



From the Extent of Segregation to its Consequences in Terms of Wellbeing*

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Abstract

We offer a reflection on the measurement of segregation, gathering methodological contributions from both sociology and economics, and we use some of them to explore occupational segregation by gender and nativity in Spain. Our goal is to offer a guide to the tools that can be used in empirical analysis, connecting them with theoretical discussions. Our empirical analysis shows that the occupational segregation of immigrant women is a more intense phenomenon than that of native-born women or immigrant men, although it decreased significantly over the period 2006-2024. Despite this decline, immigrant women still tend to cluster in low-paying occupations to a much greater extent than immigrant men and native-born women. Moreover, their occupational sorting places them at a great disadvantage even after controlling for basic attributes. Unlike them, most of the segregation of immigrant men that we observe is a consequence of their lower educational attainments. Once we control for basic attributes, the concentration of immigrant men in low-paying occupations is substantially reduced, although their hourly wages remain lower than those of their native peers. As opposed to immigrant women and men, native-born women tend to cluster in occupations with wages slightly above the national average, although this wage advantage vanishes once we control for characteristics. Native-born women earn lower hourly wages than their male peers (especially after removing the composition effect) due to both differences in their occupational distributions and wage disparities within occupations. The gender gap is larger among natives than among immigrants.

Keywords: Segregation, Gender, Migration status, Wage gaps, Intersectionality.

JEL Classification: D63, J15, J16, J31.

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1. Introduction

The measurement of segregation has a long tradition in sociology, with approaches linked to the measurement of income inequality in economics and others developed outside this field (James and Taeuber, 1985; Massey and Denton, 1988; Charles and Grusky, 1995; Reardon and Firebaugh, 2002). As in the income inequality literature, this scholarship has followed an axiomatic approach because there is general agreement on the desirability of defining the basic properties that any segregation measure must meet. It is within sociology that these properties have been discussed to the greatest extent, especially to quantify overall or aggregate segregation, i. e., the simultaneous discrepancies among all the mutually exclusive groups into which society had been partitioned across organizational units (whether these units are occupations, industries, workplaces, schools, neighborhoods of a city, etc.).

For a long time, this literature focused on the segregation between two groups (e. g., occupational segregation by gender, residential segregation between Black and White households, and school segregation between pupils living in poverty and those who are not) using binary segregation measures (Duncan and Duncan, 1955; Karmel and MacLachlan, 1988). However, as societies grew more diverse, it became necessary to develop measures with which to quantify overall segregation in a multigroup context (e. g., residential segregation among Whites, Blacks, and Hispanics and occupational segregation by both gender and race/ethnicity; Reardon and Firebaugh, 2002).

The methodological contributions of economics to this field are various. They include, inter alia, the development of new binary measures (Silber, 1989; Hutchens, 1991, 2004), the extension of binary measures to a multigroup context (Boisso *et al.*, 1994; Silber, 1992), decomposition methods (Deutsch *et al.*, 2009; Frankel and Volij, 2011), and the development of an axiomatic framework to deal with the measurement of the segregation of a group in a multigroup context, called local segregation to distinguish it from overall segregation (Alonso-Villar and Del Río, 2010a; Del Río and Alonso-Villar, 2022), which has opened the door to explore the consequences of segregation in terms of wellbeing (Alonso-Villar and Del Río, 2017a).¹

Throughout these pages, we offer a reflection on the measurement of segregation, gathering methodological contributions from both sociology and economics, and we use some of them to explore occupational segregation by gender and nativity in Spain. Our aim is not to provide a review of the extensive literature on segregation but to offer a guide to the tools that can be used in empirical analysis, connecting them with theoretical discussions. Focusing on segregation from an evenness perspective, we provide both indicators that allow us to quantify overall segregation between two groups (e. g., women and men), as well as those that measure overall segregation in a multigroup context (e. g., segregation by both gender and nativity) and those with which to measure the segregation of a group in a multigroup context (e. g., segregation of immigrant women). We also show how the segregation of one group is related to overall segregation and how the consequences of segregation for incumbent groups can be measured in terms of wellbeing (i. e., we assess the sorting of the groups across organizational units). Additionally, we discuss the methodological approaches that the literature has used to explain why segregation in some economies is greater than it is in others, allowing us to explain differences across time and space.

Finally, we use several of these measures to explore the extent of occupational segregation by gender and nativity in Spain and its consequences in monetary terms for the incumbent groups. Drawing on the Spanish Labor Force Survey (*Encuesta de Población Activa*, EPA henceforth), we document the evolution of the phenomenon for the period 2006-2024. Using the most recent data sets, the 2024 EPA and the 2022 Structure of Earnings Survey (*Encuesta de Estructura Salarial*, EES henceforth), we also explore the role that occupations play in explaining the gender-native wage gaps, both before and after controlling for basic characteristics.

Our analysis shows that the segregation of immigrant women decreased significantly throughout the period 2006-2024, stopping this reduction in 2021. Notwithstanding, the high concentration of immigrant women in low-paying occupations, which is larger than that of immigrant men and native-born women, occurs even after controlling for basic characteristics, causing them to have lower hourly wages than their native-born or male peers. Unlike them, the concentration of immigrant men in low-paying occupations is substantially reduced once we control for basic attributes, although their hourly wages remain lower than those of their native peers. As opposed to immigrant women and men, native-born women tend to cluster in occupations with wages slightly above the national average, although this wage advantage vanishes once we control for characteristics. Native-born women earn lower hourly wages than their male peers (especially after removing the composition effect) due to both differences in their occupational distributions and wage disparities within occupations. The gender gap is larger among natives than among immigrants.

The paper is structured as follows. Section 2 discusses the measurement of overall segregation, both in the two-group case and in a multigroup context. Section 3 provides several local segregation measures with which to quantify the segregation of a group in a multigroup context and connects them to overall segregation measures. Next, it shows how to assess the distribution of a group across organization units in terms of wellbeing. It also offers indicators of the total advantage or disadvantage of a group when accounting for both the distribution of the group across organizational units and the relative position of the group within organizational units. Section 4 discusses different approaches that the literature has taken to explain differences in segregation across locations or over time. Section 5 offers the empirical illustration using data from the Spanish labor market. Section 6 presents the main conclusions of this analysis.

2. Overall Segregation: Binary and Multigroup Measures

Before presenting the different measures that exist in the literature, it is necessary to clarify what segregation means. Reskin (1999, p. 183) argues that “segregation is a social mechanism that preserves inequality among groups”. Reardon and O’Sullivan (2004, p. 122) point out that “segregation can be thought of as the extent to which individuals of different groups occupy and experience different social environments”. But how can we operationalize it? Segregation can be seen from different angles, but evenness is the most popular one (Reardon and Firebaugh, 2002). According to this perspective, segregation exists when the mutually exclusive groups into which society has been partitioned are unevenly distributed across organiza-

tional units, i. e., when some groups are underrepresented in some units and overrepresented in others. For example, occupational segregation by gender exists when men and women work in different types of occupations, which has important effects in terms of wages given that feminized occupations tend to be lower paid. Likewise, when children of some ethnicities (or with an immigrant background) are overrepresented in public schools and underrepresented in private schools, we say that there is school segregation by ethnicity (or nativity), which may have important consequences in terms of educational opportunities and achievements.

As already mentioned, measuring segregation is closely related to measuring inequality (although moving from one scenario to the other involves important changes, as we discuss in the Appendix). This explains why many of the segregation measures presented here are inequality-based measures.

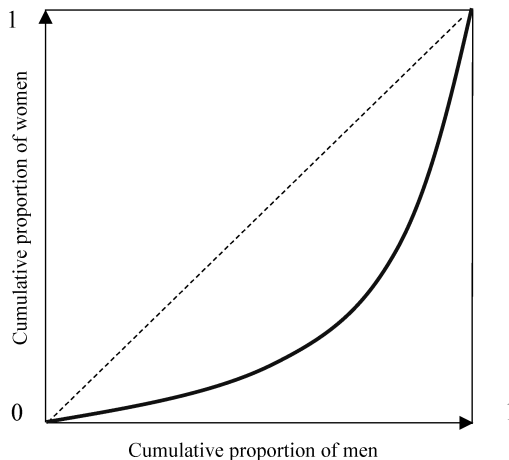
2.1. Binary Measures

The dissimilarity index put forward by Jahn *et al.* (1947) and popularized by Duncan and Duncan (1955), who assessed it in terms of basic properties, is the segregation measure most widely used in empirical work, despite the criticisms it has received. In the case of occupational segregation by gender, this index can be expressed as:

$$D = \frac{1}{2} \sum_j \left| \frac{c_j^f}{C^f} - \frac{c_j^m}{C^m} \right|, \quad (1)$$

where j stands for organizational units (e. g., occupations), c_j^f and c_j^m are the number of female and male workers, respectively, in unit j , and C^f and C^m are the total number of females and males. This index is connected to a Lorenz-type curve (Figure 1), called the segregation curve.

Figure 1
SEGREGATION CURVE BY GENDER



To build this curve (Duncan and Duncan, 1955), first, the units have to be ranked in ascendent order by the ratio $\frac{c_j^f}{c_j^m}$ and, then, the cumulative proportion of women in those units (vertical axis) is plot against the cumulative proportion of men in the same units (horizontal axis). This means that we first look at what happens in the first unit, then we move to the first two units, then to the first three units, and so on. The dissimilarity index measures the highest vertical distance between the curve and the 45° line.²

The D index ranges between 0 (achieved when there is no segregation, i. e., when the proportion of men and women in each occupation equals their population shares in the total) and 1 (achieved when there is full segregation, i. e., when women work in occupations with no men and reciprocally). This makes this index very convenient to compare different scenarios. However, D is not consistent with the dominance criterion given by the segregation curves,³ so that when the curve of an economy is above another (i. e., when the former is closer to the 45° line than the latter), the index does not necessarily rank these two economies in the same way.⁴

The dissimilarity index can be interpreted as the percentage of women (or men) who would have to move from one occupation to another to have the same occupational sorting as the other gender. This means that the reference against which the occupational sorting of women (men) is compared is that of men (women), which is not the occupational structure of the economy. To avoid this problem, inter alia, Karmel and MacLachlan (1988) proposed the I_p index:

$$I_p = \frac{C^m}{T} \frac{1}{2} \sum_j \left| \frac{c_j^m}{C^m} - \frac{t_j}{T} \right| + \frac{C^f}{T} \frac{1}{2} \sum_j \left| \frac{c_j^f}{C^f} - \frac{t_j}{T} \right|, \quad (2)$$

where T is the total number of workers in the economy (i. e., $T = C^f + C^m$) and t_j is the number of workers in occupation j ($t_j = c_j^f + c_j^m$).⁵ The I_p index can be interpreted as the percentage of workers who would have to swift among occupations to ensure that there is no gender segregation, without altering the occupational structure of the economy. This index has become quite popular because, together with the dissimilarity index, has been used to monitor occupational and industrial segregation by gender in the European Union (Bettio and Veraschagina, 2009).

