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Coral del Río
Olga Alonso-Villar

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Coral del Río
Olga Alonso-Villar†
Universidade de Vigo and EQUALITAS

Abstract

This paper proposes an index that quantifies the well-being (ill-being) of a target group as associated with its occupational segregation: that is, it assesses the gains/losses of that group which are derived from its underrepresentation in some occupations and overrepresentation in others. This index has several good properties. In particular, it is equal to zero when either the group has no segregation or all occupations have the same wage, and increases when individuals of the group move into occupations that have higher wages than those left behind. Moreover, our well-being measure permits to rank different demographic groups using distributive value judgments that are in the line of those conducted in the literature on economic inequality.

Keywords: Segregation measures; occupations; status; well-being; ill-being.

JEL Classification: D63; J0; J15; J71.

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†**Corresponding author**: Universidade de Vigo; Facultade de CC. Económicas; Departamento de Economía Aplicada; Campus Lagoas-Marcosende s/n; 36310 Vigo; Spain. Tel.: +34 986812507; fax: +34 986812401. E-mail: ovillar@uvigo.es.

1. Introduction

Segregation, the mechanism by which different groups occupy different social environments, is a widespread phenomenon both historically and geographically. A good example is the different positions that women and men held in the past, and still hold in today's labor markets all over the world. Differences in race, ethnicity, and migration status across organizational units (e.g., occupations, sectors, neighborhoods, and schools) are also evident. The analysis of segregation in the labor market (e.g., workplace segregation, occupational segregation, and industrial segregation) and segregation in space (e.g., residential segregation and school segregation) have played an important role in studies conducted over decades by sociologists and economists concerned about the consequences that a low level of integration in society have for the demographic groups that suffer it.

With respect to occupational segregation, which is the focus of this paper, the literature has traditionally focused on segregation by gender and more recently has turned its attention to race and ethnicity, especially in the United States. There are several reasons why researchers and policy-makers care about this matter (Anker, 1998; Kaufman, 2010). A large part of the salary differences between women and men is due to occupational segregation by sex. In the case of the U.S., Hegewisch et al. (2010) documents that median earnings in male-dominated occupations are still higher than they are in female-dominated occupations even after one has controlled for the skills these occupations require. Segregation also explains salary differences by race/ethnicity (Huffman, 2004). Furthermore, it often involves worse working conditions in occupations dominated by women or minorities.

The tendency of these groups to concentrate in low-pay/low-status jobs also has an adverse impact on how others see them, and also on how they see themselves. This effect reinforces stereotypes and fosters poverty, with important consequences for both female-headed households and minorities. In addition, the tendency to segregate has an adverse effect on the education of future generations, particularly regarding the fields of study that boys and girls opt to enter. By another line of reasoning, excluding women and minorities from certain occupations leads to a waste of human resources; the results are extremely inefficient when these are highly skilled people. Moreover, segregation imposes important rigidities, and thus reduces the ability of the market to respond to labor changes, which is a problem in a global economy concerned with efficiency and competitiveness.

Since the pioneer work of Duncan and Duncan (1955), various scholars have developed measures aimed at quantifying segregation, some of them paying increasing attention to the challenges that arise when more than two social groups are involved. Thus, thanks to works by Silber (1992), Reardon and Firebaugh (2002), and Frankel and Volij (2011), several tools can be used now to quantify the extent to which the distributions of the various demographic groups depart from one another. These tools are especially helpful for quantifying overall segregation in a multigroup context.

To explore the situation of one (or several) demographic groups in a multigroup context, usually scholars have to deal with the matter of choosing a group against which to compare the group under consideration. Thus, for example, in studies on occupational segregation by gender and race, the distribution of African American women across occupations is traditionally contrasted with that of White women, White men, African American men, and, more recently, with that of Hispanic women as well (King, 1992; Kaufman, 2010; Mintz and Krymkowski, 2011). Alternatively, Alonso-Villar and Del Río (2010) propose to compare the distribution of the target group with the occupational structure of the economy so that the group is said to be segregated so long as it is overrepresented in some occupations and underrepresented in others, whether the latter are filled by White men, White women, or any minority. This segregation measurement makes it possible to obtain a summary value of the segregation of the group, which seems particularly helpful in analyses in which not all pair-wise comparisons move in the same direction. Moreover, the segregation of a group according to these measures, labeled local segregation measures, is consistent with overall segregation measures proposed in the literature, since the latter can be obtained as the weighted average of the segregation of the mutually exclusive groups into which the population can be partitioned, with weights equal to the demographic share of each group.

However, the overall and the local segregation measures mentioned above do not allow one to approximate either the well-being loss that disadvantage groups have for being concentrated in low-paid (or low status) occupations or the well-being gains of those being in the highly paid. When one is concerned with the consequences of segregation, it is important not only to determine how uneven the distribution of a group across occupations is with respect to others but also to identify the "quality" of the occupations that the group tend to fill or, on the contrary, not to fill. So far, few studies have included the status of occupations in their segregation measurement. The few studies that do include the status of occupations in their proposals have focused on overall segregation by considering either an ordinal categorization of occupations in a multigroup context or a cardinal categorization in a two-group context (Reardon, 2009; Hutchens, 2006, 2009). In a recent paper, Del Río and Alonso-Villar (2012) develop several tools to quantify status-sensitive local segregation in a multigroup context by invoking a cardinal measure of status. Their tools take into account the discrepancies between the distribution of a target group and that of total employment by penalizing the concentration of the group in low-paid occupations. None of these measures are, however, suitable to quantify the well-being/ill-being associated with segregation.

The disadvantaged position of a group in the labor market has been measured in the literature in various ways. One may just determine the share of total earnings that the target group has and compare it with the population share of the group, or deal with the wage discrimination faced by that group. This paper approaches the problem from a different perspective.

The aim of this paper is to assess the consequences of occupational segregation, evaluating the distribution of the group across occupations according to their respective statuses, which are here measured by the average wage. Therefore, of all salary disadvantages (advantages) that a group may face, this paper concerns only the penalty (advantage) that arises from being concentrated in low-paid (high-paid) occupations at a higher extent than in the highly (low-) paid, and so wage disparities within occupations are overlooked. In doing so, this paper builds on both status-sensitive local segregation measures and local segregation measures (Del Río and Alonso-Villar, 2012; Alonso-Villar and Del Río, 2010).

