.92
INTEGRATED	25.34	21.83	22.83	31,77				
Agriculture: 15	12.01	9.28	10.06	34,17	1.05	1.65	2.69	8.97
Blue Collar	5.69	7.73	7.14	22,79				
16.	4.58	6.52	5.97	21,98	1.64	6.40	8.05	26.79
17.	1.11	1.20	1.18	26,89	0.11	4.87	4.98	16.56
White Collar: 18.	7.64	4.82	5.63	38,89	3.50	10.55	14.05	46.76

managerial occupations, respectively, while the remaining 0.8% is in the military. Naturally, the proportion of female workers increases as we move from male to integrated and female occupations (see column 4).

Regarding the age/education partition in 1977, some descriptive statistics are presented in the first 4 columns of Table II. Notice that still in 1977 as much as 16.8% of the Spanish population had a low education (either illiterate or without studies), while only 19.8% had a secondary or a College education (see column 3). The high percentage of workers with only primary education is due to the fact that

Table I. (Continued.)

OCCUPATION	Labor force distribution across occupations			Female shares by occupation ^d	Gender segregation indices			Contribution to total segregation ^h
	Female ^a	Male ^b	Total ^c		Between ^e	Within ^f	Total ^g	
FEMALE	64.48	15.26	29.35	62.88				
Agriculture: 19.	3.12	1.19	1.75	51,21	16.20	8.96	25.16	83.72
Blue Collar	13.86	3.06	6.15	64,48				
20.	6.90	2.60	3.83	51,56	16.69	3.50	20.19	67.19
21.	6.97	0.46	2.32	85,76	102.64	3.70	106.34	353.91
White Collar	37.95	7.32	16.09	67,51				
22.	10.55	2.78	5.00	60,39	31.40	1.47	32.86	109.38
23.	7.68	1.46	3.24	67,80	47.37	5.89	53.25	177.24
24.	5.25	2.30	3.14	47,81	11.81	3.04	14.85	49.42
25.	7.44	0.36	2.39	89,16	116.69	6.32	123.01	409.41
26.	4.87	0.13	1.48	93,88	139.16	3.91	143.08	476.19
27.	2.15	0.30	0.83	74,37	64.58	8.61	73.19	243.58
Prof. & Manag.	9.55	3.68	5.36	50,98				
28.	5.15	2.43	3.21	45,87	9.61	5.39	15.00	49.93
29.	4.40	1.25	2.15	58,59	28.03	1.31	29.34	97.66
TOTAL	100.00	100.00	100.00	28.62	27.00	3.04	30.04	

^a $100(F_j/F)$;^b $100(M_j/M)$;^c $100(T_j/T)$;^d $100(F_j/T_j)$;^eDirect gender segregation induced by occupational choices: $(T_j/T)I_j$;^fGender segregation induced by age/education characteristics within occupations: $(T_j/T)I^j$;^gGender segregation in the employed population: $(T_j/T)(I_j + I^j) = (T_j/T)I(j)$;^h $\alpha_j = 100[((T_j/T)I(j))/I]/(T_j/T) = 100(I(j)/I)$.

as late as 1970 compulsory education in Spain had only reached up to that level. Columns 1 and 2 in Table II shows that the percentages of males and females at different educational levels are surprisingly similar. Nevertheless, in different age brackets the educational experience by gender varies considerably:¹² the percentage of young females (16–30 years old) with a primary or, above all, a secondary education, is larger than the corresponding percentages of young males, while the opposite is the case among workers of more than 30 years of age.

Finally, it is interesting to notice that at all educational levels, except the lowest one, the lower the age bracket, the greater is the proportion of female workers (column 4). This reflects the fact that female labor participation rates for younger females with at least a primary education are above the population average.

Table II. Descriptive statistics and gender segregation indexes in the partition by age/education characteristics, 1977

EDUCATION age (years)	Labor force distribution across age/education			Female shares by age/ education ^d	Gender segregation indices			Contribution to total segregation ^h
	Female ^a	Male ^b	Total ^c		Between ^e	Within ^f	Total ^g	
LOW/	17.35	16.54	16.77					
1. 16–50	8.76	9.32	9.16	27.38	0.06	31.23	31.29	104.13
2. More than 50	8.58	7.22	7.61	32.29	0.46	26.35	26.81	89.24
PRIMARY/	60.22	64.79	63.48					
3. 16–30	25.57	18.92	20.82	35.15	1.45	35.34	36.78	122.42
4. 31–50	21.93	29.40	27.26	23.03	1.15	28.65	29.81	99.20
5. More than 50	12.71	16.47	15.40	23.64	0.91	21.99	22.90	76.22
SECONDARY/	16.84	13.36	14.36					
6. 16–30	12.81	6.68	8.43	43.48	7.19	27.80	34.99	116.46
7. 31–50	3.02	4.79	4.29	20.19	2.69	24.19	26.88	89.47
8. More than 50	1.00	1.89	1.64	17.51	4.81	16.23	21.04	70.02
COLLEGE/	5.60	5.31	5.39					
9. 16–30	2.34	1.17	1.50	44.64	8.32	22.77	31.09	103.48
10. 31–50	2.28	2.70	2.58	25.35	0.39	23.73	24.11	80.26
11. More than 50	0.97	1.45	1.31	21.21	2.06	20.22	22.28	74.15
TOTAL	100.00	100.00	100.00	28.62	1.77	28.27	30.04	

^a $100(F_i/F)$;

^b $100(M_i/M)$;

^c $100(T_i/T)$;

^d $100(F_i/T_i)$;

^eDirect gender segregation induced by age/education characteristics: $(T_i/T)I_i$;

^fGender segregation induced by occupational choices within age/education characteristics: $(T_i/T)I^i$;

^gGender segregation in the employed population: $(T_i/T)(I_i + I^i) = (T_i/T)I(i)$;

^h $\alpha_i = 100[(T_i/T)I(i)]/I = 100I(i)/I$.

3.2. THE ROLE OF OCCUPATIONS AND HUMAN CAPITAL CHARACTERISTICS IN GENDER SEGREGATION IN 1977

As shown in Section 2, the gender segregation index in the employed population, I , can be decomposed into two terms which measure the direct gender segregation in all occupations, $I_{(j)}^B$, and the gender segregation induced by age/education characteristics within the partition by occupations, $I_{(j)}^{Wi}$. Similarly, the index I can be

decomposed into the direct gender segregation attributable to age/education characteristics, $I_{(i)}^B$, and the gender segregation that takes place due to occupational choices within each human capital group, $I_{(i)}^{Wj}$, (see Equation (12)). Following Equation (13), $I = \sum_j (T_j/T) I(j) = \sum_i (T_i/T) I(i)$, where $I(j) = I_j + I^j$ and $I(i) = I_i + I^i$. Columns 5, 6, and 7 in Table I (and Table II) present detailed information for the 29 occupations (and the 11 age/education categories), on the following statistics: I_j , I^j , $I(j)$ (and I_i , I^i , $I(i)$). To facilitate the reading, all indexes have been multiplied by 100.