To measure overall segregation in the case of two groups, the literature also uses the Gini index (Jahn *et al.*, 1947; Duncan and Duncan, 1955), which is equal to twice the area between the segregation curve and the 45° line, and the square root index (Hutchens, 2001, 2004), which is adapted from the generalized entropy family of inequality indices. These two indices are consistent with the dominance criterion provided by the segregation curves, as shown by Hutchens (1991, 2001) following what Foster (1985) did with Lorenz curves.

2.2. Multigroup Measures

Some of the binary segregation measures mentioned above have been extended to measure segregation in a multigroup context and, therefore, can be easily obtained as particular

cases of more general expressions. This is the case of the *generalized* I_p index (which we call GI_p here) proposed by Silber (1992):

$$GI_p = \frac{1}{2} \sum_g \frac{C^g}{T} \left(\sum_j \left| \frac{c_j^g}{C^g} - \frac{t_j}{T} \right| \right), \quad (3)$$

where g denotes any of the demographic groups into which the population has been partitioned, c_j^g is the number of group g individuals in unit j , and C^g is the total size of group g .

Other (unstandardized) multigroup measures proposed in the literature are the Gini index proposed by Alonso-Villar and Del Río (2010a):⁶

$$G_u = \frac{1}{2} \sum_g \sum_{i,j} \frac{t_i t_j}{T T} \left| \frac{c_i^g}{t_i} - \frac{c_j^g}{t_j} \right|, \quad (4)$$

and the mutual information index proposed by Theil and Finizza (1971):

$$M = \sum_g \frac{C^g}{T} \left(\sum_j \frac{c_j^g}{C^g} \ln \frac{c_j^g / C^g}{t_j / T} \right). \quad (5)$$

Another (unstandardized) multigroup segregation measure satisfying basic properties, which as the M index is related to the generalized entropy family of inequality indices, is the C_u index based on the squared coefficient of variation (Alonso-Villar and Del Río, 2010a):

$$C_u = \sum_g \frac{C^g}{T} \left[\sum_j \frac{t_j}{T} \left(\frac{c_j^g / C^g}{t_j / T} - 1 \right)^2 \right]. \quad (6)$$

Multigroup segregation measures GI_p , G_u , M , and C_u are unstandardized indices. In other words, their maximum value is not 1 when there is complete segregation (i.e., when each group works in occupations with no members of other groups). Although there is no consensus in the literature about whether standardized or unstandardized indices should be used, given that normalization usually comes at a cost in terms of decomposability properties (Mora and Ruiz-Castillo, 2011; Del Río and Alonso-Villar, 2022), standardized versions of the above indices also exist.⁷

The standardized version of M is the popular H index (Theil and Finizza, 1971), an index advocated by Reardon and Firebaugh (2002) in terms of desirable properties, a matter that will be discussed below. The standardized versions of G_u and C_u were also proposed by Reardon and Firebaugh (2002), who called them the generalized Gini index (G) and the square coefficient of variation (C), respectively. The standardized version of the GI_p index is the generalized dissimilarity index, proposed by Morgan (1975) and Sakoda (1981) and assessed by Reardon and Firebaugh (2002) in terms of properties. In Table 1, we use the names given by Reardon and Firebaugh (2002) to these indices, although in some cases they are the same as the binary versions.

In addition to the above aspatial measures, the literature also provides measures that account for distances among units, which seems especially convenient when dealing with some types of segregation, as is the case of residential segregation (Reardon and O’Sullivan, 2004).⁸ There are also ordinal segregation measures that rank units according to a certain criterion, which allows the incorporation of another dimension in the analysis, given that not all units are equally good (Reardon, 2009).

3. Local Segregation

Along with the extent of overall segregation (e. g., occupational segregation by gender and race/immigration), one may be interested in finding out the degree of unevenness of each target group (e. g., the occupational segregation of immigrant women). To deal with this, the literature has mainly undertaken pairwise comparisons between the target group and any other group using binary segregation measures (Reskin and Cassirer, 1996; Mintz and Krymkowski, 2011; Iceland *et al.*, 2014), a process that becomes cumbersome when many groups are involved. Other scholars opt to compare the distribution of the target group across units with that of its complementary (Queneau, 2009; Marcinczak *et al.*, 2016).

Alonso-Villar and Del Río (2010a) follow a different approach and develop a framework within which this measurement can be formally addressed. They establish the basic properties that these measures, called local segregation measures, must satisfy, and propose several measures meeting them. In what follows, we provide the (unstandardized) local measures associated with the above (unstandardized) overall measures:

$$D^g = \frac{1}{2} \sum_j \left| \frac{c_j^g}{C^g} - \frac{t_j}{T} \right|, \quad (7)$$

$$G^g = \frac{\sum_{i,j} \frac{t_i t_j}{T T} \left| \frac{c_i^g}{t_i} - \frac{c_j^g}{t_j} \right|}{2 \frac{C^g}{T}}, \quad (8)$$

$$\Phi_1^g = \sum_j \frac{c_j^g}{C^g} \ln \frac{c_j^g / C^g}{t_j / T}, \text{ and} \quad (9)$$

$$\Phi_2^g = \frac{1}{2} \sum_j \frac{t_j}{T} \left[\left(\frac{c_j^g / C^g}{t_j / T} \right)^2 - 1 \right]. \quad (10)$$

D^g is a local index linked to overall index GI_p , given that the latter can be written as the weighted average of the segregation of each group using the former: $GI_p = \sum_g \frac{C^g}{T} D^g$. Like-

wise, the local index G^g is associated with the overall index G_u , $G_u = \sum_g \frac{C^g}{T} G^g$. The local index Φ_1^g is the one associated with the mutual information index, $M = \sum_g \frac{C^g}{T} \Phi_1^g$, and the local index Φ_2^g is the one corresponding to the overall index C_u , $C_u = \sum_g \frac{C^g}{T} \Phi_2^g$.

The D^g index was proposed by Moir and Shelby Smith (1979) in an empirical paper to analyze gender segregation in the Australian labor market. However, these authors did not explore the properties of this index to measure the segregation of a group in a multigroup context. Their goal was to explore gender segregation using a modified version of the dissimilarity index that compared the distribution of women across units with the distribution of total workers across the same units, rather than the distribution of men (as the dissimilarity index does). This index is known as Gorard's index in the literature on school segregation.

D^g can be interpreted as the percentage of group g individuals who would have to move among units to reach zero segregation (i. e., to be distributed across units in the same way as the total population is). It also has a graphical interpretation: it measures the highest vertical distance between the local segregation curve proposed by Alonso-Villar and Del R  o (2010a) and the 45° line. To construct this curve, the units must be ranked ascendingly by $\frac{c_j^g}{t_j}$ and then we look at the first unit, the first two units, the first three units, and so on. Next, we plot the cumulative proportion of the target group in the corresponding units against the cumulative proportion of total population in the same units (Figure 2).

Figure 2
LOCAL SEGREGATION CURVE

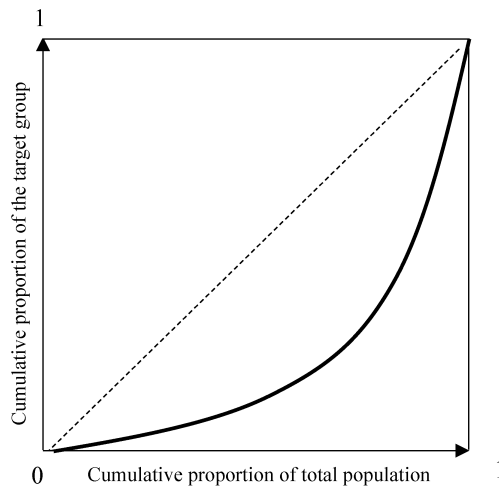


Table 1
SEGREGATION IN A THREE-AXIS SETTING: MULTIGROUP VERSUS BINARY, OVERALL VERSUS LOCAL,
AND STANDARDIZED VERSUS UNSTANDARDIZED INDICES

		UNSTANDARDIZED INDICES		STANDARDIZED INDICES		
BINARY			I_p index Karmel and MacLachlan (1988)	Dissimilarity index D	Jahn <i>et al.</i> (1947); Duncan and Duncan (1955)	
				Gini index G	Jahn <i>et al.</i> (1947); Duncan and Duncan (1955); Silber (1989)	
				Variance ratio index/ the square of the correlation ratio index V/Ea^2	Duncan and Duncan (1955)	
				Square root index O	Hutchens (2001)	
MULTIGROUP	Local indices [Alonso-Villar and Del Río, 2010a]	Overall indices				Local indices [Del Río and Alonso-Villar, 2022]
	D^g	Local dissimilarity index (Moir and Selby Smith, 1979)	Generalized I_p index G^g_Ip	Generalized dissimilarity index D	\bar{D}^g	Standardized local dissimilarity index
	G^g	Local Gini index	Multidimensional G-Segregation index G_s	Generalized Gini index G	\bar{G}^g	Standardized local Gini index
	Φ^g_1	Local entropy index	Mutual information index M	Information theory index H	Φ^g_1	Standardized local entropy index
	Φ^g_2	Local index based on the squared coefficient of variation	Overall index based on the squared coefficient of variation C_n	Squared coefficient of variation C	Φ^g_2	Standardized local index based on the squared coefficient of variation

Source: Adapted from Del Río and Alonso-Villar (2022).

Indices G^g , Φ_1^g , and Φ_2^g satisfy several properties that rend them consistent with the dominance criterion given by the local segregation curves (Alonso-Villar and Del Río, 2010a). In other words, when a local segregation curve is above another (or equals it at some points), these indices rank these two distributions in the same way as the curves do: the segregation of the group is lower for the distribution whose curve is closer to the 45° line. However, index D^g is not consistent with the above dominance criterion.

Standardized versions of the above local measures, whose values range between zero and one, can also be built. They are linked to standardized overall measures in a way analogous to the one mentioned for the unstandardized measures, although with different weights (Del Río and Alonso-Villar, 2022). To facilitate the reading of this paper, we do not bring here the corresponding expressions. However, it is worth mentioning that when measuring the segregation of a group using the above unstandardized local measures, we are measuring how far the local segregation curve is from the egalitarian distribution (given by the distribution of the total population among units). When using instead the standardized versions, we are quantifying how far the local curve is from the curve of maximum segregation (which depends on the group's size). Therefore, the use of standardized and unstandardized measures permits to look at the segregation of a group from a different angle. Given the link between local and overall measures, these ideas are also behind overall measures.