To quantify the well-being (ill-being) of a target group associated with its segregation, this paper proposes an index that satisfies several good properties. The index is equal to zero when either the group has no segregation or all occupations have the same wage. The index increases when individuals of the group move into occupations that have higher wages than those left behind. Therefore, the index is positive when the group tends to fill high-paid occupations and negative when the opposite holds. Moreover, the index is sensitive against movements across occupations in the sense that, *ceteris paribus*, it gives more emphasis to movements taking place lower down in the distribution of occupations (ranked by wages). In other words, it increases more the lower is the wage of the occupation left behind. In addition, the index considers small improvements for many people to be more important than large improvements for a few.

Our well-being measure will permit researchers to rank different demographic groups in a given year (and also explore a group's evolution across time) using distributive value judgments that are in the line of those conducted in the literature on economic inequality. This distributive approach differs from that followed by Del Río and Alonso-Villar (2014) (DR-AV hereafter) in a recent paper. These authors offer an intuitive well-being index characterized by the fact that the monetary gains experienced by the group for being overrepresented in some occupations (i.e., the extra wage earned) is exactly offset by losses of the same magnitude derived from being underrepresented in others. This is not the case of our proposal. Our index takes into account not only the mean wage growth derived from changes in the distribution of the group across occupations but also where those changes occur, assigning a higher value to those changes which involve a reduction in the share of the group in low-paid occupations. The properties of the DR-AV index will be also analyzed in this paper and contrasted with those of our new proposal.

This paper is structured as follows. Section 2 presents the background framework on which this paper is based. Section 3 proposes an index to quantify the well-being (ill-being) of a target group associated with its uneven distribution across occupations that differ in status and analyzes its properties. It also explores whether the index proposed by DR-AV satisfies those properties. The usefulness of our index is illustrated in Section 4 by U.S. data for the period 1980-2010 to explore the segregation of several gender-racial/ethnic groups. This illustration shows the potential of this approach, which offers useful hints for distinguishing between occupational distributions that are similar in terms of shares but differ in terms of assessment of those shares. The differences between this index and that proposed by DR-AV are also shown. Finally, Section 5 offers the main conclusions.

2. Assessing the Impact of Occupational Wage Inequality on Segregation: Background Framework

As mentioned above, few studies have included the status of occupations in their segregation measurement proposals cardinally, and those which exist have focused on segregation in a two-group context (Hutchens, 2006, 2009). An exception is Del Río and Alonso-Villar (2012), who extend local segregation measures by incorporating status in a multigroup context cardinally. These measures can be used to assess a target group's occupational segregation by penalizing its concentration in low-status occupations. These measures aggregate the employment gaps of the target group across occupations by taking into account their wages, but, as we discuss below, they cannot be used to rank demographic groups according to their well-being. They can be used, however, to construct well-being measures associated with segregation. Therefore, before defining a measure with which the well-being of a group can be measured, we present here the measures developed by Alonso-Villar and Del Río (2010) and Del Río and Alonso-Villar (2012) on which our well-being measure is based.

The index of dissimilarity proposed by Duncan and Duncan (1955) is the most popular segregation index. This index compares the proportion of a group in each occupation with the proportion of another group and aggregates those gaps in a certain way. It has been used to quantify, for example, the segregation between women and men, as well as the segregation between Blacks and Whites. This index is actually an overall segregation index, since it measures the segregation between two groups rather than the segregation of one of the groups. As mentioned above, in recent years, overall segregation measures have also been proposed in a multigroup context to quantify discrepancies among all groups taken together (Silber, 1992; Reardon and Firebaugh, 2002; Frankel and Volij, 2011).

To explore the situation of a target group in a multigroup context, what scholars usually do is to consider all pair-wise comparisons between this group and other groups and thence to calculate a segregation index (mainly the index of dissimilarity) for each of these cases (King, 1992; Reskin, 1999; Kaufman, 2010; Mintz and Krymkowski, 2011). When many groups are involved, however, these comparisons become cumbersome, and the performance of a target group is difficult to summarize.

Local Segregation Measures

The segregation measures proposed by Alonso-Villar and Del Río (2010) make it possible to quantify the segregation of a target group in a multigroup context, and are labeled as local segregation measures to distinguish them from overall segregation measures. These measures compare the distribution of the target group across J occupations, $c \equiv (c_1, c_2, ..., c_J)$, with the distribution of total employment across these occupations, $t \equiv (t_1, t_2, ..., t_J)$. This means that the target group is segregated, so long as it is overrepresented in some jobs and underrepresented in others (whether the latter are filled by one particular demographic group or another). Depending on how the discrepancies between c and t are taken into account, several indices can be defined to measure the segregation of the target group. We show here only one of these indices, the one on which our well-being measure is based:

$$\Phi_1(c;t) = \sum_j \frac{c_j}{C} \ln\left(\frac{c_j/C}{t_j/T}\right), \tag{1}$$

where $T = \sum_j t_j$ is the total number of workers in the economy and $C = \sum_j c_j$ is the total number of workers in the target group. This index is related to the Theil index used in the literature of income distribution. This local segregation index is consistent with the mutual information index, axiomatically explored by Frankel and Volij (2010), which is used to quantify overall segregation in a multigroup context. Thus, if we partition the economy into several mutually exclusive groups, the mutual information index can be written as the weighted average of the local segregation of each of these groups according to index Φ_1, where the weighting scheme is given by the population shares of the groups.

Apart from local segregation indices, Alonso-Villar and Del Río (2010) also propose the use of the local segregation curve, $S(\tau_j) = \frac{\sum_{i \le j} c_i}{C}$, where $\tau_j \equiv \sum_{i \le j} \frac{t_i}{T}$ is the proportion of employment represented by the first j occupations ranked in ascending order of the ratio $\frac{c_j}{t_j}$ (see Figure 1). The value of this curve at point 0.1 shows the proportion of individuals of the target group who work in occupations in which this group has the lowest representation ($\frac{c_j}{t_j}$) and that account for 10% of total employment. The curve at point 0.2 shows the proportion of target individuals who work in occupations that represent 20% of total employment and in which they have the lowest representation, and so on.[1] Therefore, this curve shows the underrepresentation of the target group with respect to the occupations' size, percentile by percentile. If the target group were distributed across occupations in the same manner as the distribution of total employment (i.e., if $\frac{c_j}{C}$ were equal to $\frac{t_j}{T}$), the curve would be equal to the 45º line, and no segregation would exist for this group. The more distant the curve is from this line, the higher the group's segregation.