It turns out that $I_{(j)}^B = 27.01$, $I_{(j)}^{Wi} = 3.04$, $I_{(i)}^B = 1.76$ and $I_{(i)}^{Wj} = 28.29$. Thus, the degree of overall gender segregation is given by:

$$I = 27.01 + 3.04 = 1.76 + 28.29 = 30.05.$$

The first conclusion is inescapable: workers' educational choices, even combined with age differences, induce a very low degree of direct gender segregation (1.76 index points, or 5.9% of the total). Alternatively, given the occupational choices, the gender segregation attributable to differences in human capital characteristics within occupations is very low (3.04 index points, or 10.1% of the total). Thus, most of the gender segregation observed in Spain in 1977 takes place within age/education subgroups or, in other words, between occupations.

This is not surprising in view of the fact that the female proportion across human capital categories differs much less from the overall proportion than the female proportion across occupations (see column 4 in Tables II and I, respectively). Consequently, the range of variation in the index of total gender segregation across age/education categories goes from 21.04 for older workers with a secondary education, to 36.79 for younger workers with a primary education. Instead, this range goes from 2.69 in occupation 15, an integrated agricultural occupation consisting of *Employees in livestock production*, to 143.08 in occupation 26, a white collar female occupation consisting of *Domestic service personnel, typists and other operators* (see column 7 in Tables II and I).¹³ As a final symptom of the lesser role of age/education characteristics in gender segregation, only young workers with a secondary or a College education have a direct gender segregation index above 7 points (see column 5 in Table II), while only within occupations 18, 19 and 27 do the age/education characteristics induce a gender segregation value above 8 index points (see column 6 in Table I).

It should be mentioned that, as pointed out in Charles et al. [13], previous research indicates that the connection between certain human capital investments and occupational segregation depends on the extent to which gender distinctions prevailing in the labor market can be incorporated into the educational system. For instance, vocational programs provide training for occupations with strong gender labels and at an early age when pressures to conform to gender stereotypes are especially intense. Thus, using a two-digit classification that combines educational levels and educational subjects into 54 categories, Borghans and Groot [9] find that direct education segregation accounts for 80% of occupational segregation

in The Netherlands. However, the segregation induced by 5 broadly defined educational levels is 5 times smaller. Similarly, in their comparative study Charles et al. [13] find that in Switzerland, where a highly differentiated system provides more opportunities for sex segregation within secondary education, incumbency in a female-dominated occupation is strongly and negatively related to overall levels of educational investment. Instead, in the U.S., where the educational system emphasizes general training and offers fewer opportunities for gender differentiation, the relationship between occupational sex-typing and quantity of educational investment is comparatively attenuated.¹⁴

However, as it has been seen, the data for this paper refers only to broad educational categories, combined with information on age brackets. In any case, the asymmetric role of the partitions by human capital and occupation in accounting for overall gender segregation in the Spanish case does not preclude the detailed analysis of what happens inside each partition. For this purpose, starting with the partition by occupations, recall that the direct segregation index for any occupation, I_j , results from the discrepancy between the proportion of females in the employed population, $W = 28.6\%$, and the proportion of females in that occupation, W_j (see column 4 in Table I). Naturally, the direct segregation indexes reach high values in the male and female occupations, and low values in the integrated occupations (see column 5 in Table I). Moreover, although small, the gender segregation induced by age/education characteristics is typically larger in female than in male occupations (see column 6 in Table I). Consequently, total gender segregation tends to be larger in female occupations.

The last column in Table I includes the ratio

$$\alpha_j = 100[(T_j/T)I(j)]/I/(T_j/T) = 100(I(j)/I).$$

The numerator in this expression is the j th occupation relative contribution to the total gender segregation I , while the denominator is this occupation's demographic importance within the employed population. Therefore, when $\alpha_j > 100$ (<100), this ratio indicates that occupation j is contributing to total gender segregation above (below) what could be expected from its demographic weight. In particular, female white collar occupations 23, 27, 25, and 26, as well as the blue collar occupation 21, contribute to total gender segregation from 80% to 380% more than what could be expected from their demographic importance (see column 8 in Table I). Among male occupations, only blue collar occupations 3 and 6 and the *Armed forces* (occupation 14) contribute between 50% and 60% more than what could be expected from their demographic weight. Finally, not surprisingly, all integrated occupations contribute to total gender segregation well below their demographic weight.

In the partition by age/education, two points deserve mentioning. In the first place, column 7 in Table II shows that the greater the educational level, the smaller is total gender segregation for all age groups (with the sole exception of older workers with a College education that only accounts for 1.3% of total employ-

ment). This means that, given the age bracket, the greater the education level, the closer are the proportions of females in the different occupations to the female proportion in the education category in question. This important finding suggests that, as conjectured in the Introduction, more educated female workers encounter fewer barriers to allocate themselves more evenly among the different occupations.¹⁵

In the second place, interestingly enough, the segregation among the old is smaller than among the previous age brackets in all educational categories.¹⁶ As pointed out before, except for the lower educated, the proportion of females among the employed in 1977 decreases monotonically with age in all educational categories (see column 4 in Table II). But it would appear that, at every educational level, those females who remain employed in the later part of their life-cycle are less segregated by occupation than at the beginning of their employment career. As highlighted in the Introduction, this fact can be interpreted from a human capital perspective. Given that women must be temporarily absent from their jobs more often than men because of the family obligations they are supposed to attend to, they would tend to choose those occupations where their skills depreciate less over time.

4. Intertemporal comparisons

4.1. THE ROLE OF OCCUPATIONS AND HUMAN CAPITAL CHARACTERISTICS IN GENDER SEGREGATION IN 1992

As pointed out in the Appendix, the fundamental changes in the *National Classification of Occupations* and the *National Classification of Industries* that took place in 1993 and 1994, makes it impossible to compare the 1977 data with the period starting in 1993. Therefore, the period of study is 1977–1992. This is an interesting period because, as will be seen presently, there are important changes in male and female behavior relating to labor market participation, investment in human capital through formal education, and occupational choices. The information about the population in 1992 in the partition by age/educational characteristics is in Table III.

The comparison with Table II shows the following differences. In the first place, the proportion of females in the employed population has increased by more than 5 percentage points, from 28.6% to 32.9%. In the second place, the employed population is younger in 1992 than in 1977: the presence of workers older than 50 years decreases by 5.1 percentage points. This decrease is somewhat larger among females (5.6 points) than for males (4.7 points). In the third place, there has been a remarkable improvement in educational achievements. As a result, 9.8% of the population has a low education (*versus* 16.8% in 1977), whereas 53.8% has a secondary or a College education (*versus* 19.8% in 1977).