The distinction between the three axes we have mentioned so far –binary versus multigroup measures, local versus overall measures, and standardized versus unstandardized measures– allows us to classify many of the segregation measures that the literature provides and connect them (see Table 1, where arrows link local and overall indices, solid lines link binary and multigroup indices, and dashed lines connect standardized and unstandardized). This classification, adapted from Del Río and Alonso-Villar (2022), allows us to shed some light on academic debates about the convenience of using one index or another to measure segregation. As these authors discuss, in the case of school segregation between two groups, there has been a debate about whether to use index D^g (known as Gorard's index in that field) or the dissimilarity index D (Allen and Vignoles, 2007; Gorard and Taylor, 2002), without realizing that the former is an unstandardized local segregation measure while the latter is a standardized overall binary measure. In a binary context, the standardized version of D^g equals the dissimilarity index, which means that, ultimately, the matter is whether to use a standardized measure or not.

3.1. Connecting the Segregation of a Group with Overall Segregation

We have mentioned that measuring the segregation of a group with local measures is consistent with the way overall segregation is quantified, given that the latter can be expressed as the weighted average of the segregation of the groups involved. These weights equal the groups' demographic shares in the case of using unstandardized measures:

$$I = \sum_g \frac{C^g}{T} I^g, \quad (11)$$

where I stands for overall segregation and I^g is the segregation of group g using the corresponding local segregation index. What we have not discussed yet is what this decomposition implies. This decomposition tells us that the use of local measures can be especially helpful when working with small groups (e. g., racial minorities, sexual minorities, or recent immigrants) because in these cases their impact on overall segregation is small (given their low weights) and, therefore, what happens to them may be hidden when using overall measures (Del Río and Alonso-Villar, 2019a,b).

The use of this local segregation framework has also permitted us to delve deeper into the properties that overall measures should satisfy. First defining the properties of the local segregation measures and building from them the properties that overall segregation must meet seems a natural and simple way to approach this measurement. (This is not how scholarship has done it, since overall segregation was thought of before addressing the segregation of a group).⁹ Reardon and Firebaugh (2002) show that, among the standardized indices they assess (Glp , G , H , and C), H is the only one that satisfies the *principle of transfers* (i. e., the index decreases whenever an individual in a group moves from one unit to another in which that group has a lower representation), although they wonder whether this invalidates the other indices. Del Río and Alonso-Villar (2022) address this issue and suggest that, in light of the local segregation approach, violation of *the principle of transfers* by an overall measure should not be a problem as long as the corresponding standardized local segregation measures comply with *sensitivity to disequalizing movements type III* (i. e., the unevenness of the group decreases when an individual of the group moves to another unit in which the group's representation is lower). This means that G and C can be seen as sensible segregation measures as well.

3.2. Measuring the Consequences of Segregation in Terms of Wellbeing

The literature on segregation has paid little attention to the connection between segregation and welfare from a normative point of view. A few proposals deal with the measurement of unevenness while accounting for the status or “quality” of units (Reardon, 2009; Del Río and Alonso-Villar, 2012a), but they measure segregation, not the welfare associated with that situation.

By looking at each group separately, the local segregation framework opens new avenues of research, allowing for questions that have not been answered before. Thus, we may address whether an uneven distribution across units gives advantages or disadvantages to the group. This inquiry would be pointless in the field of income inequality because in that context inequality is a bad thing per se. However, when we talk about segregation, say occupational segregation, unevenness benefits or harms a group to the extent that the group is concentrated in high-paying or low-paying jobs, respectively. In what follows, we expose how this topic can be addressed focusing on occupational segregation, although it could be adapted to other types of segregation as long as the quality or status of units can be measured cardinally.

We denote by $t \equiv (t_1, t_2, \dots, t_j)$ the distribution of total employment across J occupations and by $c^g \equiv (c_1^g, c_2^g, \dots, c_j^g)$ the distribution of group g across these same units. To assess

the occupational sorting of group g we need to incorporate another element in the analysis. We have to be able to distinguish between good and bad occupations, and the relative wage of each occupation seems a sensible way to do this. Let's $w \equiv (w_1, \dots, w_j)$ be the occupational wage distribution (i.e., the average wage of each occupation) and $\frac{w_j}{\bar{w}}$ be the relative wage of occupation j , where $\bar{w} = \sum_j \frac{t_j}{T} w_j$ is the average wage of the economy. Following Alon-

so-Villar and Del R o (2017a) and using a social welfare function $W(\cdot)$ to assess the state in which a society is, we can measure the wellbeing loss or gain that group g has due to its occupational sorting, denoted by $\Psi(c^g; t; w)$, as the loss or gain g has from departing from evenness (in per capita terms). Namely,

$$\Psi(c^g; t; w) = \frac{1}{C^g} \left[W(c^g; t; w) - W\left(\frac{C^g}{T} t; t; w\right) \right], \quad (12)$$

where $\frac{C^g}{T} t \equiv \left(\frac{C^g}{T} t_1, \dots, \frac{C^g}{T} t_j\right)$ is the egalitarian distribution in this case, so that in each occupation the group accounts for $\frac{C^g}{T}$ percent of the employment there.

Alonso-Villar and Del R o (2017a) established the properties that an index aimed at assessing the sorting of a group across occupations in terms of wellbeing should meet and proposed a family of indices based on them:

$$\Psi_\varepsilon(c^g; t; w) = \begin{cases} \sum_j \left(\frac{c_j^g}{C^g} - \frac{t_j}{T}\right) \frac{\left(\frac{w_j}{\bar{w}}\right)^{1-\varepsilon} - 1}{1-\varepsilon} & \varepsilon \neq 1 \\ \sum_j \left(\frac{c_j^g}{C^g} - \frac{t_j}{T}\right) \ln \frac{w_j}{\bar{w}} & \varepsilon = 1 \end{cases} \quad (13)$$

where $\varepsilon > 0$ is a parameter of aversion to inequality within the group (i.e., to the fact that some members of the group are in highly paid occupations while others are in low-paid occupations).¹⁰ As these authors point out, underrepresentation (respectively, overrepresentation) in an occupation only penalizes the index when this occurs in highly (respectively, poorly) paid jobs.

In the limit case where $\varepsilon = 0$, $\Psi_0(c^g; t; w) = \sum_j \left(\frac{c_j^g}{C^g} - \frac{t_j}{T}\right) \frac{w_j}{\bar{w}}$, which is the Γ^g index

defined by Del R o and Alonso-Villar (2015) to quantify the monetary loss or gain that group g has associated with its occupational sorting (in per capita terms), expressed as a proportion of the average wage of the economy (\bar{w}). In other words, Γ^g measures the loss or gain in group wellbeing without taking into account the inequality that exists within the group due to some of its members working in well-paid occupations and others in poorly paid occupations.

Note that the wellbeing of each group into which the whole economy has been partitioned can be aggregated to determine the welfare loss that society experiences due to segregation (Del R o and Alonso-Villar, 2018). This has been done adding the losses of disadvantaged groups in a similar way to what is done in the literature on economic deprivation, since these losses can be thought of as deprivation gaps, and defining curves of social welfare losses associated with segregation (WLAS curves) and indices consistent with them.¹¹

3.3. The Total Advantage or Disadvantage of a Group

Along with the advantage or disadvantage of a group due to its occupational sorting, whether in monetary terms or in terms of wellbeing, the group may receive wages above or below those of other groups working in the same occupations. In what follows, we explain how the total wage advantage or disadvantage of a group can be decomposed into these two components. Here we provide the decomposition when there is no inequality aversion, although similar expressions exist for $\varepsilon > 0$ (Alonso-Villar and Del R o, 2017a).

As shown by Del R o and Alonso-Villar (2015), the earning gap of a group, $EGap^g = (w^g - \bar{w}) \frac{1}{\bar{w}}$ (i.e., the difference between the average wage of the group and the average wage of the economy divided by the latter), can be decomposed as follows:

$$EGap^g = \underbrace{\left[\sum_j c_j^g (w_j^g - w_j) \right]}_{\Delta^g} \frac{1}{C^g \bar{w}} + \underbrace{\sum_j \left(\frac{c_j^g}{C^g} - \frac{t_j}{T} \right) \frac{w_j}{\bar{w}}}_{\Gamma^g}, \quad (14)$$

where w_j^g denotes the (average) wage of group g within occupation j , Γ^g is the group's gain/loss associated with its occupational sorting, and Δ^g is the gain/loss arising from whether the group's wage within each occupation is higher or lower than that of other groups. This decomposition allows us to determine whether the fact that a group has a wage above or below average arises mainly from the occupations in which it tends to work, from earning more/less than other groups who work in the same occupations, or from both sources. We will use this decomposition in our empirical analysis, which for simplicity is called the within-between decomposition.

Each component can be further decomposed to determine the contribution of each occupation to the $EGap^g$ (Alonso-Villar and Del R o, 2023a). Thus,

$$\Gamma^g = \sum_j \left(\frac{c_j^g}{C^g} - \frac{t_j}{T} \right) \frac{w_j}{\bar{w}} = \sum_j \underbrace{\left(\frac{c_j^g}{C^g} - \frac{t_j}{T} \right) \frac{(w_j - \bar{w})}{\bar{w}}}_{\Gamma_j^g} \quad \text{and} \quad (15)$$

$$\Delta^g = \sum_j c_j^g (w_j^g - w_j) \frac{1}{C^g \bar{w}} = \sum_j \underbrace{\left(\frac{c_j^g}{C^g} \right) \left(\frac{w_j^g - w_j}{\bar{w}} \right)}_{\Delta_j^g}. \quad (16)$$

Expression (15) allows us to single out the occupations that bring advantages to the group. Occupations that contribute positively to Γ_j^g , $\Gamma_j^g > 0$, are those well-paid occupations in which the group is overrepresented and those low-paid occupations in which the group is underrepresented. On the contrary, $\Gamma_j^g < 0$ when j is either a low-paid occupation in which the group is overrepresented or a highly paid occupation in which the group is underrepresented. Analogously, expression (16) allows us to identify the occupations in which the group receives wages below the occupational wage ($w_j^g - w_j < 0$) or above it. The magnitude of this effect also depends on the importance of that occupation for the group $(\frac{c_j^g}{C^g})$.

4. Explaining Segregation

So far, we have discussed how to measure the extent of segregation, or its consequences in terms of wellbeing. In this section, we examine the methods that the literature has used to explain segregation. When comparing two countries, regions, or cities, or when comparing a country over time, we may be interested in determining whether segregation is greater in an economy than the other because some groups have more difficulties integrating there (i.e., “pure” segregation is greater) or because the size of organizational units or groups differs between these two economies. To address this, some scholars opt to use margin-free segregation measures, which do not change when the units or groups change their relative sizes (Charles and Grusky, 1995). In other words, with these measures, the differences in segregation between two economies do not arise from differences in their marginal distributions (e. g., the distributions of genders and occupations).