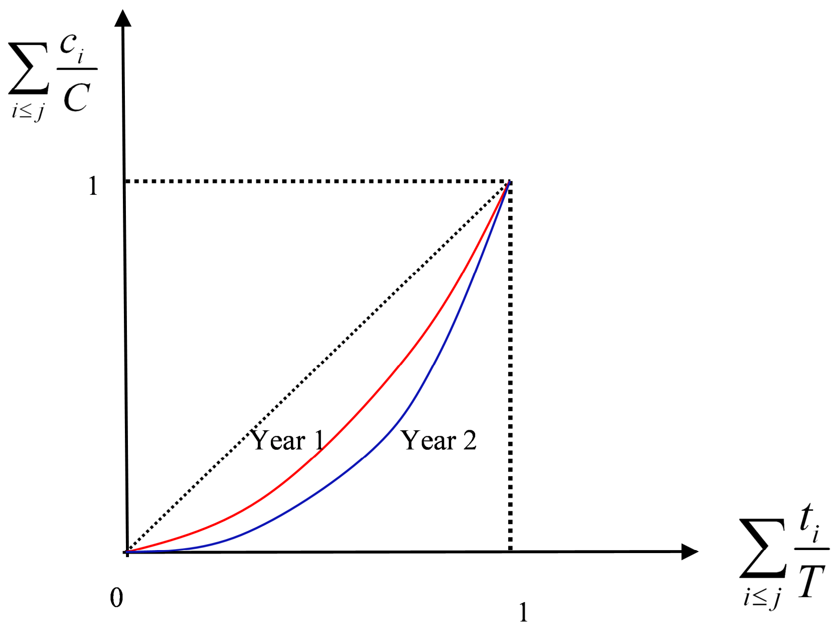

Figure 1. Local segregation curves of the target group, S, in two years

When the distribution of the group is compared in two years, if the curve in year 1 lies at no point below year 2 and at some point above (as in Figure 1, where year 1 dominates year 2), the index defined above (together with other indices that are not given here) will always lead to the same conclusion as the curves do: Segregation is higher in year 2. However, if curves cross or if one is interested in quantifying the extent of segregation, the use of an index becomes necessary.

[1] This local segregation curve is related to the Lorenz curve used in the literature on income distribution, and is also related to the segregation curve proposed by Duncan and Duncan (1955).

Status-sensitive Local Segregation Measures

Del Río and Alonso-Villar (2012) define the status-sensitive (local) segregation curve of the target group as $S^w(\lambda_j) = \frac{\sum_{i \le j} c_i}{C}$, where $\lambda_j \equiv \sum_{i \le j} \frac{t_i \frac{w_i}{\overline{w}}}{T} = \sum_{i \le j} \frac{t_i w_i}{\sum_i t_i w_i}$ (w_j being the wage of occupation j and $\overline{w} = \sum_j \frac{t_j w_j}{T}$ the weighted average wage) and occupations are now ranked in ascending order of the ratio $\frac{c_j}{t_j w_j}$ (see Figure 2 while considering $x_i = c_i$ and $X = C$).

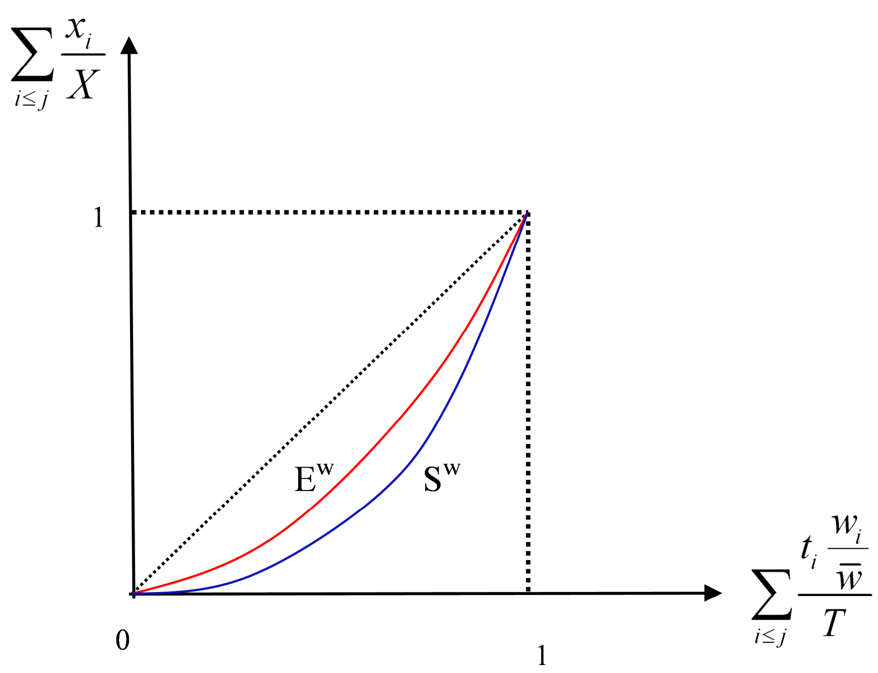

Figure 2. Status-sensitive segregation curve of the target group, S^w, and status-sensitive curve of total employment, E^w

The interpretation of this curve is simple: It shows the cumulative discrepancy between the employment distribution of the target group and the distribution it would have if it followed the distribution of wage revenues ($t_j w_j$) across occupations (wage differences within occupations being neglected). The further the curve is from the 45º line, the larger is the group's status-sensitive segregation.

The corresponding status-sensitive (local) segregation index in the case of index Φ_1 is:

$$\Phi_1^w(c;t) = \sum_j \frac{c_j}{C} \ln\left(\frac{c_j/C}{\left(t_j \frac{w_j}{\overline{w}} \right) / T} \right). \tag{2}$$

This index (together with other not shown here) is consistent with the dominance criterion that these curves give so that, when one curve is above another, it will lead to the same conclusion: a lower status-sensitive segregation for the distribution situated above.

It is important to note that the discrepancy between the employment distribution of the target group across occupations and the distribution of wage revenues across occupations is the result of two inequality sources: the occupational segregation of the target group and wage inequality across occupations. Both factors, which are jointly considered in the above measures, determine the economic position of the target group in the labor market. This explains why the status-sensitive segregation measures are not exactly segregation measures. As Del Río and Alonso-Villar (2012) show, these measures are not equal to zero when local segregation is zero if occupational wage inequality exists.