What are the implications of this upgrading in educational achievements, particularly among the young, for the gender segregation induced by age/education characteristics? In this framework, differences in gender segregation must come from gender differences in the above patterns. The comparison of column 1 in Ta-

Table III. Descriptive statistics and gender segregation indexes in the partition by age/education characteristics, 1992

EDUCATION/ age (years)	Labor force distribution across age/education			Female shares by age/ education ^d	Gender segregation indices			Contribution to total segregation ^h
	Female ^a	Male ^b	Total ^c		Between ^e	Within ^f	Total ^g	
LOW/	10.06	9.67	9.80					
1. 16–50	4.38	4.33	4.35	33.18	0.00	34.81	34.81	118.71
2. More than 50	5.68	5.34	5.45	34.28	0.06	28.12	28.18	96.09
PRIMARY/	30.25	39.48	36.44					
3. 16–30	4.45	5.53	5.18	28.27	0.72	35.51	36.23	123.53
4. 31–50	17.10	21.90	20.32	27.68	0.92	31.24	32.15	109.64
5. More than 50	8.70	12.05	10.95	26.16	1.55	25.32	26.87	91.63
SECONDARY/	42.09	40.28	40.88					
6. 16–30	25.66	20.77	22.38	37.72	0.74	29.15	29.89	101.94
7. 31–50	14.76	16.54	15.95	30.45	0.20	26.01	26.21	89.36
8. More than 50	1.67	2.98	2.55	21.59	4.50	19.29	23.80	81.14
COLLEGE/	17.60	10.57	12.88					
9. 16–30	6.42	2.22	3.60	58.67	20.07	15.91	35.98	122.70
10. 31–50	9.58	6.36	7.42	42.50	2.89	19.84	22.73	77.52
11. More than 50	1.59	1.99	1.86	28.16	0.75	24.38	25.13	85.71
TOTAL	100.00	100.00	100.00	32.90	1.66	27.67	29.33	

^a $100(F_i/F)$;

^b $100(M_i/M)$;

^c $100(T_i/T)$;

^d $100(F_i/T_i)$;

^eDirect gender segregation induced by age/education characteristics: $(T_i/T)I_i$;

^fGender segregation induced by occupational choices within age/education characteristics: $(T_i/T)I^i$;

^gGender segregation in the employed population: $(T_i/T)(I_i + I^i) = (T_i/T)I(i)$;

^h $\alpha_i = 100[(T_i/T)I(i)]/I = 100I(i)/I$.

bles II and III indicates that the proportion of females with a secondary or a College education has increased, approximately, by a factor of 2.5 and 3, respectively, while the proportion with a low education or, above all, with a primary one, has decreased dramatically. However, judging from the evidence presented in column 2 of these two tables, something similar has also taken place among the males.

Therefore, relative to 1977 the degree of direct gender segregation among the two lowest educational levels has changed very little, while the considerable increase in segregation experienced by College graduates below 50 years of age is offset by the decrease among those with a secondary education and older College educated workers who represent a larger proportion of the population. The end result is that $I_{(i)}^B$, the direct gender segregation induced by human capital characteristics, takes almost the same low value at the beginning and the end of the period (see column 5 in Tables III and II). In 1992,

$$I = I_{(i)}^B + I_{(i)}^{Wj} = 1.66 + 27.67 = 29.33,$$

so that the direct gender segregation in the partition by age/education characteristics, $I_{(i)}^B$, amounts to only 5.8% of the total.¹⁷ Thus, the Spanish employed population in 1992 is considerably more educated than in 1977, but although investment in human capital has been particularly large among females, workers' educational choices in 1992 again induce a very low degree of gender segregation.

As in 1977, column 7 in Table III shows two facts: except for the young and the older workers with a College education, the greater the educational level, the smaller is total gender segregation. Moreover, the greater the age, the smaller is gender segregation in all educational categories.

4.2. ACCOUNTING FOR CHANGES IN GENDER SEGREGATION

As we have just seen, overall gender segregation in 1992 is equal to 29.33. Therefore, relative to 1977, there is a slight decrease in total gender segregation of 0.7 points, which represents a 2.4% drop from the 1977 index value.¹⁸ Sampling error can potentially be the source of small changes in gender segregation indexes. In this case, upper (95%) and lower (5%) bootstrap bounds from 5,000 empirical sample replications are equal to 0.14 and -1.46 , respectively. Therefore, although the point estimate for the change in gender segregation from 1977 to 1992 implies a decrease in overall gender segregation, this reduction is not statistically significant at the 10% confidence interval.

Given a population partition, overall gender segregation is a demographically weighted average of gender segregation within the partition subgroups. Consequently, changes in overall segregation can be decomposed into two terms. In the partition in age/education characteristics, for instance, the first term would capture changes in gender segregation in each partition subgroup at constant, reference demographic weights β_i , $i = 1, \dots, 11$. The second term would capture the differences between these reference weights β_i and the actual demographic weights (T_{i92}/T_{92}) and (T_{i77}/T_{77}) in the two years under comparison.¹⁹

In intertemporal gender segregation studies, it is interesting to know the sign of the gender composition first term, and whether its impact has been offset or reinforced by the differences in the groups' relative importance captured in the second term. Even in the present context where there is no significant change in overall

segregation, it is important to know whether the two terms in this decomposition are negligible, or whether they have different signs but similar non-negligible sizes. Moreover, it is always interesting to know whether all subgroups in a partition have behaved in a similar way, or whether most of the action has taken place in a subset of the partition subgroups. These are the topics investigated in this subsection for different population partitions.

4.2.1. *The Partition By Human Capital Characteristics*

Denote by $\Delta \equiv I_{92} - I_{77}$ the change in overall gender segregation. Given the reference demographic weights β_i in the partition by age/education characteristics, $i = 1, \dots, 11$, the following decomposition will be used in the sequel:

$$\begin{aligned}\Delta &= \sum_i (T_{i92}/T_{92})I(i_{92}) - \sum_i (T_{i77}/T_{77})I(i_{77}) \\ &= \sum_i GC_i + DM_i = \sum_i TOTAL_i,\end{aligned}\tag{14}$$

where

$$GC_i = [I(i_{92}) - I(i_{77})]\beta_i\tag{15}$$

and $GC = \sum_i GC_i$ measures the change in gender segregation induced by gender composition changes in the partition by age/education characteristics, while

$$DM_i = [(T_{i92}/T_{92}) - \beta_i]I(i_{92}) + [\beta_i - (T_{i77}/T_{77})]I(i_{77})\tag{16}$$

and $DM = \sum_i DM_i$ shows the change in gender segregation induced by changes in the demographic mix of the age/education categories. Finally,

$$TOTAL_i = GC_i + DM_i.$$

This decomposition can be implemented once the values for β_i are chosen. Reasonable alternatives for β_i include, for example, T_{i92}/T_{92} , T_{i77}/T_{77} , or any linear combination of the two values. For brevity, only the case $\beta_i = T_{i77}/T_{77}$ will be presented here in Table IV. In this case, for each i Equation (16) becomes $DM_i = [(T_{i92}/T_{92}) - (T_{i77}/T_{77})]I(i_{92})$.

Two points deserve to be noticed. (i) Changes in the gender composition lead to a positive GC term. This is mainly due to the moderate increase in gender segregation among workers with a low education or with a primary education and more than 30 years of age. (ii) The slight decrease in overall gender segregation during the period is due to the offsetting influence of changes in the mix of age/education categories that lead to a negative value of the DM term, which is equal to -1.9 . The improvement in the employed population's educational standards is reflected in an increase in the proportion of workers in the upper tail of the educational distribution that leads to positive DM terms. This is offset by the reduction in the proportion of

Table IV. 1977 versus 1992: Gender composition and demographic mix effects in the partition by age/education (1977 demographic weights, i.e. $\beta_i = (T_{i77}/T_{77})$)

	Gender composition ^a	Demographic mix ^b	Total ^c
Low education			
1. 16–50	0.3	–1.7	–1.4
2. More than 50	0.1	–0.6	–0.5
Primary education			
3. 16–30	–0.1	–5.7	–5.7
4. 31–50	0.6	–2.2	–1.6
5. More than 50	0.6	–1.2	–0.6
Secondary education			
6. 16–30	–0.4	4.2	3.7
7. 31–50	0.0	3.1	3.0
8. More than 50	0.0	0.2	0.3
College education			
9. 16–30	0.1	0.8	0.8
10. 31–50	0.0	1.1	1.1
11. More than 50	0.0	0.1	0.2
Total	1.2	–1.9	–0.7 (–1.46, 0.14)

Upper (95%) and lower (5%) bootstrap bounds from 5,000 empirical sample replications with replacement are shown in parenthesis for the overall change in gender segregation.