However, there is no consensus in the literature about the convenience of using margin-free segregation measures, in part because we may want the index to increase when more individuals are in segregated units, which involves margin dependency, and also because margin independency may conflict with other properties (Elbers, 2023). This is why some scholars advocate the use of margin-dependent measures and propose decomposing the change in segregation between two economies into marginal changes (i.e., changes in the distributions of groups or in the distributions of units) and structural changes (i.e., changes in “pure” segregation). Thus, drawing on Theil (1972) and on the decomposition procedure provided by Karmel and MacLachlan (1988) for the I_p index, which involves gradual adjustments of the marginal distributions using iterative proportional fitting, Elbers (2023) proposes a similar method to disentangle the change in segregation in these two components for the M index.¹² Others use simple decompositions of the difference in segregation between two scenarios using an intermediate step in which the index is applied to a counterfactual economy built by changing either the unit marginals or the group marginals (Blau *et al.*, 2013; Alonso-Villar and Del R o, 2017b; Azpitarte *et al.*, 2021). The problem with this method is that the results may vary depending on whether the unit or instead the group marginals are the first to change, a problem that can be addressed by averaging the values obtained by the two paths (using the Shapley decomposition; Chantreuil and Trannoy, 2013; Shorrocks, 2013).

Scholarship has also explored whether differences in characteristics may explain differences in segregation across locations, with the country, region, city, or establishment being the unit of analysis. To do this, these studies make use of geographical variability in the characteristics of groups and locations to explain segregation, or its consequences, using regression models (Abrahamson and Sigelman, 1987; Massey and Denton, 1987; Lorence, 1992; Huffman *et al.*, 2010; Alonso-Villar *et al.*, 2012; Alonso-Villar and Del Río, 2017c; Borrowman and Klasen, 2020).

Another way to address how differences in group characteristics can explain intergroup differences or changes in segregation, across locations or over time, is to construct a counterfactual distribution that removes the composition effect (Alonso-Villar *et al.*, 2013; Gradín, 2013, 2019; Gradín *et al.*, 2015; Palencia-Esteban, 2022). This involves controlling for the groups' attributes that could affect their positions in the labor market. For example, in the case of occupational segregation by gender and immigration, these attributes could include educational achievements, age, region of residence, etc. We discuss this approach in more detail below because it is the one we follow in our empirical analysis.

To construct this counterfactual, we must partition each group into several subgroups or cells, defined by the combination of the characteristics for which we want to control, and choose the group (e.g., native-born men) whose characteristics are taken as a reference for the other groups. Next, we keep the distribution of each subgroup (e.g., immigrant women with tertiary education, in a certain age range, and living in a certain region) across units (e.g., occupations) as we observe in the actual distribution, but change the weight of that subgroup to make it equal to the weight that the corresponding subgroup has in the reference group. To do this, we can follow a simple nonparametric method, which only requires reweighting the subgroups according to their weights in the reference group (Alonso-Villar and Del Río, 2023b), or we can instead use a parametric method whose reweighting scheme involves logit estimates (based on the popular propensity score procedure proposed by DiNardo *et al.*, 1996, as adapted by Gradín, 2013).¹³ The advantage of the parametric method is that it allows for an easy decomposition, by factors, of the change between unconditional values (e.g., segregation in the actual economy) and conditional values (e.g., segregation in the counterfactual). To avoid the problem of path dependency that the original method has, which makes the decomposition depend on the order in which the different covariates are included in the analysis, Gradín (2013) proposes to use the Shapley value. The same technique can be used to determine conditional wages and the role that occupations play in explaining intergroup wage disparities after controlling for characteristics.

Reweighting procedures and regression models require different types of data. To explore, for example, the occupational segregation of a social group or overall segregation, regression models require geographical variability, and therefore observations in a large number of locations. This approach permits to include many control variables in the analysis to the extent that we know the segregation level in many locations. However, reweighting procedures can be used when there is no spatial information, although they require large samples to have enough observations for each group in each cell, which may limit the number of characteristics that can be incorporated in the analysis. An advantage of reweighting procedures is

that they generate an entire economy in which the social groups have the same basic characteristics, which allows the exploration, among others, of the distribution of each group across occupations, their wage distributions, overall segregation, etc. in this counterfactual scenario.

5. An Illustration: Occupational Segregation and Wages in Spain

Despite social advances, gender inequalities persist in the labor markets of Western countries, including Spain (Blau and Kahn, 2017; Anghel *et al.*, 2019; Adserà and Querin, 2023). However, women are not a homogeneous group, nor are men. Individuals' labor opportunities are also shaped by their migration status, race, or ethnicity (Algan *et al.*, 2010; De la Rica *et al.*, 2014; Del Río and Alonso-Villar, 2015; O'Higgins, 2015; Cantalini *et al.*, 2023; Alonso-Villar and Del Río, 2023b; Palencia-Esteban and Del Río, 2024).

In this section, we use several tools presented above to explore occupational segregation by gender and nativity, along with its effects on wages, in Spain, a country with significant migration flows since the end-1990s. We use an intersectionality framework that distinguishes among four groups: immigrant women, native-born women, immigrant men, and native-born men.¹⁴ Our analysis draws on the 2006-2024 EPAs (second quarter) and the 2022 EES (the quadrennial survey). We define immigrants as those who do not have Spanish citizenship. It is important to note that the EPA provides a smaller sample of employed individuals than the EES but has better coverage of occupations related to domestic service and agriculture, which is relevant when analyzing segregation by gender and nativity.¹⁵

Our first goal is to document the extent of segregation for the period 2006-2024, thus enlarging the period covered in previous studies (Alonso-Villar and Del Río, 2017d, 2024). Drawing on the 2024 EPA and the 2022 EES, our second goal is to explore the role that occupations play in explaining each group's position on the wage ladder before and after controlling for group characteristics. To perform the conditional analysis, we build a counterfactual economy using both parametric (DiNardo *et al.*, 1996; Gradín, 2013) and nonparametric methods (Alonso-Villar and Del Río, 2023b) mentioned earlier. To build these counterfactuals, we take native-born men as the reference group and adjust the characteristics of the other three groups to make them equal to those of native-born men. Unlike Palencia-Esteban and Del Río (2024), we do not explore why the occupational sorting of immigrants differs between countries, but rather why the occupational sorting of immigrants (and their average wages) differs from those of natives, which implies that the reference group is Spanish men and not immigrants from a country of reference (in their case, immigrant women and men from the UK).

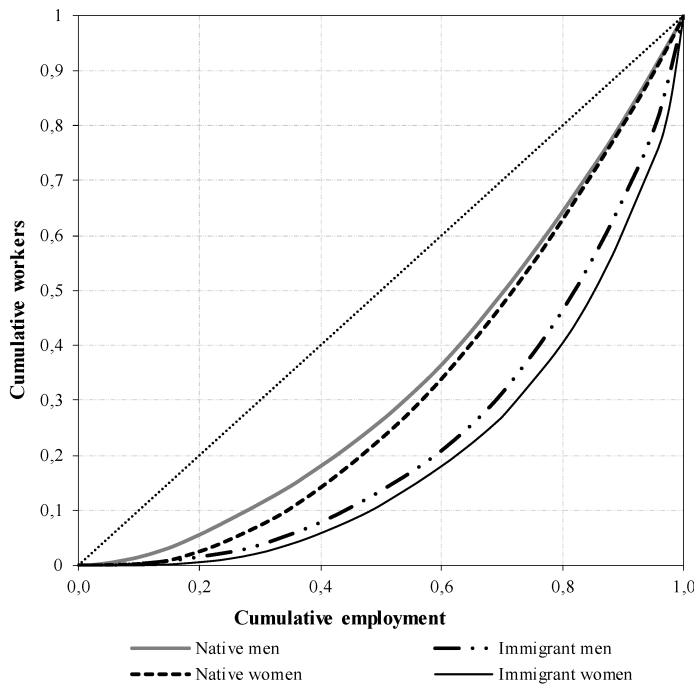
By exploring the conditional wages of the four groups simultaneously, our analysis departs from what is usually done in the literature, which tends to analyze gender and nativity wage gaps separately or explore the nativity wage gap within a gender group (Antón *et al.*, 2010; Nicodemo and Ramos, 2012; García-Pérez *et al.*, 2012; Anghel *et al.*, 2019; Pinto *et al.*, 2023). We also depart from most studies on wage gaps by exploring the role that occupations play without including them as covariates, allowing us to use a broader list of occupations. A limitation of our analysis is that, unlike methods based on wage equations, our

approach requires including only basic covariates to have enough observations of immigrant women and men with a given combination of characteristics.

The Extent of Segregation

Figure 3 displays the local segregation curves for each group in 2024 using the national classification of occupations at the three-digit level (169 occupations).¹⁶

Figure 3
LOCAL SEGREGATION CURVES FOR GENDER-NATIVITY GROUPS, 2024 EPA



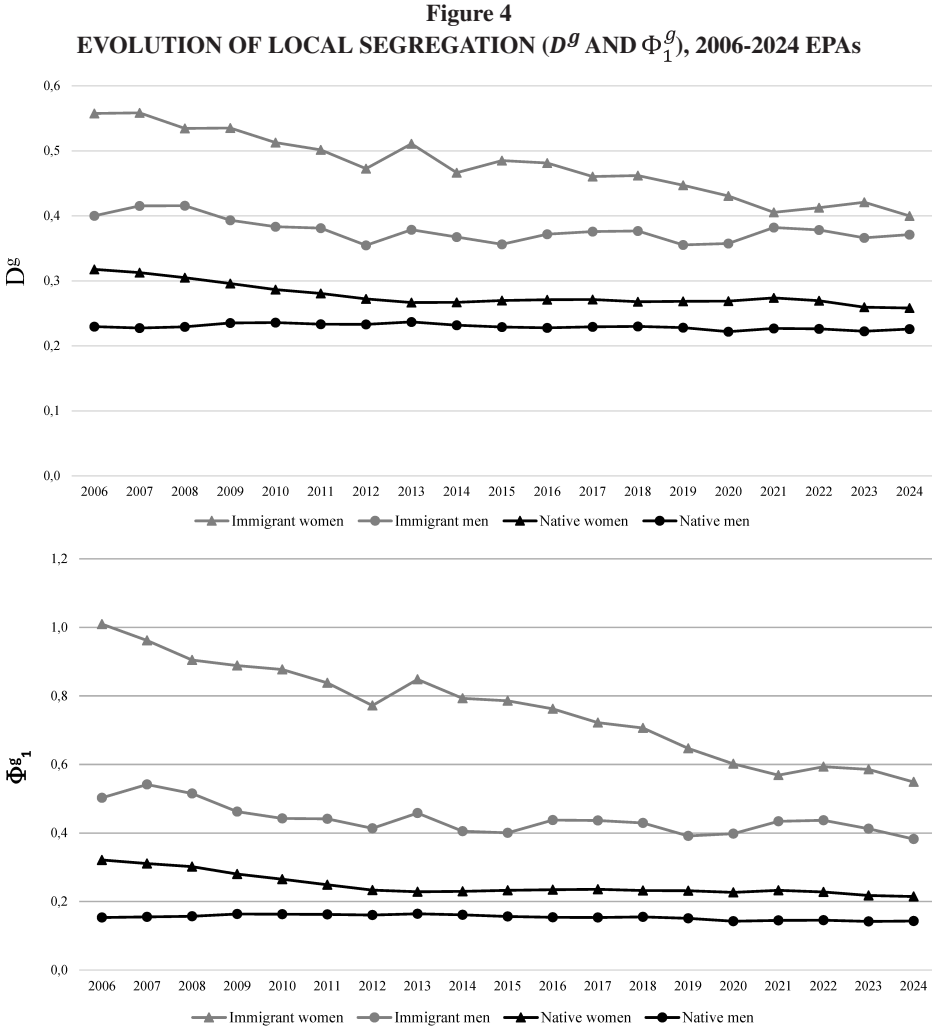
Note: Each curve shows how far the occupational sorting of the group is from the egalitarian distribution (45° line).