In fact, one may define the status-sensitive curve of total employment as $E^w(\lambda_j) = \frac{\sum_{i \le j} t_i}{T}$ where occupations are now ranked from the highest to the lowest wage (see Figure 2, where this curve is obtained in consideration of $x_i = t_i$ and $X = T$). This curve, which departs from the 45º line because there is wage dispersion across occupations, shows the status-sensitive segregation that the target group would have if it were distributed across occupations according to the occupational structure. From all of the above, it follows that changes in the distribution of wages will affect the value of the status-sensitive segregation measures, even if the segregation of the target group remains unaltered, because the situation of this group will have actually changed.

Nevertheless, the above status-sensitive segregation measures taken alone do not allow us to quantify the group's well-being. The fact that the status-sensitive segregation curve of one group is below that of another group does not necessarily imply that the former group is worse than the latter. What it really means is that its distribution across occupations is more distant from the distribution of wage revenues across occupations, but this could be a consequence of a higher concentration of the group in either low- or high-paid occupations, since in both cases the curve can be far away from the 45º line. Despite this, the status-sensitive segregation measures seem to be a helpful tool, and we use them in the next section to build our well-being index.

3. The Well-being/Ill-being Associated to Segregation

The status-sensitive segregation measures shown in Section 2 can be thought of as modified local segregation measures in which high-paid occupations gain importance, given that they have a higher weight in the distribution of wage revenues ($t_j \frac{w_j}{\overline{w}}$) than in the employment distribution (t_j). Contrasting local segregation with the status-sensitive segregation measures seems a reasonable strategy to approximate the effect that occupational wage inequality has on the segregation of the group.

3.1 A Well-being Index Associated to Segregation: A Proposal

To quantify the well-being of the target group associated with its uneven distribution across occupations that differ in wages, we propose index $\Psi_1(c;t)$, which results from the difference between the local segregation index $\Phi_1(c;t)$ and the status-sensitive (local) segregation index $\Phi_1^w(c;t)$, adjusted by the wage inequality across occupations given by $\Phi_1^w(t;t)$.[2] Namely,

$$\Psi_1(c;t;w) = \Phi_1(c;t) - \Phi_1^w(c;t) + \Phi_1^w(t;t) .$$

The difference between the first two terms allows us to quantify how much the status-sensitive segregation departs from the local segregation. The third term makes the index equal to zero when the group has no segregation (if $\Phi_1(c;t) = 0$ then $\Phi_1^w(c;t) = \Phi_1^w(t;t)$). After some calculations, the expression becomes simpler:

$$\Psi_1(c;t;w) = \sum_j \left(\frac{c_j}{C} - \frac{t_j}{T} \right) \ln\left(\frac{w_j}{\overline{w}} \right). \tag{3}$$

[2] $\Phi_1^w(t;t)$ can be obtained from expression (2) by replacing distribution *c* by *t*.

In what follows, we will show the properties that this new index holds.

Property 1. *Monotonicity Regarding Increasing-Wage Movements*: Let $(c';t;w)$ be a vector obtained from $(c;t;w)$ in such a way that $c_i' = c_i - n$, $c_k' = c_k + n$ $\left(0 < n \le c_i\right)$, and $c_j' = c_j$ $\forall j \ne i,k$. If occupations i and k satisfy that $w_i < w_k$ (respectively, $w_i > w_k$), then $\Psi_1(c';t;w) > \Psi_1(c;t;w)$ (respectively, $\Psi_1(c';t;w) < \Psi_1(c;t;w)$).

In other words, index Ψ_1 rises (respectively, diminishes) when individuals of the target group move from an occupation to another with a higher (respectively, lower) wage. To prove this, note that, if n individuals move from occupation i to occupation k while the occupational structure and wages remain unaltered, the change in the index will be equal to $\Psi_1(c';t;w) - \Psi_1(c;t;w) = \frac{n}{C}\ln(\frac{w_k}{w_i})$. Therefore, if $\frac{w_k}{w_i} > 1$, the index increases and if $\frac{w_k}{w_i} < 1$, the opposite holds true.[3]

This seems a suitable property because the index is intended to measure a target group's well-being and not its segregation. Thus, if the group's segregation increases in consequence of a higher concentration in highly paid occupations, we want our index to reflect this change as an improvement for the group.

Property 2. *Sensitivity Against Increasing-Wage Movements*: Let $(c';t;w)$ a vector obtained from vector $(c;t;w)$ such that $c_i' = c_i - n$, $c_k' = c_k + n$, where occupations i and k satisfy that $w_k = w_i + x$ ($x > 0$), and $c_j' = c_j$ $\forall j \ne i,k$. Let $(c'';t;w)$ be another vector obtained from vector $(c;t;w)$ such that $c_h'' = c_h - n$, $c_l'' = c_l + n$, where occupations l and h satisfy that $w_l = w_h + x$ and also $w_i < w_h$, and $c_j'' = c_j$ $\forall j \ne h,l$ $\left(0 < n \le \min\{c_i, c_h\}\right)$. Then, $\Psi_1(c';t;w) - \Psi_1(c;t;w) > \Psi_1(c'';t;w) - \Psi_1(c;t;w) > 0$.

This means that, when some individuals of the target group move into an occupation that has, for example, an extra wage of 10 monetary units, then the lower is the wage of

[3] From this proof, it follows that, when n individuals move from an occupation to another with a higher wage, the rise in index is n times the rise the index would have if only one of these individuals had moved.

the occupation being left behind, the higher the rise in index Ψ_1. This property holds because $\Psi_1(c';t;w)-\Psi_1(c;t;w)=\frac{n}{C}\left(\ln w_k-\ln w_i\right)$ and $\ln(w)$ is a concave function, which implies that when wages rise, as the magnitude of this growth hold constant, the function increases lower and lower.

Property 3. *Preference for Egalitarian Improvements*: Let $(c';t;w)$ be a vector obtained from $(c;t;w)$ such that $c_i'=c_i-n$, $c_k'=c_k+n\left(0<n\leq c_i\right)$, and $c_j'=c_j\ \ \forall j\neq i,k$, where occupations i and k satisfy that $w_k=w_i+x\ \ (x>0)$. Let $(c'';t;w)$ be a vector obtained from $(c;t;w)$ such that $c_i''=c_i-1$, $c_h''=c_h+1$, and $c_j'=c_j\ \ \forall j\neq i,h$, where $w_h=w_i+nx$. Then, $\Psi_1(c';t;w)-\Psi_1(c;t;w)>\Psi_1(c'';t;w)-\Psi_1(c;t;w)>0$.