^aChange in gender segregation induced by gender composition changes in the partition by age/education characteristics: $GC_i = [I(i_{92}) - I(i_{77})]\beta_i$.

^bChange in gender segregation induced by changes in age/education categories' demographic mix: $DM_i = [(T_{i92}/T_{92}) - \beta_i]I(i_{92}) + [\beta_i - (T_{i77}/T_{77})]I(i_{77})$.

^cTOTAL_{*i*} = GC_{*i*} + DM_{*i*}.

workers in the lower tail of the distribution, which is weighted by relatively high values of total gender segregation indexes in 1992, $I(i_{92})$ (see Equation (16) with $\beta_i = T_{i77}/T_{77}$ for all i). At both tails of the distribution, the DM effect is stronger for the group through which the main change takes place, namely, the young.²⁰

4.2.2. The Partition by Occupations

The relevant information when $\beta_j = T_{j77}/T_{77}$ for all j is presented in Table V, which is organized as follows. First of all, changes in gender composition across

Table V. 1977 versus 1992: gender composition and demographic mix effects in the partition by occupations. Selected occupational categories (1977 demographic weights, i.e. $\beta_i = (T_{i77}/T_{77})$)

Occupation ^a	Female distribution ^b	Female shares ^c	Gender composition ^d	Population distribution ^e	Demographic mix ^f	Total ^g
Group 1	-26.5	(-)	-3.8	-14.3	-2.4	-6.2
I. Agriculture (1, 2, 15, 19)	-11.1	(+)	-0.2	-10.8	-0.7	-0.9
II. Female, WC, Pr (22, 24, 25)	-7.3	(-)	-2.3	-0.7	-0.8	-3.1
III. Female, BC (20, 21)	-6.9	(-)	-1.1	-2.2	-0.8	-1.9
IV. Integrated, BC (16, 17)	-1.2	(-)	-0.2	-0.5	0.0	-0.2
Group 2	9.8	(+)	-1.1	7.5	1.3	0.2
V. Male, WC (7, 8, 9)	2.5	(+)	-0.5	2.4	0.4	-0.1
VI. Male, PM (10, 11, 12, 13)	3.1	(+)	-0.4	2.3	0.2	-0.1
VII. Female, PM (28, 29)	4.1	(+)	-0.2	2.8	0.6	0.4
Group 3	16.8	(+)	1.1	6.9	4.2	5.3
VIII. Male, BC (3, 4, 5, 6)	0.5	(+)	0.7	-0.1	0.1	0.8
IX. Integrated, WC (18)	6.0	(+)	0.2	2.6	0.5	0.7
X. Female, WC, Pu (23, 26, 27)	10.2	(+)	0.1	4.4	3.7	3.7
XI. Armed Forces: (14)	0.0	($\approx$)	0.1	-0.1	-0.1	0.0
Total	0.0	(+)	-3.8	0.0	3.1	-0.7

See the Appendix for the list of occupations. For clarity of presentation, the 29 available occupations are classified into three equally large categories referred to as Male, Integrated, and Female, plus the Armed Forces.

^aBC: Blue Collar; WC: White Collar; PM: Professional and Managerial; Pr: Private Sector; Pu: Public Sector.

^bChange in the female frequency distribution across occupations: $(F_{j92}/F_{92}) - (F_{j77}/F_{77})$.

^cChange in the female proportion across occupations: $W_{j92} - W_{j77}$.

^dChange in gender segregation induced by gender composition changes in the partition by occupations: $GC_j = [I(j_{92}) - I(j_{77})]\beta_j$.

^eChange in the population frequency distribution across occupations: $(T_{j92}/T_{92}) - (T_{j77}/T_{77})$.

^fChange in gender segregation induced by changes in occupations' demographic mix: $DM_j = [(T_{j92}/T_{92}) - \beta_j]I(j_{92}) + [\beta_j - (T_{j77}/T_{77})]I(j_{77})$.

^gTOTAL_j = GC_j + DM_j.

occupations depend on two factors: changes in the frequency distribution of women, denoted by $(\Delta F_j/F)$, and changes in the female proportion within each occupation, denoted by ΔW_j . Therefore, columns 1, 2, and 3 of Table V refer to $(\Delta F_j/F)$, ΔW_j and GC_j, respectively. In order to facilitate the discussion, the 29 occupations have been aggregated into 11 categories,²¹ classified into four groups according to the sign of both the change in the female frequency distribution and the sign of GC.²² In the second place, changes in the occupational mix depend on changes in

the population frequency distribution, denoted by $(\Delta T_j/T)$. Therefore, columns 4 and 5 contain the information on $(\Delta T_j/T)$, and DM_j . Finally, column 6 in this table captures the sum of the two factors in Equation (14), that is, $TOTAL_j = GC_j + DM_j$.

4.2.2.1. *Changes in the occupational mix of the economy* From 1977 to 1992 the employed population increases by only 2 per cent, approximately. By activity sectors, the pattern of change is the following (see column 4 of Table V): agricultural (category I) and blue collar occupations (categories III, IV, and VIII) decrease by 10.8% and 2.8%, respectively, while all white collar (categories II, V, IX and X) and professional and managerial occupations (categories VI, and VII), increase by 6.1% and 5.1%, respectively. The relative size of the *Armed forces* (XI) remains essentially the same. Thus, the decline of agriculture and industrial activities, and a tertiarization of the economy in which the public sector plays a major role characterize this period.²³

These changes in the pattern of economic activity affect the distribution of the employed population across male, integrated and female occupations. (i) Integrated occupations, which represent 22.8% of the population in 1977, go down to 19.5%. Essentially, this decrease is driven by occupation 15 (*Agricultural workers in livestock production*) whose relative size decreases by 5.5 points. (ii) The proportion of male occupations remains constant. This is because the decrease in agricultural occupations 1 and 2 is offset by the corresponding increase in white collar occupations (7, 8, 9) and the professions grouped in occupations 10 to 13, while male blue collar occupations maintain their relative importance at 25.8% of total employment. (iii) Thus, the decrease in integrated occupations is matched by an increase in female occupations. However, female blue collar occupations closely related to agricultural activities (*Textile and tobacco industries*, 20, and the *Clothing industry*, 21), as well as what has been called the private white collar ones (category II in Table V), lose ground during this period. On the contrary, female professional and managerial occupations, as well as white collar public occupations (category X in Table V), increase their relative importance during the period.

As a consequence of these trends we should expect DM negative values for agricultural occupations (category I in Table V), female blue collar occupations closely related to agricultural activity (category III), as well as the female private white collar ones (category II). We should also expect positive values for tertiary occupations, namely, the different groups of professional and managerial occupations (categories VI and VII), as well as white collar occupations (categories V and IX), particularly those linked to the public sector (category X). This is, indeed, what is found in column 5 of Table V.

4.2.2.2. *Changes in gender composition across occupations* In order to study the evolution of gender composition during this period, the first fact to be stressed is the important increase in the overall proportion of female workers from 28.6% to

32.9%. The key to understanding the change in gender segregation indexes across occupations is the connection between this fact and the set of female proportions W_j for every j . Columns 1 and 2 in Table V inform about the changes in the female frequency distribution and female proportions, while column 3 presents the implications for GC values.