Source: Authors' calculations.

Since the curve for immigrant women is below those of the other groups, occupational segregation is greater for them using a broad set of segregation indicators (like G^g , Φ_1^g , and Φ_2^g , inter alia). We also see that the curve for immigrant women is closer to zero for a wider range of abscissa values. Immigrant women have no presence in occupations that account for about 10% of employment (and is extremely small up to 20%), while this proportion is 5% in the case of immigrant men.

Hereafter, we use the national classification of occupations at the two-digit level given that, to later assess the occupational distributions of the groups, we need information on wag-

es and the EES does not provide it at the three-digit level.¹⁷ Figure 4 displays the evolution of the D^g and Φ_1^g indices for each group for 2006-2024, while Figure 5 illustrates the evolution of segregation by gender, by nativity, and by gender-nativity using the corresponding overall segregation indices (I_p and M , respectively).¹⁸



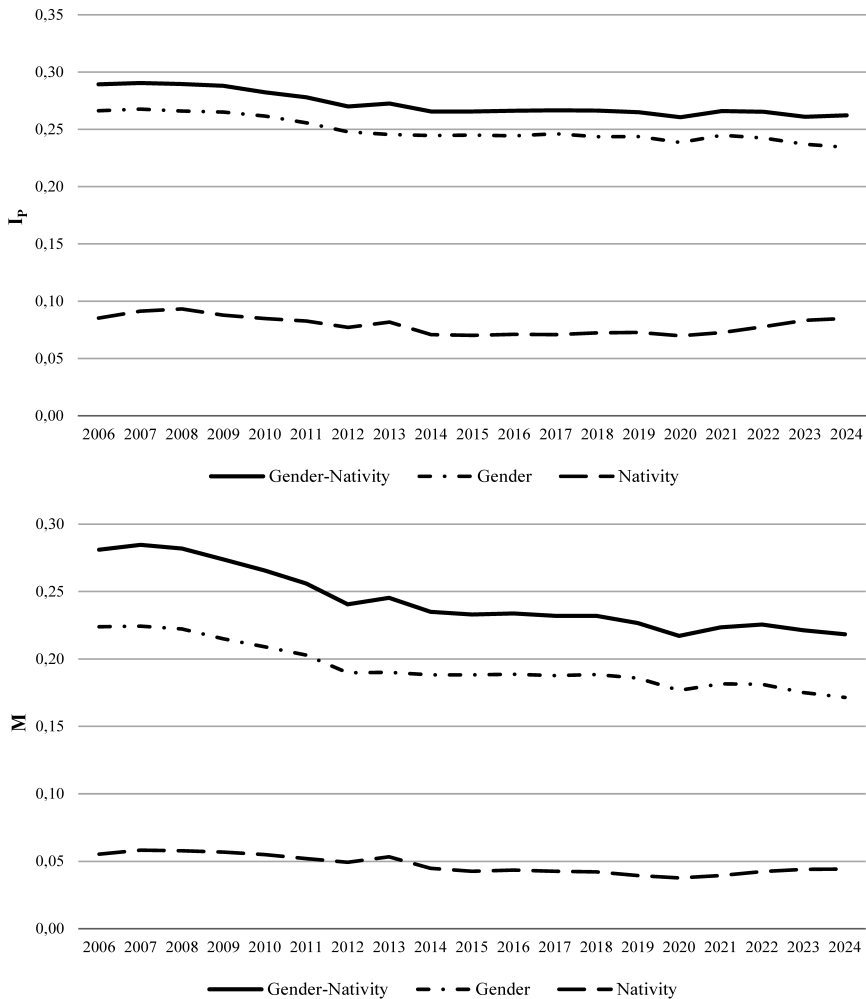
Note: The charts show the degree of segregation of each group using two indices.

Source: Alonso-Villar and Del Río (2024) and authors' calculations.

Figure 4 shows that immigrant women experienced an important drop in segregation throughout the period, although the process stopped in 2021. In 2024, around 40% of immigrant women would have to change occupations to be evenly distributed across them ($D^g = 0.4$), while in 2006, it was 56%. This drop arises from their lower presence in occu-

pations in which they were highly overrepresented (such as catering service workers and domestic employees) and a greater presence in many occupations in which they were underrepresented (including different types of technicians and professionals, support professionals, and office employees who do not deal with the public). This change in their occupational sorting could be associated with changes in the composition of the group. Over the period, immigrant women experienced a sharp increase in education, an increase in age, and changes in country of origin (Table A1 in the Appendix).

Figure 5
EVOLUTION OF OVERALL SEGREGATION (I_p AND M) BY GENDER, NATIVITY, AND GENDER-NATIVITY, 2006-2024 EPAs



Note: The charts show the degree of total segregation using two indices.

Source: Alonso-Villar and Del Río (2024) and authors' calculations.

Segregation also decreased for native women and immigrant men over the period, although with much lower intensity and only lasting a few years (until around 2012). In 2024, 26% of native women would have to change their occupation to be evenly distributed among them, while in 2006 it was 32%. The percentages for immigrant men are 37% and 40%, respectively. However, the degree of unevenness for native men has remained quite stable throughout the period (around 23% of them would have to change occupation). Females and males tend to converge over the period in terms of segregation, especially among the immigrant population.

Alonso-Villar and Del Río (2013b) showed that the increase in the immigrant population that took place in Spain between 1996 and 2006 was accompanied by an increase in the occupational segregation of immigrants (women and men considered together), especially in the period 1998-2004. This increase was clearly linked to the model of economic growth that prevailed in Spain during that decade. Figure 4 suggests that this trend changed in subsequent years since there is a certain convergence among the four groups, mainly driven by immigrant women catching up with immigrant men.

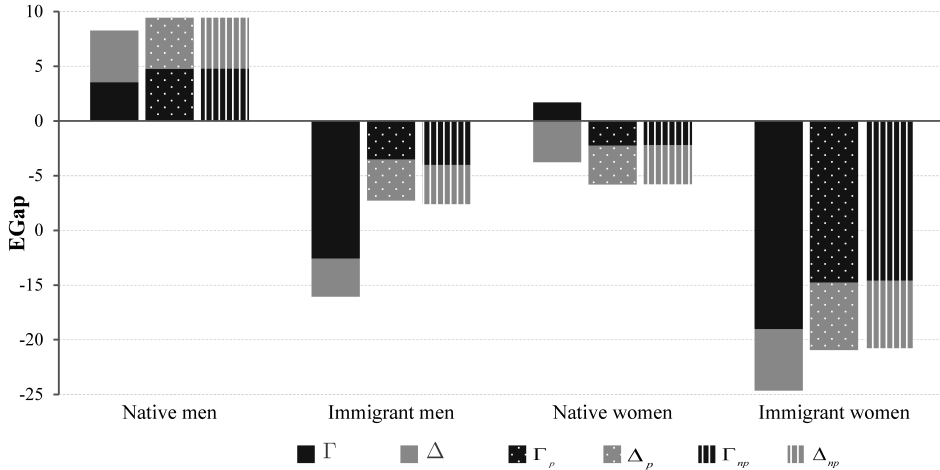
Figure 5 reveals that most of the gender-nativity segregation that we observe in the Spanish labor market is driven by gender; segregation by nativity is of lesser magnitude. Moreover, the evolution of the gender-nativity segregation seems to parallel that of gender segregation, both of which experienced a fall in the first years of the great recession (2008-2012). Gender segregation also appears to have experienced a small decline after the pandemic (2022-2024), a pattern that is not reflected in terms of gender-nativity segregation, perhaps due to the small increase in nativity segregation in recent years.

Note that even though segregation by nativity does not change much over the period, the segregation of immigrant women did experience an important drop, as already mentioned. The fact that this decline is not fully reflected in overall segregation may be because a group's contribution to overall segregation depends on its size, as discussed above. The use of local segregation measures is especially helpful when working with small groups.

The Consequences of Segregation for the Incumbent Groups

As explained in Section 4.3, a group's occupational sorting may bring it a monetary advantage or disadvantage, depending on whether the group tends to be concentrated in high- or low-paying occupations. The group may also have a wage advantage or disadvantage within occupations compared to other groups. Figure 6 provides the hourly wage advantage or disadvantage ($EGap$) of each group with respect to the national average wage, as well its two components Γ and Δ (see expression (14)). For simplicity, the superscript that refers to the group is removed. Employment data comes from the 2024 EPA, while wages for each group in each occupation come from the 2022 EES.¹⁹ Results are shown before and after controlling for characteristics. The values obtained in the counterfactual economy that we construct using the parametric method are denoted by the subscript p , and those based on the nonparametric are denoted by np .