When *n* target individuals move from an occupation to another which has an extra wage of *x* monetary units, index Ψ_1 increases more than it would do if only one individual had moved from an occupation to another having an extra wage of *nx* monetary units. This means that the index considers small improvements in many people to be more important than large improvements in a few individuals. This property is a consequence of the concavity of function *ln*, since $\frac{n}{C}\ln(\frac{w_i+x}{w_i})>\frac{1}{C}\ln(\frac{w_i+nx}{w_i})$.

Property 4. *Path-Independence*: Let $(c';t;w)$ be a vector obtained from vector $(c;t;w)$ such that $c_i'=c_i-1$, $c_k'=c_k+1$, and $c_j'=c_j\ \ \forall j\neq i,k$, where occupations i and k satisfy that $w_k=w_i+x\ \ (x>0)$. Let $(c'';t;w)$ be a vector obtained from $(c;t;w)$ such that $c_i''=c_i-1$, $c_h''=c_h+1$, and $c_j''=c_j\ \ \forall j\neq i,h$ while $(c''';t;w)$ is obtained from $(c'';t;w)$ in such a way that $c_h'''=c_h''-1$, $c_k'''=c_k''+1$, and $c_j'''=c_j''\ \ \forall j\neq h,k$, where $w_h=w_i+x_1$, $w_k=w_h+x_2$, and $x=x_1+x_2$ ($x_1,x_2>0$). Then, $\Psi_1(c';t;w)-\Psi_1(c;t;w)=\Psi_1(c'';t;w)-\Psi_1(c;t;w)+\Psi_1(c''';t;w)-\Psi_1(c'';t;w)$.

This property is a kind *of path-independence* property (Moulin, 1987; Zoli, 2003). It means that the change in index Ψ_1 is the same whether an individual moves from an occupation to another which has an extra wage of x monetary units or moves gradually to better occupations that account for a total wage increase of x units. To prove it, note that $\frac{1}{C}\ln(\frac{w_i+x_1+x_2}{w_i})=\frac{1}{C}\ln(\frac{w_i+x_1}{w_i}\frac{w_i+x_1+x_2}{w_i+x_1})=\frac{1}{C}\ln(\frac{w_i+x_1}{w_i})+\frac{1}{C}\ln(\frac{w_i+x_1+x_2}{w_i+x_1})$.

Property 5. *Normalization*: If either the group has no segregation or all occupations have the same wage, $\Psi_1(c;t;w)=0$.

This property holds because, on the one hand, when the group has zero segregation, $c_j=t_j$ and, on the other hand, when there are no wage disparities across occupations, $w_j=\overline{w}$.

Because of properties 1 and 5, beginning with a situation in which the target group has zero segregation, if some of its members move from an occupation to another with a higher wage, the index will become positive, whereas it will become negative if individuals move toward an occupation with a lower wage. Therefore, when several movements occur, the index will be positive if the upgrading movements are more valued than the downgrading; otherwise, it will be negative. Some of the upgrading movements may involve changes in the index that exactly offset those in the other direction, leading to an index value equal to zero.

Property 6. *Scale Invariance*: If α and β are two positive scalars such that $\alpha c_j \leq \beta t_j$ for any occupation *j*, then $\Psi_1(\alpha c;\beta t;w)=\Psi_1(c;t;w)$.

This property means that our well-being index does not change when the total number of jobs in the economy and/or the total number of target individuals vary, so long as their respective shares in each occupation remain unaltered. In other words, only employment shares matter, not employment levels.

When $\alpha=\beta$, the above property becomes the s*ize invariance* or *replication invariance* property. It means that, if we have an economy in which c and t are obtained by the replication of initial distributions, the well-being of the target group does not change, as we state in the next property.

Property 7. *Replication Invariance:* If α is a positive scalar, then $\Psi_1(\alpha c;\alpha t;w)=\Psi_1(c;t;w)$

Property 8. *Symmetry in Occupations*: If $(\Pi(1),...,\Pi(J))$ represents a permutation of occupations $(1,...,J)$, then $\Psi_1(c\Pi;t\Pi;w\Pi)=\Psi_1(c;t;w)$, where $c\Pi=\left(c_{\Pi(1)},...,c_{\Pi(J)}\right)$, $t\Pi=\left(t_{\Pi(1)},...,t_{\Pi(J)}\right)$, and $w\Pi=\left(w_{\Pi(1)},...,w_{\Pi(J)}\right)$.

This property means that the "occupation's name" is irrelevant, so that, if we enumerate occupations in a different order, the group's well-being remains unchanged.

Property 9. *Insensitivity to Proportional Divisions:* If vector $(c';t';w')$ is obtained from vector $(c;t;w)$ such that $c'_j=c_j$, $t'_j=t_j$, $w'_j=w_j$ for any $j=1,...,J-1$, and $c'_j=c_J/M$, $t'_j=t_J/M$, and $w'_j=w_J$ for any $j=J,...,J+M-1$, then $\Psi_1(c';t';w')=\Psi_1(c;t;w)$.

This property says that subdividing an occupation into several categories of equal size (both in terms of total employment and in terms of target individuals) and equal wage does not affect the group's well-being.

It is easy to prove that properties 6 through 9 hold as consequences of $\Phi_1(c;t),\Phi_1^w(c;t)$, and $\Phi_1^w(t;t)$ satisfying them (Alonso-Villar and Del Río, 2010; Del Río and Alonso-Villar, 2012).