The first four rows of Table V consider cases in which there is a decrease in the presence of women, while the next six rows consider occupational categories in which there is an increase (see column 1 in that table).

(i) The greatest decrease, which is parallel to the decline in employed population in the agricultural sector as a whole, has been in agricultural occupations (category I). Except in occupation 15 (*Agricultural workers in livestock production*, an integrated occupation), there are minor increases in female proportions (see column 2 in Table V); that is to say, relatively more males have abandoned agricultural activities. These changes give rise to GC small negative values in all but occupation 2 (*Fish, game, and forestry workers*).

(ii) By construction, women proportions in female occupations are characterized by high values. However, in categories III (female blue collar occupations closely related to agriculture), and II (white collar occupations where the private sector predominates, including *Sales assistants and representatives in retail and other industries; Chefs, cooks, and food service personnel in hotels and restaurants, and other personnel in services different from education and health*, as well as *Concierges, building supervisors, and cleaning personnel in the household sector*), such high female proportions have diminished during this period. This, together with the increase in the female proportion for the population as a whole, W , gives rise to GC negative values. In category IV, consisting of integrated blue collar occupations, there is a smaller decrease of female proportions; given the important increase in W , this translates into smaller GC negative values.

(iii) In categories V and VI (male white collar, and male professional and managerial occupations, respectively), the increase in the proportion of women more than offsets the increase in W , giving rise also to GC negative values. In female professional and managerial occupations (grouped in category VII) already characterized in 1977 by a high female proportion, this pattern generates a smaller GC negative value.

(iv) In the last group of occupations, all GC values become positive. On one hand, the explanation lies in the large increase in female proportions in white collar occupations dominated by the public sector (category X), which were already characterized in 1977 by very high female proportions. On the other hand, the entrance of women in male blue collar and integrated white collar occupations (category VIII and IX, respectively) would lead us to expect a decrease in gender segregation; however, that increase is offset by the relatively larger increase in W , resulting in GC positive values.

In all categories in group 1, gender composition and occupational mix effects reinforce each other giving rise to a total effect equal to -6.2 index points. In

group 2, GC and DM offset each other, while in group 3 positive GC and DM effects yield an increase in total segregation equal to 5.3 index points. This accounts for the decline in gender segregation in $0.7 = -6.2 + 0.2 + 5.3$ index points. However, there is a decline of 3.8 index points due to gender composition effects. This indicates that, had we not had a positive DM effect, equal to 3.1 index points, the reduction in overall gender segregation might have been close to 10 per cent of the 1977 value.²⁴

5. Conclusions

The property of additive decomposability for any partition has been extensively studied in the field of income inequality for quite some time. In the presence of two (or more) classification variables, this property is also essential in the field of gender segregation. Following up on the seminal work by Theil in income distribution theory, this paper has presented an additively decomposable gender segregation index based on the entropy concept used in information theory.

Overall gender segregation in a given year has been decomposed into a *between-group* term that measures, for instance, the direct gender segregation that can be attributed to human capital characteristics; and a *within-group* term, that captures gender segregation caused by occupation within human capital categories. The index has a commutative property that permits a similar decomposition where the role of the two partitions is interchanged. In intertemporal comparisons, the change in total gender segregation has also been decomposed into two terms. The first measures the effect of changes in gender composition in the groups of a given partition, while the second captures the impact of changes in the groups' relative demographic importance.

These two decompositions have been applied to Spanish data in 1977 and 1992. In both years, it has been found that, even when differences in broad educational categories across age groups are taken into account, the direct gender segregation induced by broad human capital characteristics accounts for less than 10% of total gender segregation. This result should be treated with caution for two reasons. First, increases in educational levels may affect segregation via labor participation decisions. Second, the absence of information on educational subjects unfortunately prevents the study of the role of subject segregation, a potentially important source of segregation as shown by Borghans and Groot [9]. Nevertheless, as conjectured in the Introduction, the higher the educational level (the older the group), the smaller is gender segregation in most age groups (educational categories).

Together with the decline in agriculture and blue collar occupations, the most important change in the employment structure during the 1977–1992 period in Spain is the tertiarization of the economy. This has been mainly caused by the increase in the size of the public sector. Such changes in the occupational mix caused a 10% increase in gender segregation. This is offset by changes in the gender composition across occupations in a scenario characterized by a consid-

erable increase in the proportion of females, which goes from 28.6% to 32.9% of the employed population. The net result is a small, not statistically significant 2% decrease in gender segregation over this period.

The occupational categories where changes in gender composition induce a reduction in gender segregation are the following: agriculture and closely related female blue collar occupations; female white collar occupations where the private sector plays a larger role than the public sector; and male white collar, professional and managerial occupations. The main occupational categories responsible for an increase in gender segregation are the male blue collar occupations, where the inroads made by women are not enough to offset the increase in the proportion of females in the employed population. In integrated white collar occupations, as well as female white collar occupations where the public sector has a dominant position, the increased presence of women also leads to slight increases in gender segregation.

This last result is intriguing, because in Spain, as in many other countries, openings in certain occupations within the public sector are filled through publicly advertised examinations, open to anyone with the appropriate educational credentials. Therefore, it would appear that in the public sphere there is less room for gender discrimination and we might expect occupational gender segregation in the public sector to be smaller than in the private sector. Hence, gender segregation in female white collar occupations where the public sector has a dominant position might be smaller than in other occupations. In fact, to properly study differences between the private and the public sector, it would be necessary to focus the attention to those occupations where the public sector reaches a minimum size. In that context, it would be meaningful to ask whether gender segregation is larger in the private or the public sector, and whether gender segregation has increased or not in these two sectors. These issues, which are being separately investigated,²⁵ provide a good example of the type of problems that can be analyzed using the additive decomposability property of the gender segregation index presented in this paper.

On the other hand, to our knowledge, all previous studies on gender segregation, including this one, refer exclusively to the employed population. However, individual occupational choices are conditional on the labor market participation and human capital investment decisions made prior to the occupational choice. Thus, a possible extension of this paper's approach is to consider, not only the gender segregation of the employed population, but also the gender segregation of the entire non-student population of legal working age.

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Notes

¹ For instance, the effect of aggregation on the gender segregation induced by occupational choice, or the relative importance of the gender segregation induced by either the occupational or the industrial choice – see, Sections 7.2 to 7.5 in Flückiger and Silber [17]. Borghans and Groot [9] analyze the relationship between educational and occupational segregation that, as will be seen presently, provides the main empirical motivation for this paper.

² For time-series analysis of individual countries, see, *inter alia*, Gross [20], Blau [5], Blau and Hendricks [6], England [16], Beller [4], Albelda [1], Jacobs [26, 27], Watts and Rich [48, 49], Jacobsen [29, 30], Blau et al. [7], and Weeden [50]. For cross-country studies, see Jacobs and Lim [28], Charles [10, 11], Charles et al. [13], Charles and Grusky [12], Grusky and Charles [21], Anker [3], and Dolado et al. [15]. For a recent treatise on segregation, see Flückiger and Silber [17].

³ See, *inter alia*, Roos [38], King [34], Hakim [22], and Jacobsen [29, 30] for the U.S., Borghans and Groot [9] for the Netherlands, and Charles et al. [13] for a comparative study between the U.S. and Switzerland.