Figure 6
WITHIN-BETWEEN DECOMPOSITION OF THE HOURLY WAGE ADVANTAGE OR DISADVANTAGE OF EACH GROUP (relative to the national average) IN THE ACTUAL ECONOMY AND IN THE COUNTERFACTUALS, 2024 EPA



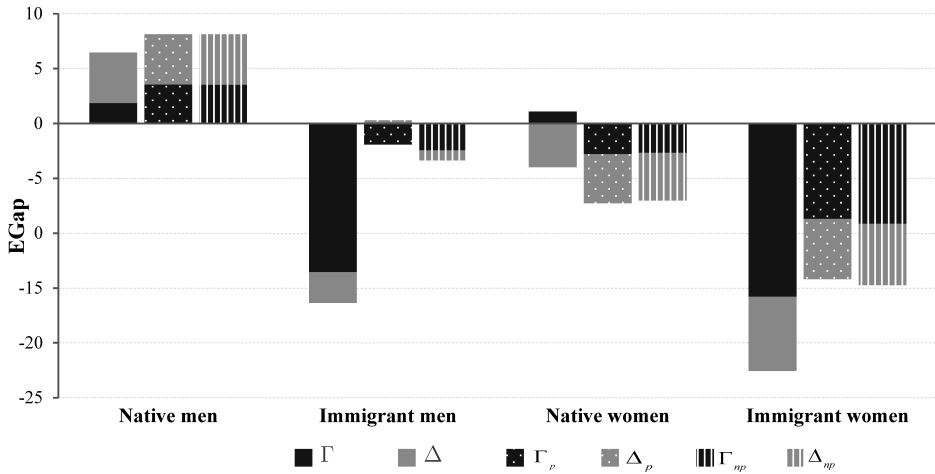
Note: p (parametric) and np (nonparametric) counterfactuals. The dark grey bar represents the earnings wage advantage (if greater than zero) or disadvantage (if less than zero) of the group based on its occupational sorting. The light grey bar is analogous but refers to the group’s wages compared to those of other groups working in the same occupations.

Source: Author’s calculations using employment from the 2024 EPA and wages from the 2022 EES.

The chart reveals that the unadjusted hourly wages of immigrant women and men are well below the national average, especially those of the former (25% versus 16%), with occupational sorting explaining most of their wage disadvantage.²⁰ Figures A1-A4 in the Appendix display the contribution of each occupation to Γ and Δ using the decompositions provided in expressions (15) and (16). Figure A1 shows that there are occupations that penalize immigrant women due to the group’s overrepresentation in low-paying occupations (e. g., catering, cleaning work, personal care, and especially domestic work) or their underrepresentation in highly paid ones (sciences and engineering professions and health professions). In all of them, immigrant women are also underpaid compared to other groups, especially in the last two. The problem of overrepresentation in bad occupations and underrepresentation in good ones is not as intense for immigrant men, although they are overrepresented in agriculture and fishing, construction, and catering and underrepresented in health professions (Figure A3). While they are also underpaid in these occupations, their underpayment is not as intense as previously shown for immigrant women, except in the case of agriculture and fishing. Native women are also highly concentrated in cleaning, retail sales, or care work (Figure A2), but this group’s position on the wage ladder does not seem to arise from a disadvantaged occupational sorting as a whole (Figure 6). Notwithstanding, native women do not have the occupational advantage that native men have. And native women also have wage disadvantages within occupations, which are especially significant in some of them (Figure A2).

As already mentioned, to calculate the conditional *EGap* of each group, together with the conditional Γ and Δ values, we build a counterfactual economy taking native men as the reference group with respect to which the characteristics of the other groups are adjusted. This involves reweighting the cells in each group to replicate those of native men. The counterfactual economy shows how the occupational sorting of the groups, and their wages, would be if the four groups had been equal in terms of basic characteristics. The covariates included in the conditional analysis are: educational attainment, age, and location.²¹ To have enough observations of immigrants in each category (cell), we distinguish only among three educational levels: lower secondary education at most, upper secondary education, and tertiary education. We have three age groups: up to 30 years old, between 30 and up to 55, and 55 or older. Since immigrants are not evenly distributed across regions, and taking into account that there are wage disparities among regions, we also distinguish between individuals living in regions with wages above and below the national average. This means that, in the conditional analysis, we partition each group into 18 (3x3x2) subgroups or cells.

Figure 7
WITHIN-BETWEEN DECOMPOSITION OF THE HOURLY WAGE ADVANTAGE OR DISADVANTAGE OF EACH GROUP (relative to the national average) IN THE ACTUAL ECONOMY AND IN THE COUNTERFACTUALS, 2022 EES



Note: p (parametric) and np (nonparametric) counterfactuals. The dark grey bar represents the earnings wage advantage (if greater than zero) or disadvantage (if less than zero) of the group due to its occupational sorting. The light grey bar is analogous but refers to the group's wages compared to those of other groups working in the same occupations.

Source: Author's calculations using employment and wages from the 2022 EES.

Figure 6 shows that the situation improves significantly for immigrant men after controlling for characteristics, their conditional wages are 7-8% below average, mainly because they have a more favorable distribution across occupations. Unlike them, the conditional hourly wage of immigrant women, which is 21% below the average, barely improves

compared to their unconditional value (25%). Our analysis shows that occupational sorting strongly penalizes immigrant women even after controlling for characteristics. Unlike what happens with immigrants, when comparing the actual economy and the counterfactual (i. e., before and after removing the composition effect), the wages of native women decrease, since in the counterfactual the occupational sorting of native women penalizes them, although only slightly.

Figure 7 provides the same information as Figure 6 but using only the 2022 EES for both employment and wages. In this case, for each individual, we have not only their education, age, and location, but also their wage, allowing us to build a more accurate counterfactual for the sectors included in this data set.

When comparing Figures 6 and 7, we observe that intergroup disparities are more evident with the EPA, perhaps because the EES does not include all sectors, which has an important effect on the size of some occupations in which immigrants tend to be concentrated. This is the case of domestic service, for example, which may explain why the wage disadvantage of immigrant women, and the role that occupations play, is smaller with the EES. In any case, the patterns detected earlier for the EPA remain when using the EES.

Finally, the intersectionality approach followed in this research allows us to show that the gender wage gap in Spain is higher among the native population than it is among immigrants (10.3% of the average wage versus 8.6% with the 2024 EPA in the actual economy), and the wage nativity gap is larger for men than it is for women (24.3% of the average wage versus 22.6%).²²

6. Final Comments

After offering some reflections about how the literature has approached the measurement of segregation, this paper has explored occupational segregation by gender and nativity in Spain in an intersectionality framework. The analysis has revealed that the occupational segregation of immigrant women is a more intense phenomenon than that of native-born women or immigrant men, although it decreased significantly over the period 2006-2024 (the process came to a halt in 2021). Part of the segregation of immigrant women and men arises from a composition effect, mainly from their lower educational attainments. However, occupational disparities seem to go further, especially for immigrant women. Their occupational sorting strongly penalizes them even after controlling for education (and other basic characteristics). In fact, immigrant women are highly concentrated in low-paying occupations in the counterfactual economy that we build in which the four groups are alike in terms of characteristics. Unlike them, the distribution of immigrant men across occupations is not especially harmful after accounting for characteristics.

By using an intersectionality approach, we can compare the wages of the four groups simultaneously. This has allowed us to move beyond comparisons between immigrants and natives of the same gender, as usually done in the literature. We show that, after removing

the composition effect, the (conditional) hourly wages of immigrant women are well below those of the other three groups, mainly due to the occupational disadvantage of the former just mentioned. The (conditional) hourly wages of native-born women are also lower than those of native-born men, although occupations play a much smaller role in explaining their wage gap (with respect to the national average wage). As expected, in the counterfactual economy the gender wage gap among natives is larger than it is in the actual economy, due to the higher educational attainments of native-born women.²³ Native-born women's (conditional) hourly wages are closer to those of their immigrant male peers than to those of their native male peers.

This paper contributes to the literature on intersectionality documenting that the gender wage gap in Spain is (slightly) greater among natives than it is among immigrants while the nativity gap is (slightly) greater among men than it is among women. The fact that the gender gap is smaller for minorities and/or that the minority-majority gap is larger for men is also detected in racial and ethnic studies for the US and some European countries (Algan *et al.*, 2010; Alonso-Villar and Del Río, 2023b; Cantalini *et al.*, 2023; Sprengholz and Hmjediers, 2024). However, in other countries, the gender wage gap for ethnic minorities or immigrants is larger than for the majority group (Algan *et al.*, 2010; O'Higgins, 2015; Drolet and Amini, 2023), which evidences distinctive patterns among countries and also among minorities.

Appendix

From Measuring Income Inequality to Segregation

Many of the segregation measures that exist in the literature, together with the properties required to them, are borrowed from the literature on income inequality. In what follows, we briefly discuss how scholarship has addressed the measurement of income inequality and then we deal with the measurement of segregation. This will allow us to clarify which views of inequality have dominated the literature on segregation.

There is general agreement on how to rank income distributions that have the same total income in terms of inequality. The basic properties that any inequality measure should satisfy are *symmetry* and the *Pigou-Dalton principle of transfers*.²⁴ The former means that inequality does not depend on who enjoys each income level, which brings anonymity to the measurement. The latter requires that inequality decreases when there is a progressive transfer without re-ranking between two individuals (i.e., when a richer person gives money to a poorer person in such a way that the initially poorer person does not end up with more income than the other). However, in empirical analysis, we usually need to compare income distributions with different means. This implies that some value judgments must be incorporated into the measurement because there is no consensus about the mean-invariance property the indices must meet.

Following a relative approach, which is the most common path in empirical research, we say that, when income increases, inequality does not change if the additional income is distributed across individuals according to the share of income that individuals had in the initial distribution (*scale invariance* axiom). And, therefore, relative inequality increases when individuals with higher incomes receive higher proportions of the extra income than they had initially. The absolute approach requires instead that inequality remain unaltered when the additional income is distributed in equal amounts among all individuals (*translation invariance* axiom). Consequently, absolute inequality increases when individuals with higher incomes receive higher amounts of the extra income. Kolm (1976) labeled relative and absolute inequality measures as rightist and leftist measures, respectively, and proposed an intermediate or centrist view between these two extremes.²⁵

When using intermediate and absolute inequality measures, an additional axiom has been recently invoked, the *unit-consistency* axiom. It requires that the ranking between two distributions does not depend on the currency unit in which those incomes are expressed (Zheng, 2007), a criterion that all relative measures satisfy. This requirement allows us to incorporate centrist and leftist views into the inequality measurement without compromising its empirical usefulness.

The literature provides a wide set of relative inequality measures satisfying good properties. For example, the Lorenz curves and the indices consistent with the dominance criterion given by these curves, as is the popular Gini index, the Atkinson family of indices, or the generalized entropy family of indices (which includes the Theil indices).²⁶ Thus, when the Lorenz curve of an income distribution A is never below that of distribution B (i.e., A is equal

to B at some points and is above it at others), we know that all these indices would rank these two distributions as the Lorenz criterion does (Foster, 1985): A is more egalitarian than B.