3.2 The Relation between Our Proposal and Other Well-being Measures

To measure the well-being/ill-being of a target group associated with its occupational segregation, Del Río and Alonso-Villar (2014) have recently proposed an alternative index that bears a remarkable resemblance to index Ψ_1:

$$\Gamma=\sum_j\left(\frac{c_j}{C}-\frac{t_j}{T}\right)\frac{w_j}{\overline{w}}.$$

The main advantage of this index is that it has a very intuitive interpretation. First, note that $\sum_j C\left(\frac{c_j}{C}-\frac{t_j}{T}\right)w_j$ can be thought of as the gains or losses that the target group has as a consequence of its uneven distribution across occupations (i.e., its overrepresentation in some occupations and underrepresentation in others). Since this index assesses occupational segregation but not wage discrimination, it takes into account only wage disparities that arise from differences across occupations, while ignoring salary differences within occupations. Second, dividing the above expression by *C*, we obtain $\sum_j \left(\frac{c_j}{C}-\frac{t_j}{T}\right) w_j$, which measures the per capita losses/gains of each member of the group in monetary terms. This raw well-being index would enable comparisons among groups that differed in their size, but it would not be suitable for comparing groups in economies with different occupational wages. However, by dividing this expression by the average wage of occupations, $\overline{w}$, we obtain the losses/gains of each member of the group as a proportion of that average wage, which makes it possible to compare not only the well-being of different groups in an economy but also the well-being of groups in different economies. This expression is precisely index Γ.

Despite its intuitive interpretation, index Γ does not satisfy some of the properties we have mentioned above: unlike Ψ_1, it does not capture distributive issues. Thus, note for example that, if *n* target individuals move from occupation *i* to occupation *k*, the change in the index will be equal to $\Gamma(c';t;w)-\Gamma(c;t;w)=\frac{n}{C}\frac{w_k-w_i}{\overline{w}}$, which is a linear function of w_k-w_i (on the contrary, $\Psi_1(c';t;w)-\Psi_1(c;t;w)$ is a concave function of $\frac{w_k}{w_i}$). This means that, according to Γ, the effect of moving toward an occupation that has a higher wage does not depend on the starting point. An increase of 100 monetary units has the same effect whether the occupation left behind was high- or low-paid. On the other hand, the effect of an individual's moving to an occupation with an extra wage of 100 monetary units has the same effect as 10 individuals moving into an occupation with an additional 10 units paid. Therefore, index Γ does not satisfy properties 2 and 3. On the contrary, it is easy to see that properties 1 and 4 through 9 do hold.

The same kind of problem arises when one uses the average income to quantify the welfare level of an economy without taking distributive issues into account. Both the average income and income inequality are important elements and should be taken into account in the measurement. Likewise, we consider that both Γ and Ψ_1 can be used to quantify the well-being of a group, since each of them brings a different point of view. In our empirical illustration, we will compare them.

4. Assessing Segregation: An Illustration

To illustrate our index, in this section we assess the occupational segregation of women and men of two large minorities in the U.S., Hispanics and Asians, together with Whites. We show the evolution of this index for these six groups from 1980 to 2010. Our data come from the IPUMS samples, which are based on the 1980-2000 U.S. decennial census and the 2008-2010 American Community Survey (ACS), and are homogenized by the Minnesota Population Center of the University of Minnesota, assigning uniform codes to variables (Ruggles et al., 2010).

During this period, the Census Bureau reorganized its occupational classification system several times, but this dataset offers a consistent long-term classification for the whole period based on the 1990 classification, which accounts for 387 occupations. In any case, the harmonization process involved several adjustments, which implies that the classification has some empty employment occupations in several years. Consequently, the number of occupations with positive employment is not the same every year. The “real” number of occupations in 1980, 1990, 2000, and 2008-10 are, respectively, 382, 384, 337, and 333. Fortunately, the majority of the empty occupations have low employment in the years in which they appear.

Analyzing the occupational segregation patterns of six ethnic/racial groups in the U.S. in the mid-2000s, Alonso-Villar et al. (2012) found that Asians and Hispanics, who are two minorities that share a recent immigration profile, were the groups with the highest segregation while Whites were the least segregated. As documented by Del Río and Alonso-Villar (2014), segregation has been particularly intense for Hispanic men since the 1990s, while the segregation of Hispanic women is currently similar to that of Asian women and slightly higher than that of Asian men (see Figure 3).