⁴ For an alternative decomposition using the Gini-Segregation Index, see Silber [41], Boisso et al. [8], Deutsch et al. [14], and Sections 7.4 and 7.5 of Flückiger and Silber [17]. For the decomposition of the Karmel and MacLachlan [33] segregation index, see Silber [42], Watts [46], and Borghans and Groot [9]. On the topic of multidimensional indices of gender segregation, see also Watts [47].

⁵ Examples of this approach can be found in Fuchs [18], Blau and Hendricks [6], and Flückiger and Silber [17], Chapter 8. Karmel and MacLachlan [33] point out that holding all factors constant except one in order to isolate the effect of that factor is not an appropriate technique in segregation measurements because of the lack of independence of the various factors. Their approach addresses this problem by implementing an iterative procedure to identify a joint distribution of occupations and gender for, say, the first period that closely follows the same marginal distributions of the second period and keeps the original association structure between gender and occupation (see also [45]). For a full discussion of this issue in the context of entropy-based measures of segregation, see Mora and Ruiz-Castillo [36].

⁶ See *inter alia*, James and Taeuber [31], and Siltanen et al. [43]. For a recent survey, see Chapters 4 and 5 in Flückiger and Silber [17].

⁷ For the case of a single variable, Fuchs [18] suggests $E - \mu$ as an index of segregation, but the connection with a definition of direct gender segregation analogous to the one given in Equation (7) is never explored. For the properties of this segregation measure, see Chapter 5 in Flückiger and Silber [17].

⁸ This is a useful result which has been applied in Herranz et al. [23] to evaluate the impact of aggregation on the measurement of gender segregation.

⁹ For brevity, this will be referred to as “segregation induced by occupational choice”. This terminology, however, should not be interpreted as suggesting that segregation occurs only because of differences in preferences between genders. In fact, even if preferences are identical, any technological constraints that favor some gender skills over others in certain occupations, and any economic or cultural processes that increase the costs of gender-atypical choices or serve as a mechanism for societal enforcement of discrimination, will lead to occupational segregation.

¹⁰ In the decomposition of the Karmel and MacLahlan index suggested by Borghans and Groot [9], the occupational and educational indexes that they denote by OS and ES correspond to our direct segregation indexes $I_{(i)}^B$ and $I_{(j)}^B$, respectively.

¹¹ See the Appendix for a brief explanation of the data and the full description of the 29 occupational categories and 11 human capital levels.

¹² Given the structure of the data set, we cannot distinguish between age and cohort effects. Thus, caution should be exercised when interpreting the results concerning the age effect. We would like to thank a referee for drawing our attention to this point.

¹³ Recall that while weighted gender segregation indexes are bounded between 0 and 100, each unweighted direct segregation index is bounded only from below.

¹⁴ See also Jacobs [27], p. 41. For the small role of educational attainments in reducing occupational segregation, see Roos [38], p. 61, Hakim [22], p. 161, and Albelda [1].

¹⁵ This is the same pattern found in Jacobsen [29, 30] for the U.S. in 1980 and 1990. On the other hand, according to King [34], segregation between white and black women in the U.S. from 1940 to 1980 is always smaller for those with some College education and College graduates, and it is strictly decreasing with educational attainments in 1980 and 1988.

¹⁶ Women in the U.S. are also decreasingly likely to work in sex-typical occupations over time (see [19, 26, 39], as well as [13], for the U.S. and Switzerland). However, Jacobsen [29, 30] finds a weak pattern in the opposite direction for the U.S. in 1980 and 1990.

¹⁷ Similarly, the gender segregation attributable to differences in human capital characteristics within occupations is even lower than in 1977 (2 index points, or 6.7% of the total in 1992).

¹⁸ In the only comparable study for the Spanish economy, Sánchez [40] obtains very similar results using 62 occupations from the same data source for the 1977–1988 period. According to the dissimilarity index, there is a 0.14 per cent decrease in gender segregation; using the Karmel–MacLachlan index, there is a 0.02 per cent increase. On the other hand, the slight decline in gender segregation observed for the Spanish economy in the 1977–1992 period is broadly consistent with the relative stability shown by the dissimilarity index in the U.S. throughout the first half of the twentieth century (see [26, 27], and the discussion in England 1991 of the early papers on the U.S.). This period is characterized by low female labor participation rates comparable to the Spanish ones: in 1960, that rate was 37.7 per cent in the U.S. – see [4]. For a general discussion of the main theories on the persistence of occupational segregation, see, for example, Anker [2] and Preston and Brandeis [37]. Notice, however, that using a log-linear approach Weeden [50] concludes that extreme forms of segregation in the U.S. withered away between 1930 and 1940, and that roughly half of the change in segregation between 1910 and 1990 took place before 1970.

¹⁹ It should be stressed that the first term of the decomposition is not composition invariant as defined in James and Taeuber [31] because the term is affected by the overall proportion of females for each year. There exist alternative ways to address this issue, but this line of inquiry would take us far beyond the scope of this paper. The interested reader may see Mora and Ruiz-Castillo [36], where several decompositions are proposed, each assuming different benchmarks concerning the composition of the population.

²⁰ This result is robust to the choice of weights: using the 1992 population weights, $\beta_i = T_{i92}/T_{92}$ for all i in Equations (14) and (15), the GC and DM terms become 0.1 and -0.8 , respectively.

²¹ In particular, the original female white collar occupations include occupations 22 to 27. However, in 1992 the proportion of employment in the public sector in occupations 22, 24 and 25 is only 0.8%, 2.0% and 0.4%, while in occupations 23, 26, and 27 this proportion is 31.3%, 9.9%, and 59.8%, respectively. Therefore, in Table V this set of occupations is subdivided into two categories: occupations 22, 24 and 25 are classified as “private”, while occupations 23, 26, and 27 are classified as “public”.

²² The information for the full partition of 29 occupations is available on request.

²³ Whereas employment in the private sector actually decreases by 600,000 persons, in the public sector there is an increase of 847,000 jobs. As a consequence, the percentage represented by the public sector increases from 10.8 to 17.4 per cent.

²⁴ This result is robust to the choice of weights: using the 1992 population weights, the GC and DM terms become -3.1 and 2.4 , respectively. On the other hand, using the Karmel–MacLachlan decomposition, Sánchez [40] also obtains for the 1977–1988 period that a DM term and a term that includes our GC concept have positive and negative signs, respectively.

²⁵ See Mora and Ruiz-Castillo [35].

Data appendix

The Spanish data for this study comes from EPA (*Encuesta de Población Activa*), a labor force survey conducted by the *Instituto Nacional de Estadística*. The EPA consists of about 50,000 household observations per quarter, representative of the Spanish household population living in private residential housing. It investigates the relationship with economic activity and other characteristics of every household member over 14 years of age. The EPA is a rotating panel in which each household is interviewed during 7 consecutive quarters; thus, one eighth of the sample is renewed every quarter. In this paper, data from the second quarter is taken as representative of the year as a whole.

The time period in this paper starts in 1977, the first year for which micro-economic data is available in electronic support. In 1993 and 1994 there are fundamental changes in the National Classification of Occupations (NCO) and in the National Classification of Industries (NCI), making it impossible to compare the 1977 data with the period starting in 1993. Therefore, the period studied is 1977 – 1992.