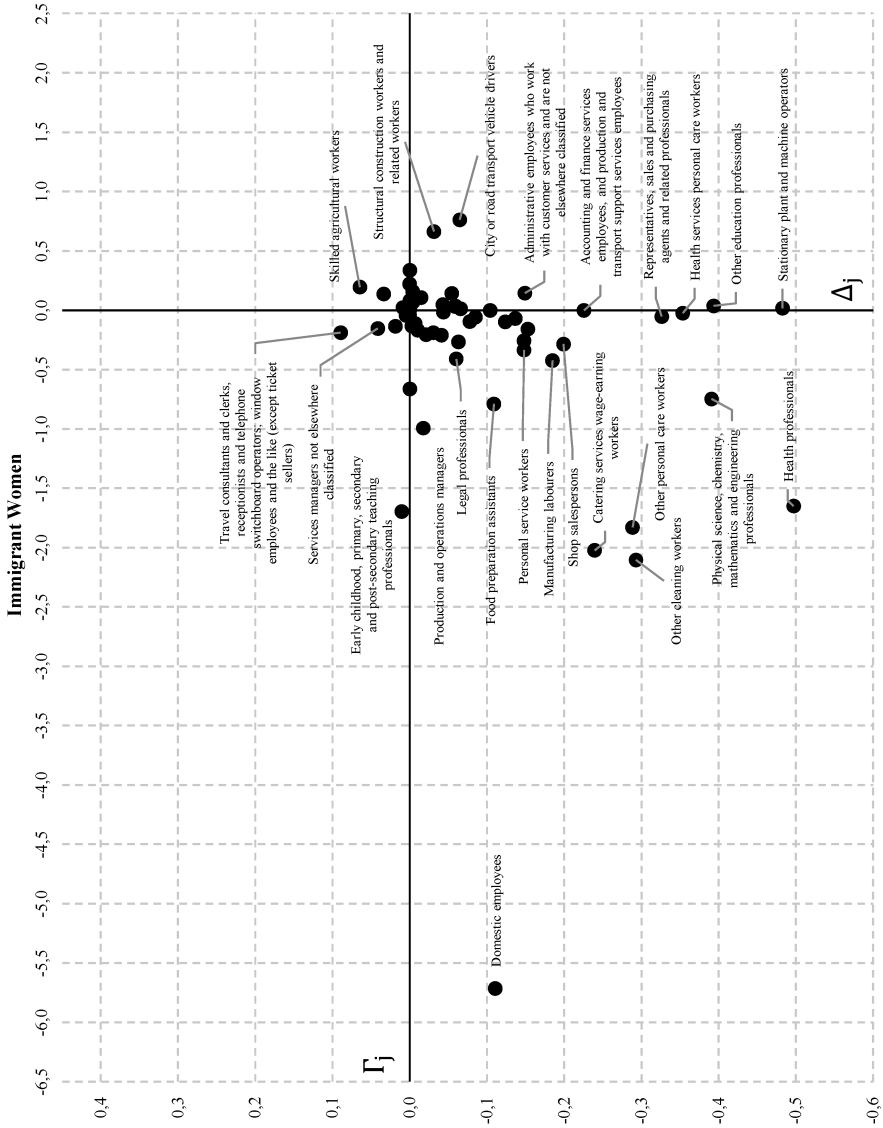
To measure segregation, scholarship has followed this relative view of inequality and has adapted it to the needs of the new context. The measurement of segregation involves important changes with respect to that of income inequality.²⁷ First, the analysis is not undertaken at the individual level because the subject of interest is the group. Second, the egalitarian distribution is not one in which all individuals have the same income, but rather the distribution (among units) of a reference population with which the distributions of other groups are compared. In the case of occupational segregation by gender, for example, this reference can be the occupational sorting of the total population or the occupational sorting of men. Third, to build Lorenz-type curves with which to quantify segregation, the units must be ranked from those in which the target group is underrepresented to those in which it is overrepresented (rather than ranking individuals from low to high income). And what under and overrepresentation means varies depending on whether we are measuring overall segregation or local segregation, as we show in the main text. Fourth, to compare different economies, we must specify how segregation measures should behave when an organizational unit is split in several units, which gives rise to the *organizational equivalence* axiom (in the case of overall segregation; James and Taeuber, 1985) and the *insensitivity to proportional divisions* axiom (in the case of local segregation; Alonso-Villar and Del Ríó, 2010a). Fifth, the translation of the Pigou-Dalton transfers principle has led to two different versions in the case of overall segregation (*transfers* axiom and *exchanges* axiom) and three versions in the case of local segregation (*sensitivity to disequalizing movements type I, II, and III*).²⁸ This is so because when a member of a group moves from one unit to another, this has an effect on the sizes of the units and the representations of the other groups and, therefore, it is necessary to specify the circumstances under which we expect the index to increase.

Table A1
BASIC CHARACTERISTICS OF THE GROUPS IN 2006 AND 2024

	2006 EPA			2024 EPA		
	Native men	Immigrant women	Total	Native men	Immigrant women	Total
Sample size	37,497	2,029	1,638	24,401	2,217	2,032
Population share (%)	52.4	6.8	5.2	45.5	8.0	6.8
<i>Educational attainment (%)</i>						
Lower secondary education at most	50.0	46.4	36.6	31.9	49.3	22.1
Upper secondary education	20.7	33.0	39.4	23.6	27.1	22.4
Tertiary education	29.4	20.7	40.4	44.6	23.6	55.6
<i>Age (%)</i>						
Up to 30 years old	22.4	30.8	25.2	14.0	19.6	14.1
Between 30 and up to 55	63.9	65.4	60.3	63.1	66.5	63.5
Over 55	13.6	3.7	9.8	22.9	13.8	22.5
<i>Location (%)</i>						
Regions with wages below the national average	63.7	53.7	52.2	62.8	53.5	60.8
Regions with wages above the national average	36.3	46.3	47.8	37.2	46.6	39.2
<i>Citizenship (%)</i>						
Bulgaria & Romania	15.5		18.6	14.4		15.8
Rest of Europe	15.6		15.7	18.5		22.2
Africa	23.3		7.4	20.6		8.1
Central and South America	42.3		56.0	37.1		46.1
Asia	3.2		2.0	8.9		7.1
Rest of the world and stateless	0.2		0.3	0.5		0.7

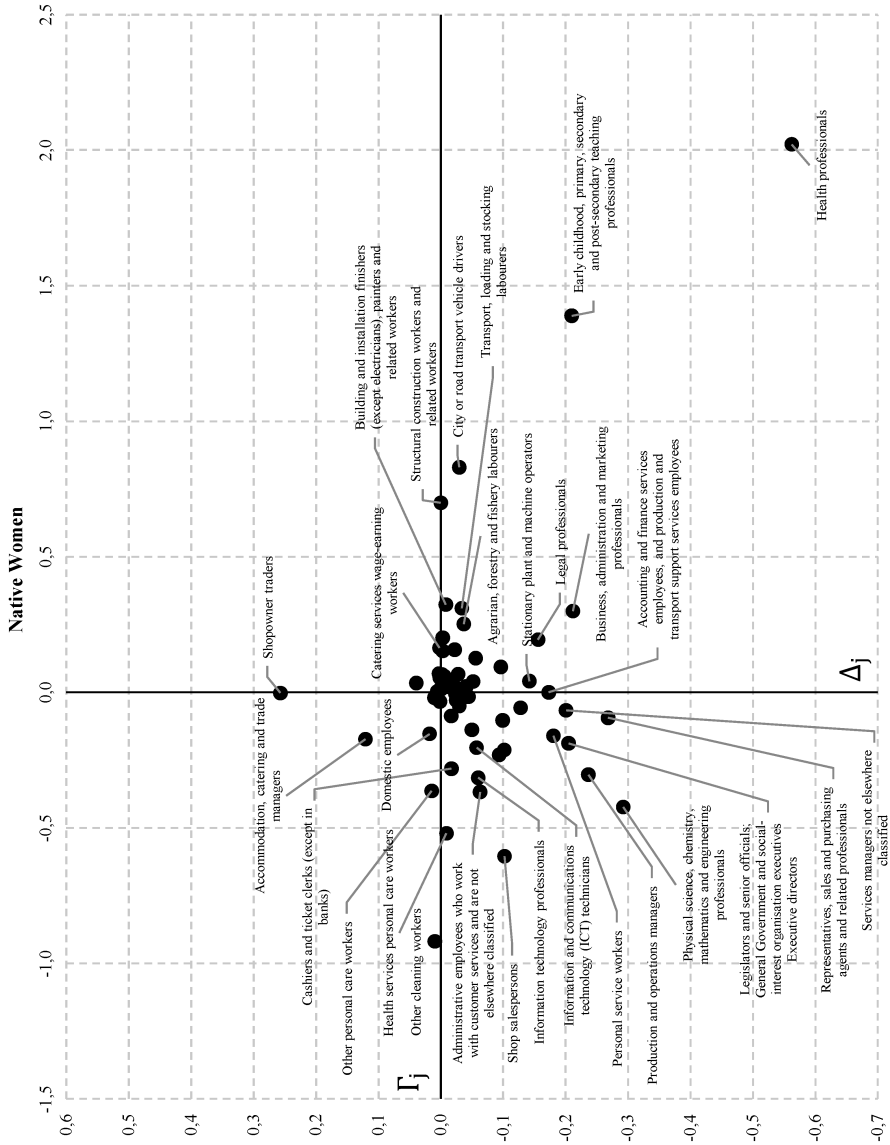
Source: Author's calculations based on the EPAs.