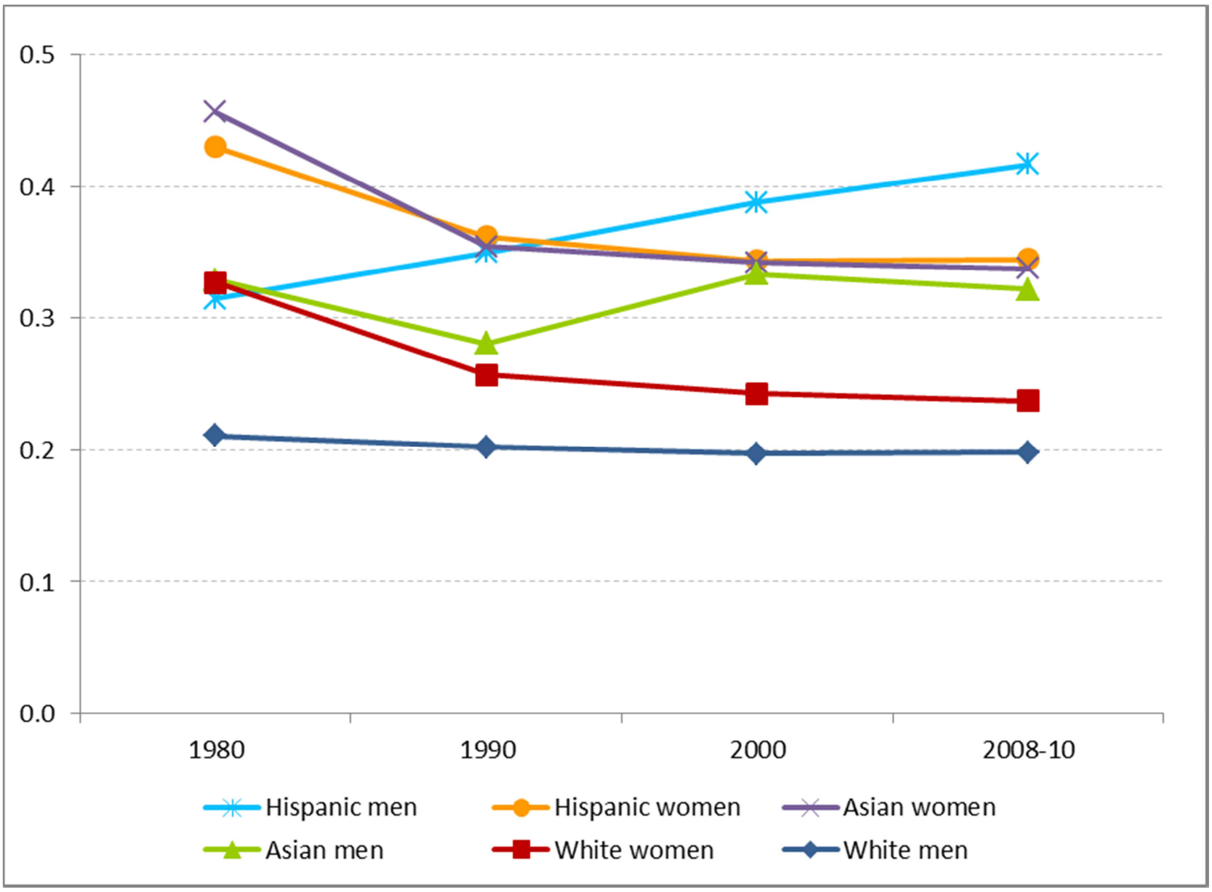

Figure 3. Segregation index Φ_1 for Whites, Asians, and Hispanics, 1980-2010
Source: Del Río and Alonso-Villar (2014)

To assess the segregation of these gender-race/ethnic groups, we now use the tools presented in section 3. The wage of each occupation is proxied by the average wage per hour. Figure 4 shows index Ψ_1 for the period 1980-2010. First of all, the chart reveals that the consequences of segregation are worse for Hispanic women than for Hispanic men (the index is always higher for men), despite men being more segregated than women (Figure 3). In any case, the index is negative for both groups for the whole period, which means that the advantage of those working in high-paid occupations has never offset the large disadvantage of those working in the low-paid. Moreover, both groups have worsened in the last decade.[4] Second, the kind of segregation experienced by Hispanic women is much worse than that of Asian women despite their sharing a

[4] Since 1980, both groups have experienced an ill-being increase derived from their occupational segregation, especially men. It seems that the demographic growth experienced by the Hispanic population during these years has resulted, in the case of men, in a higher concentration in low-paid occupations (*construction laborers*; *gardeners and groundskeepers*; *farm workers*; *cooks*; and *janitors*) some of which worsened in terms of relative wages. However, Hispanic women have held some of the worst paid jobs in the economy since 1980 (*housekeepers*; *cashiers*; *nursing aides, orderlies, and attendants*; *child care workers*; *waiter/waitress*; *waiter's assistant; food prepare workers*; and *textile sewing machine operators*, among others).

similar segregation level. In fact, index Ψ_1 in 2008-2010 is negative for Hispanics and positive for Asians, which means that the occupational segregation of Asian women brings the group more advantages than disadvantages whereas this is not the case for Hispanic women.[5] Third, in the last decade, although White women and men have lower segregation than Asians, the consequences of segregation are better for the latter, since they have higher values of Ψ_1 than their White counterparts.

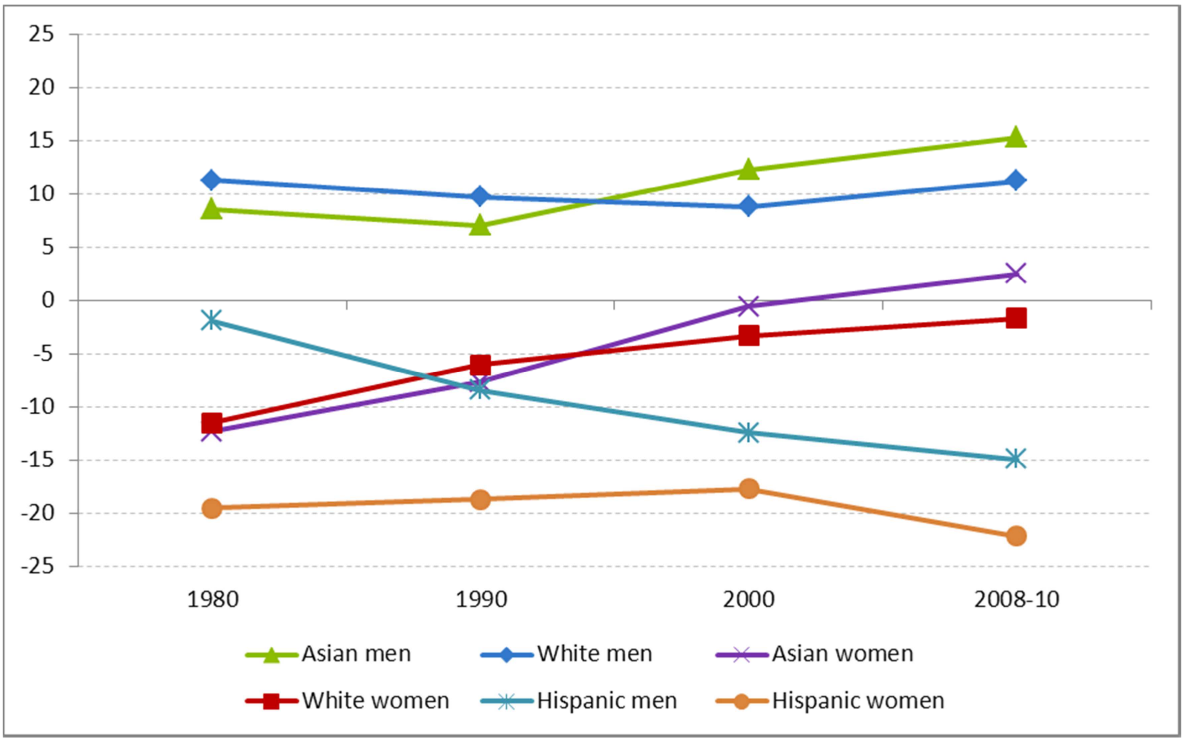

Figure 4. Index Ψ_1 (multiplied by 100) for Whites, Asians, and Hispanics, 1980-2010

Figure 4 also reveals that, up to 2000 no female group had positive values. In the 2000s, the occupational segregation of Asian women begun to bring the group more advantages than disadvantages, since the index became positive. Nevertheless, the improvement experienced by White women from 1980 to 2010 has not allowed them to surpass the zero value. Finally, the value of the index is always higher for males than for females of the same race/ethnicity, which evidences the persistency of the concentration of women in lower paid occupations.

[5] Thus, in 2008-10, Asian women not only exhibit a high concentration in some of the lowest paid occupations (*hairdressers and cosmetologist*; *nursing aides, orderlies and attendants*; *cashiers*; and *waiters/waitress*), but also in some well-paid occupations such as *health diagnosing occupations* (*physicians* and *dentists*); *pharmacists*; and *computer software developers*.