According to EPA, the employed population in 1977 and 1992 is, approximately, 12,148,346 and 12,361,738 people, respectively. There are 71,864 and 62,332 individual observations in 1977 and 1992, respectively, which can be classified according to the two-digit NCI of 1974 and the two-digit NCO of 1979.* It is clear that the use of more detailed categories leads to larger index values, since broader categories mask some of the segregation within them [16]. Consequently, researchers have always sought to work with the largest possible occupation's space.** However, the idea that, *ceteris paribus*, the larger the number of occupations the better, has been questioned because of the possible bias due to small cell size [7]: random allocations of individuals across occupations may generate relatively high levels of gender segregation purely by chance. Moreover, when the number of occupations is very large, results on segregation are difficult to interpret. Finally, in this paper occupations must be large enough in order to be meaningfully

* Because EPA is a labour force survey rather than a census, there are a relatively low number of two-digit occupations and industries. In Herranz et al. [23] occupations are taken as the basic partition and are combined with the list of two-digit industries to obtain a 106 occupational classification.

** In empirical studies using Census data, the occupational space typically reaches several hundred categories. For instance, in the U.S. Blau et al. [7] work with 470 occupations from the 1970, 1980, and 1990 Census.

partitioned by age/education characteristics. Given that we are limited by a relatively small sample size because our data come from a labor force survey rather than a Census, we need to search for the smallest possible set of occupations.

As explained in Herranz et al. [23], using an algorithm based on the bootstrap an original list of 106 occupations for 1977 and 1992 can be aggregated into a common list of 29 occupational categories, which are fully described below.

Individuals in each occupation must be further partitioned according to productive characteristics. The available sample size limits the number of subgroups that can be considered. In particular, we distinguish three age categories (16–30; 31–50; 51–99), and four educational attainment levels (illiterates and without formal studies or “low education”; with less than 9 years of education or “primary education”; between 9 and 12 years of education or “secondary education”; and College education). Since it might be argued that the educational experience varies considerably by age, a final partition consisting of 11 age/education subgroups (where the low education category had to be combined with a 16–50 age interval) has been constructed.

LIST OF OCCUPATIONS

The 106 initial occupations are listed within the 29 final categories obtained with the bootstrap algorithm.

MALE

Agriculture

- 1** Independent farm workers, fishermen in farms and other agricultural production.

Farm workers, ranchers, ranch hands in other industries

- 2** Fish and game workers

Forestry workers

Blue collar

- 3** Construction workers and bricklayers

Drivers, other transport personnel

Electricians in other industries

Iron and steel workers

Miners and quarry workers.

Machine operators, radio & TV station operators, and sound-system operators

Stonemasons

Chemical laboratory workers in other industries

- 4 Construction workers in other industries
 - Foundry workers
 - Furniture makers and carpenters
 - Workers not classified in other subgroups (unskilled workers) in services
 - Graphic arts workers
 - Wood and paper mill workers
 - Painters
 - Furriers and leather workers
- 5 Mechanics, machinists, watchmakers and other precision mechanics
 - Shoemakers in repair services
- 6 Plumbers, welders, sheet metal workers

White collar

- 7 Personnel in protection and security services
 - Foremen and overseers
 - Mailroom workers and office assistants
 - Engineers, inspectors, and conductors in passenger transport
- 8 Employees in accounting, cashier, teller positions in other industries
 - Sculptors, painters, decorators, photographers
 - Sales assistants, sales representatives in wholesale trade
 - Stockbrokers, bonds brokers, real estate agents, and insurance brokers
 - Accountants and bookkeepers
 - Adding machine operators and data processors
- 9 Sales personnel and sales representatives

Professional and managerial

- 10 Companies Directors and managers
 - Owners or managers of commercial establishments in wholesale trade
 - Head of sales and head buyers
 - Inspectors of transport and communication services
 - Operator of agricultural or fishing enterprises
 - Directors and managers of commercial establishments
 - Owners or managers of commercial establishments in other industries
 - Members of governmental branches

- 11** Owners or managers of hotel, restaurant services in restaurants
Head clerks and office managers
Directors and managers of hotel in restaurant services
- 12** Physicians, veterinarians, and pharmacists
Legal professionals
Professional musicians and show business professionals
Statisticians, mathematicians, computer analysts, and other like technicians
Economists
Chemists, physicists, and geologists
Writers and journalists
Biologists and agricultural and forestry specialists
Sports professionals
- 13** Draftsmen and engineering technicians
Architects and engineers
Pilots and Officers of air and maritime navigation

Armed forces

- 14** Members of the Armed Forces

INTEGRATED

Agriculture

- 15** Farm workers, ranchers, and ranch hands in farms
Independent farm workers and fishermen in livestock production

Blue collar

- 16** Food and drink preparation workers in food and kindred products
Workers not classified in other subgroups (unskilled workers) in agriculture and industry
Cargo handlers in other industries
Cargo handlers in agriculture and mining
Glass and ceramic factory workers
Rubber and plastic manufacturing plant workers
Chemical laboratory workers in chemicals and allied products

- 17** Electricians in equipment manufacturing
Crafts people and similar not classified in above subgroups
Jewelers and silversmiths
Garment workers: upholsterers

White collar

- 18** Employees in administrative services in non-classified areas in other services
Employees in administrative services in non-classified areas in agriculture and mining
Employees in administrative services in non-classified areas in wholesale trade
Employees in administrative services in non-classified areas in hotels and restaurants
Supervisors of domestic service personnel

FEMALE

Agriculture

- 19** Farm workers, ranchers, and ranch hands in livestock production

Blue collar

- 20** Textile workers
Cargo handlers in manufacturing
Food and drink preparation workers in other industries
Shoemakers in other industries
Paper and cardboard factory workers
Tobacco production workers

- 21** Garment workers: other

White collar

- 22** Sales assistants and sales representatives in retail
Employees in administrative services in non-classified areas in retail
Sales assistants and sales representatives in other industries
- 23** Concierges, building supervisors, and cleaning service personnel in other services
Hair stylists and beauty treatment personnel

- Concierges, building supervisors, and cleaning service personnel in trade and transport,
- Chefs, cooks, and food service personnel in other industries
- Dry cleaning and laundry service employees
- Telephone and telegraph operators
- Concierges, building supervisors, and cleaning service personnel in agriculture and mining
- 24** Chefs, cooks, and food service personnel in hotels, restaurants, and other lodging services
 - Personnel in other services not classified in other subgroups in education and health
 - Personnel in other services not classified in other subgroups in other industries
- 25** Concierges, building supervisors, and cleaning service personnel in personal household
- 26** Domestic service personnel and other like personnel
 - Stenographers, typists, and key-punch operators
- 27** Medical, veterinary, and pharmaceutical assistants and technicians
 - Employees in accounting, cashier, and teller positions in trade and miscellaneous repair

Professional and managerial

- 28** Owners or managers of commercial establishments in retail
 - Owners or managers of hotel, restaurant services in hotels and other lodging services
- 29** Teachers
 - Professionals or technicians in non-classified areas

References

1. Albelda, R.: Occupational segregation by race and gender, 1958–1981, *Industrial and Labor Relations Review* **39** (1986), 404–411.
2. Anker, R.: Theories of occupational segregation by sex: An overview, *International Labour Review* **136**(3) (1997), 315–39.
3. Anker, R.: *Gender and Jobs. Sex Segregation of Occupations in the World*, International Labor Office, Geneva, 1998.
4. Beller, A.: Changes in the sex composition of U.S. occupations, 1960–1981, *J. Human Resources* **20** (1985), 235–250.
5. Blau, F.: *Equal Pay in the Office*, Heath, Lexington, 1977.