Figure A1
CONTRIBUTION OF EACH OCCUPATION TO THE WITHIN AND BETWEEN COMPONENTS OF THE ACTUAL EARNING GAP



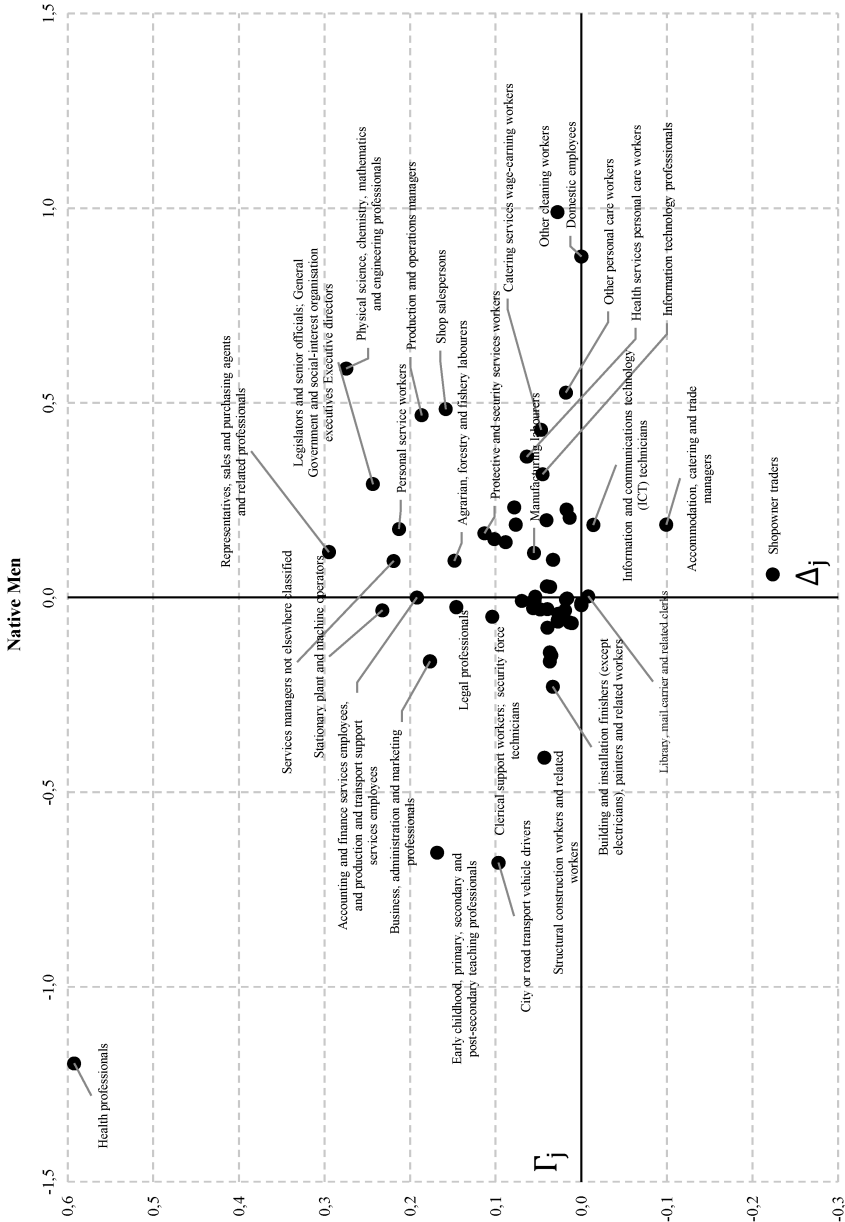
Source: Author's calculations using employment from the 2024 EPA and wages from the 2022 EES.

Figure A2
CONTRIBUTION OF EACH OCCUPATION TO THE WITHIN AND BETWEEN COMPONENTS OF THE ACTUAL EARNING GAP



Source: Author's calculations using employment from the 2024 EPA and wages from the 2022 EES.

Figure A4
CONTRIBUTION OF EACH OCCUPATION TO THE WITHIN AND BETWEEN COMPONENTS OF THE ACTUAL EARNING GAP



Source: Author's calculations using employment from the 2024 EPA and wages from the 2022 EES.

Notes

1. Silber (2012) discusses how to apply the measurement of segregation to other domains (inequality in life chances, inequality in happiness, and inequality in health).
2. In the inequality literature, the corresponding index is the Pietra index. It represents the income share that individuals with incomes above the mean must transfer to those below the mean to achieve the egalitarian distribution (Sarabia and Jordá, 2014). This index is also called the relative mean deviation (Atkinson, 1970).
3. The dominance criterion is analogous to that established with the Lorenz curves (Hutchens, 1991).
4. The reason is that this index does not satisfy the Pigou-Dalton transfers principle adapted to this context (i. e., the index may not decrease when a member of a group moves from a unit to another in which the group has a lower representation), which is one of its shortcomings (James and Taeuber, 1985). Other criticisms arise from the fact that the index is dependent on the population shares of the groups, what is called in the literature margin dependency (Charles and Grusky, 1995), and whether the benchmark should be evenness or randomness (Mazza and Punzo, 2015). However, these criticisms are of a different nature, there is no consensus on their convenience, and they not only affect this index.
5. This index can be seen as a modified version of the dissimilarity index, $I_p = 2(C^m/T)(C^f/T)D$ which satisfies the Pigou-Dalton transfers principle.
6. Boisso *et al.* (1994) developed a different generalization of the binary Gini index.
7. To obtain the standardized or normalized versions, the unstandardized indices given above must be divided by their maximum values, which in the case of Glp and G_u is $\sum_g \frac{C^g}{T} \left(1 - \frac{C^g}{T}\right)$, for M is $\sum_g \frac{C^g}{T} \ln\left(\frac{T}{C^g}\right)$, and for C_u is the total number of groups in the economy minus 1.
8. For a review of spatial measures, see Yao *et al.* (2018).
9. Unlike the segregation literature, in other economics fields the measurement of the “parts” was addressed before the measurement of the “total”. This is the case of regional economics, in which the geographical concentration of a sector was tackled, often using inequality-based indices, before dealing with the geographical concentration of the whole economic activity (Brühlhart and Traeger, 2005; Aiginger and Davis, 2004; Mulligan and Schmidt, 2005; Alonso-Villar and Del Río, 2013a).
10. Based on this approach, Alonso-Villar and Del Río (2025) develop a family of indices design to evaluate the school sorting of children of a given social group taking into account the school resources and needs.
11. These curves are similar to the TIP curves (Three Is of Poverty) used in the literature of income distribution.
12. The marginal change is further decomposed in changes associated with the units’ marginals and those involving the groups’ marginals, as Deutsch *et al.* (2009) do for the generalized I_p index (GIp), whereas the structural change can be decomposed to determine the contribution of each unit.
13. When working with small groups, it is easier to replicate the characteristics of the reference group using the nonparametric method, as illustrated in the case of conditional poverty by sexual orientation (Alonso-Villar and Del Río, 2023c).
14. Intersectionality means that the interaction of the various identities that individuals possess provides them with unique experiences, as some identities can bring advantages and others disadvantages.
15. Alonso-Villar and Del Río (2017d) provide more details on these two data sets, including the definition of immigrant.
16. The graph at the two-digit level, with 62 occupations, is similar. One could also combine occupations and sectors to take into account that women and men do not distribute equally among sectors (Alonso-Villar and Del Río, 2010b).

17. The EPA does not provide information on individual wages.
18. Note that there is a break in the series in 2011 since the national classification of occupations is CNO-94 until 2010 (66 occupations) and CNO-11 (62 occupations) since 2011. It is worth keeping in mind that segregation estimates are sensitive to the classification used.
19. Immigrant wages may be overestimated. The EES only includes workers in enterprises in industry, construction, or services who have been affiliated with social security during the month of October of the corresponding year.
20. Drawing on the 2019 European Labor Force Survey and the 2014 Structure of Earnings Survey, Palencia-Esteban and Del Río (2024) document that in Germany, Finland, Italy, and Slovenia, the occupational sorting of immigrant women penalizes them significantly as well, while in Portugal the penalty is small, and France, the Netherlands, Norway, and Sweden show intermediate levels. The concentration of immigrant men in low-paying occupations is much smaller. In fact, in the UK, the Czech Republic, and especially Portugal, immigrant men are not concentrated in low-paying jobs. Unlike Palencia-Esteban and Del Río (2024), our data sets allow us to determine not only the value of Γ for each group but also the value of Δ , and therefore the *EGap*.
21. There are important differences among immigrants by region of origin, which affects them in terms of occupations and wages (Del Río and Alonso-Villar, 2012b; García *et al.*, 2012). However, that analysis is beyond the scope of this illustration.
22. The gender gap with the 2022 EES is 9.4% for natives and 6.2% for immigrants. The nativity gap is 22.8% for men and 19.7% for women.
23. The covariates included in the counterfactual analysis were intended to control for differences between natives and immigrants and to have enough observations in the corresponding cells for both immigrant women and men. A more in-depth analysis of disparities between native women and men would require, in particular, a more detailed list of educational levels.
24. Additional properties, of a more technical nature, are often invoked as well (e.g., *normalization*, *continuity*, *differentiability*, and the *population principle*).
25. For intermediate inequality measures, see Krtscha (1994), Seidl and Pflingsten (1997), Del Río and Ruiz-Castillo (2000), and Del Río and Alonso-Villar (2010). Intermediate inequality approaches have been used to measure tax progressivity (Pflingsten, 1986; Besley and Preston, 1988; Moyes, 1992; Ledic' *et al.*, 2023).
26. The literature also provides absolute Lorenz-type curves (Moyes, 1987) and various intermediate Lorenz-type curves (Yoshida, 2005; Azpitarte and Alonso-Villar, 2014).
27. For a discussion about basic properties in the case of (overall) segregation between two groups, see James and Tauber (1985) and Hutchens (1991, 2001, 2004). Reardon and Firebaugh (2002) articulate them to measure multigroup overall segregation, and Alonso-Villar and Del Río (2010a) and Del Río and Alonso-Villar (2022) develop the properties required to measure local segregation.
28. The corresponding definitions can be found in Del Río and Alonso-Villar (2022).

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Resumen

Ofrecemos una reflexión sobre la medición de la segregación, recopilando aportaciones metodológicas tanto de la sociología como de la economía, y utilizamos algunas de ellas para explorar la segregación ocupacional por género y lugar de nacimiento en España. Nuestro objetivo es ofrecer una guía sobre las herramientas que pueden emplearse en el análisis empírico, conectándolas con las discusiones teóricas. Nuestro análisis empírico muestra que la segregación ocupacional de las mujeres inmigrantes es un fenómeno más intenso que el de las mujeres nativas o de los hombres inmigrantes, si bien disminuyó significativamente durante el período 2006-2024. A pesar de este descenso, las mujeres inmigrantes aún tienden a concentrarse en ocupaciones con bajos salarios en mucha mayor medida que los hombres inmigrantes y las mujeres nativas. Además, su distribución ocupacional las coloca en gran desventaja incluso después de controlar por atributos básicos. A diferencia de ellas, la mayor parte de la segregación de los hombres inmigrantes que observamos es una consecuencia de sus menores logros educativos. Una vez que controlamos por atributos básicos, la concentración de los hombres inmigrantes en ocupaciones de baja remuneración se reduce sustancialmente, aunque sus salarios por hora siguen siendo inferiores a los de sus pares nativos. A diferencia de las mujeres y los hombres inmigrantes, las mujeres nativas tienden a agruparse en ocupaciones con salarios ligeramente superiores a la media nacional, aunque esta ventaja salarial desaparece una vez que controlamos por características. Las mujeres nativas ganan salarios por hora inferiores a sus pares masculinos (especialmente después de eliminar el efecto composición) debido tanto a las diferencias en su distribución por ocupaciones como a las disparidades salariales dentro de las ocupaciones. La brecha de género es mayor entre la población nativa que entre la inmigrante.

Palabras clave: segregación, género, condición de inmigrante, brechas salariales, interseccionalidad.

Clasificación JEL: D63, J15, J16, J31.