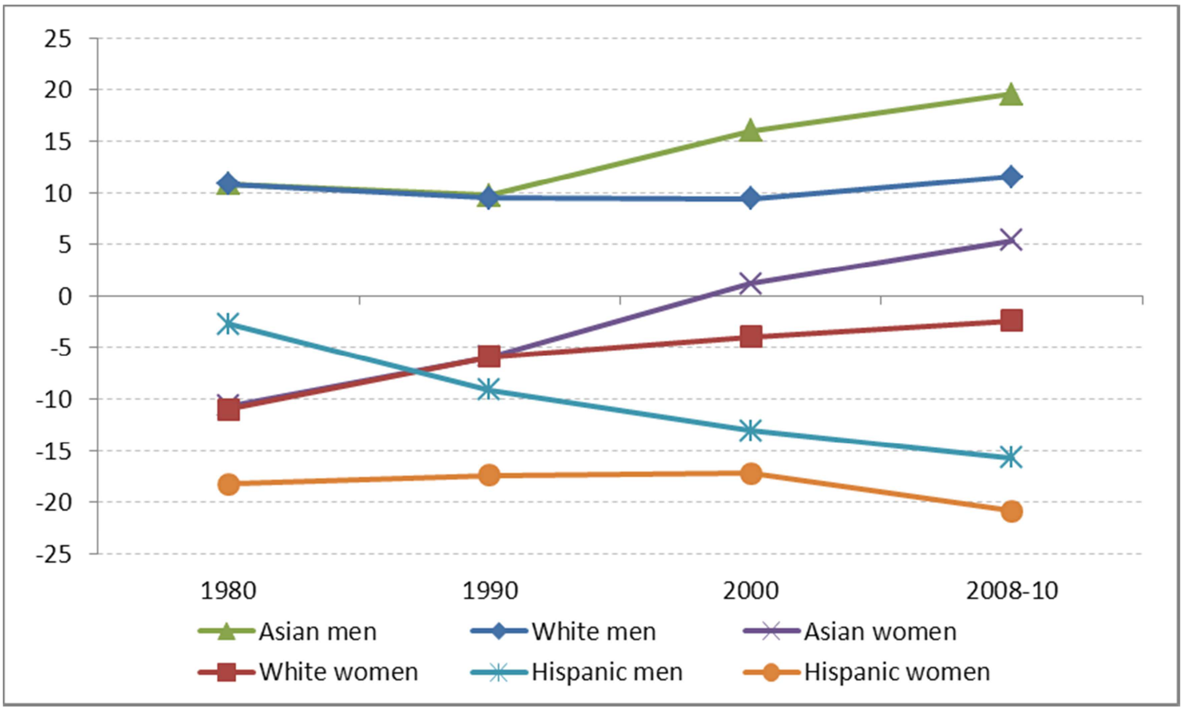

Figure 5. Index Γ (multiplied by 100) for Whites, Asians, and Hispanics, 1980-2010
Source: Del Río and Alonso-Villar (2014)

Figure 5 shows the well-being of these groups according to the index proposed by DR-AV (Γ). It is easy to see that the values of index Γ are not too different from those of index Ψ_1 , and the findings given above regarding rankings of groups and well-being evolution remain unaltered. The main differences between indices Ψ_1 and Γ involve Asian women and men. In both cases, we observe that the well-being is lower with index Ψ_1.

These lower values can be a consequence of the fact that, according to index Ψ_1, the gains of the privileged cannot fully compensate the losses of the disadvantaged, while according to index Γ, the positive contributions of upgrading movements exactly offset the negative contributions of downgrading movements of the same magnitude. This means that, when distributive issues are taken into account, the well-being of Asian groups is not as large as index Γ suggests. For Asian male and female groups, this matter seems to be more important than for other demographic groups because of Asian groups' high internal heterogeneity. Asians are highly overrepresented in both low-paid and highly paid occupations.[6] In consequence, the

[6] In the case of Asian men, they are overrepresented in several highly-paid occupations (*health diagnosing occupations* (*physicians* and *dentists*); *computer software developers*; *computer system*

well-being gaps between Asian groups and their White counterparts are not as large with index Ψ_1 as they are with index Γ, and Asian groups surpass their White counterparts later on (during the 1990s).

5. Conclusions

Occupational segregation analyses have focused mainly on measuring disparities among the occupational distributions of the demographic groups into which total population is partitioned—a phenomenon that can be labeled as overall segregation. One may, however, be interested not only in this matter but also in exploring the segregation of a target group, which has been labeled as *local segregation* to distinguish it from overall or aggregated segregation. For exploring the situation of a group, the introduction of occupations' "quality" into the analysis becomes especially relevant because the situation of a group depends not only on whether it is more concentrated in some occupations than in others but also on the characteristics of those occupations in terms of status, wages, or social prestige. The tendency of some groups to concentrate in low-paid occupations has an important impact on their well-being levels, and this situation should be clearly distinguished from that of an advantaged group. It seems convenient, therefore, not only to quantify segregation but also to assess it in economic terms, a phenomenon which, as far as we know, has been barely addressed in the literature.

This paper has assessed the occupational segregation of a target group while accounting for the "quality" of occupations (here measured by the average wage) that the group tends to fill or not to fill. It has proposed an index that quantifies the well-being (ill-being) of the group associated with its segregation: this index is equal to zero when either the group is evenly distributed across occupations or there is no wage inequality across occupations; it is positive when the group tends to fill highly paid occupations to a higher extent than low-paid ones; and it is negative when the group is concentrated mainly in the lower-paid occupations of the economy.

This index will allow researchers to rank groups in terms of well-being, a ranking that seems especially useful for distinguishing those cases which, while sharing similar

analysts and computer scientists; engineers; and *chief executives and public administrators*) and in a few low-paid occupations (mainly *cooks* and *taxi drivers*). As Wang (2004) points out, the heterogeneity of the Asian group involves not only education but also the occupation and sector in which different ethnicities tend to concentrate.

segregation levels, differ from each other in the nature of that segregation. To illustrate this measure, this paper has explored the occupational segregation of women and men of two large minorities in the U.S., namely Hispanics and Asians, along with Whites for the period 1980-2010. This has allowed us to show that the kind of segregation experienced by Hispanic workers is much worse than that of Asian workers despite their sharing of significant segregation levels.

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