6. Blau, F. and Hendricks, W.: Occupational segregation by sex: Trends and prospects, *J. Human Resources* **12** (1979), 197–210.
7. Blau, F., Simson, P. and Anderson, D.: Continuing progress? Trends in occupational segregation over the 1970s and 1980s, *Feminist Economics* **4** (1998), 29–71.
8. Boisso, D., Hayes, K., Hirschberg, J. and Silber, J.: Occupational segregation in the multidimensional case: Decomposition and test of significance, *J. Econometrics* **61** (1994), 161–171.
9. Borghans, L. and Groot, L.: Educational presorting and occupational segregation, *Labour Economics* **6** (1999), 375–395.
10. Charles, M.: Cross-national variation in occupational sex segregation, *American Sociological Review* **57** (1992), 483–502.
11. Charles, M.: Structure, culture, and sex segregation in Europe, *Research in Social Stratification and Mobility* **16** (1998), 89–116.
12. Charles, M. and Grusky, D.: Models for describing the underlying structure of sex segregation, *Amer. J. Sociol.* **100** (1995), 931–971.
13. Charles, M., Buchmann, M., Halebsky, S., Powers, J. and Smith, M.: The context of women's market careers: A cross-national study, *Work and Occupations* **28** (2001), 371–396.
14. Deutsch, J., Flückiger, Y. and Silber, J.: Measuring occupational segregation, *J. Econometrics* **61** (1994), 133–146.
15. Dolado, J., Felgueroso, F. and Jimeno, J.F.: Female employment and occupational changes in the 1990s: How is the EU performing relative to the U.S.?, *European Economic Review* **45** (2001), 875–889.
16. England, P.: Assessing trends in occupational sex segregation, 1900–1976, In: I. Berg (ed.), *Sociological Perspectives on Labor Markets*, Academic Press, New York, 1981.
17. Flückiger, Y. and Silber, J.: *The Measurement of Segregation in the Labor Force*, Physica-Verlag, Heidelberg, 1999.
18. Fuchs, V.: A note on sex segregation in professional occupations, *Explorations in Economic Research* **2** (1975), 105–111.
19. Gerson, K.: *Hard Choices: How Women Decide About Work, Career, and Motherhood*, University of California Press, Berkeley, 1985.
20. Gross, E.: Plus ça change...? The sexual structure of occupations over time, *Social Problems* **16** (1968), 198–208.
21. Grusky, D.B. and Charles, M.: The past, present, and future of sex segregation methodology, *Demography* **35** (1998), 497–504.
22. Hakim, C.: *Key Issues in Women's Work*, Cambridge University Press, Cambridge, 1996.
23. Herranz, N., Mora, R. and Ruiz-Castillo, J.: An algorithm to reduce the occupational space in gender segregation studies, *J. Appl. Econometrics* (2003), forthcoming.
24. Hutchens, R.M.: Segregation curves, Lorenz curves and inequality in the distribution of people across occupations, *Math. Social Sci.* **21** (1991), 31–51.
25. Hutchens, R.M.: Numerical measures of segregation: Desirable properties and their implications, *Math. Social Sci.* **42** (2001), 13–29.
26. Jacobs, J.: Long-term trends in occupational segregation by sex, *Amer. J. Sociol.* **95** (1989), 160–173.
27. Jacobs, J.: *Revolving Doors: Sex Segregation and Women's Careers*, Stanford University Press, CA, 1989.
28. Jacobs, J. and Lim, S.: Trends in occupational segregation by sex, *Work and Occupations* **19** (1992), 450–486.
29. Jacobsen, J.: Trends in work force sex segregation, 1960–1990, *Social Science Quarterly* **75** (1994), 204–211.
30. Jacobsen, J.: *The Economics of Gender*, 2nd edn, Blackwell, Oxford, 1998.

31. James, D.R. and Taeuber, K.E.: Measures of segregation, In: N.B. Tuma (ed.), *Sociological Methodology*, Jossey-Bass, San Francisco, 1985.
32. Kakwani, N.C.: Segregation by sex: Measurement and hypothesis testing, *Research on Economic Inequality* **5** (1994), 1–26.
33. Karmel, T. and MacLachlan, M.: Occupational sex segregation: Increasing or decreasing?, *Economic Record* **64** (1988), 187–195.
34. King, M.: Occupational segregation by race and sex, 1940–88, *Monthly Labor Review* **115** (1992), 30–37.
35. Mora, R. and Ruiz-Castillo, J.: Gender segregation by occupations in the public and the private sectors. The case of Spain in 1977 and 1992, Working Paper No. 03-16, Universidad Carlos III de Madrid, Madrid, 2003.
36. Mora, R. and Ruiz-Castillo, J.: An evaluation of an entropy based index of segregation, Working Paper No. 03-40, Universidad Carlos III de Madrid, Madrid, 2003.
37. Preston, J. and Brandeis, U.: Occupational gender segregation: Trends and explanations, *Quarterly Review of Economics and Finance* **39**(0) (1999), 611–624.
38. Roos, P.A.: *Gender and Work: A Comparative Analysis of Industrial Societies*, State University of New York Press, New York, 1985.
39. Rosenfeld, R.A. and Spenner, K.I.: Occupational sex segregation and women's early career job shifts, *Work and Occupations* **19** (1992), 424–449.
40. Sánchez, M.: La segregación de las mujeres en el mercado de trabajo español: evidencia para el período 1964–1988, *Hacienda Pública Española* (1991), 123–139.
41. Silber, J.: Factor components, population subgroups and the computation of the Gini index of inequality, *Rev. Econom. Statist.* **LXXI** (1989), 107–115.
42. Silber, J.: Occupational segregation indices in the multidimensional case: A note, *Economic Record* **68** (1992), 276–277.
43. Siltanen, J., Jarman, J. and Blackburn, R.: *Gender Inequality in the Labor Market: Occupational Concentration and Segregation, A Manual on Methodology*, International Labor Office, Geneva, 1993.
44. Theil, H. and Finizza, A.J.: A note on the measurement of racial integration of schools by means of information concepts, *J. Math. Sociol.* **1** (1971), 187–194.
45. Watts, M.: How should occupational segregation be measured?, *Work, Employment and Society* **6** (1992), 475–487.
46. Watts, M.: Trends in occupational segregation by race and gender in the USA, 1983–1992: A multidimensional approach, *Review of Radical Political Economics* **27** (1995), 1–36.
47. Watts, M.: Multidimensional indexes of occupational segregation, *Evaluation Review* **21** (1997), 461–482.
48. Watts, M.J. and Rich, J.: Equal employment opportunity in Australia? The role of part-time employment in occupational sex segregation, *Australian Bulletin of Labour* **17** (1991), 160–179.
49. Watts, M.J. and Rich, J.: Occupational sex segregation in Britain, 1979–89. The persistence of sex stereotyping, *Cambridge Journal of Economics* **17** (1993), 159–177.
50. Weeden, K.A.: Revisiting occupational sex segregation in the United States, 1910–1990: Results from a Log-linear approach, *Demography* **35** (1998), 475–487.