Universidade de Vigo

Departamento de Economía Aplicada
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Working Paper: 15/01. February 2015

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Abstract

This paper deals with the quantification of the well-being loss/gain of a demographic group associated with its occupational segregation, an issue that, as far as we know, has not been formally tackled in the literature. For this purpose, this paper proposes several properties to take into account when measuring this phenomenon. Building on standard assumptions of social welfare functions, it also defines and characterizes a parameterized family of indices that satisfy those properties. In particular, the indices are equal to zero when either the group has no segregation or all occupations have the same wage, and the indices increase when individuals of the group move into occupations that have higher wages than those left behind. In addition, *ceteris paribus*, the indices increase more the lower the wage is of the occupation left behind, and consider small improvements for many people to be more important than large improvements for a few.

JEL Classification: D63; J15; J16

Keywords: Segregation measures; occupations; well-being

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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 hold in labor markets all over the world. Differences by race, ethnicity, and immigrant status in the distribution of people 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, 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 of which 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), Boisso et al. (1994), Reardon and Firebaugh (2002), and Frankel and Volij (2011), several tools can be used now to quantify overall segregation in a multigroup context, i.e., to measure the extent to which the distributions of the various demographic groups simultaneously depart from one another.

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; Reskin, 1999; Kaufman, 2010; Mintz and Krymkowski, 2011; Gradín, 2013). 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, segregation measures do not quantify either the well-being loss that disadvantaged 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 this matter (i.e., with the consequences of segregation), one should not only determine how uneven the distribution of a group across occupations is with respect to others but also identify the "quality" of the occupations that the group tend to fill or, on the contrary, not to fill. This paper aims at quantifying the well-being loss/gain of a demographic group associated with its occupational segregation, an issue that, as far as we know, has not been formally dealt with in the literature. It is true that a few studies have included the status of occupations in their segregation measurement (Reardon, 2009; Hutchens, 2006, 2009; Del Río and Alonso-Villar, 2012) but they measure that particular phenomenon: the uneven distribution of groups across occupations (accounting for status). None of them quantify, however, the well-being loss/gain of a group associated with its segregation, which is the focus of this paper.

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 a group's occupational segregation in terms of well-being (ill-being). Thus, of all salary disadvantages (advantages) that a group may face, this paper focuses on 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.

To quantify the well-being loss/gain of a group derived from its segregation, this paper proposes a family of indices parameterized by a positive inequality aversion parameter. This family is characterized in terms of standard assumptions of social welfare functions. This paper also introduces several reasonable properties to take into account when measuring this phenomenon and proves that our indices hold all of them. Thus, our indices are equal to zero when either the group has no segregation or all occupations have the same wage. Our indices increase when individuals of the group move into occupations that have higher wages than those left behind. Therefore, our indices are positive when the group tends to fill high-paid occupations and negative when the opposite holds. Moreover, our indices are sensitive to movements across occupations in the sense that, *ceteris paribus*, they give greater emphasis to movements taking place lower down in the distribution of occupations (ranked by wages). In other words, they increase more the lower the wage is of the occupation left behind. In addition, our indices consider small improvements for many people to be more important than large improvements for a few. Consequently, our measures will permit researchers to rank different demographic groups in a given year (and also explore a group's evolution over time) using distributive value judgments that are in line with those conducted in the literature on economic inequality.

This distributive approach differs from that followed by Del Río and Alonso-Villar (2015) (DR-AV hereafter). These authors offer a very intuitive index that measures the monetary loss/gain experienced by a group by being segregated. In that index, the extra wages earned by being overrepresented in some occupations are exactly offset by losses of the same magnitude derived from being underrepresented in others. This is not the case with our proposal, which does show inequality aversion. Our indices take 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 lower-paid occupations. This paper shows that the DR-AV index can be obtained as a limit case of our family when inequality neutrality is assumed. By showing inequality aversion, our indices offer a complementary point of view to DR-AV's proposal.

In addition, this paper shows that one member of this family can be built through local and status-sensitive local segregation measures (Del Río and Alonso-Villar, 2012; Alonso-Villar and Del Río, 2010) but departs from them by measuring a different concept—well-being rather than segregation—which involves satisfying different properties. Finally, this article shows how our indices relate to the total well-being of a group resulting from both segregation and within-occupation wage disparities with respect to other groups.

This paper is structured as follows. Section 2 proposes a set of reasonable properties for indices measuring the well-being loss/gain of a group associated with its segregation. Building on standard assumptions of social welfare functions, Section 3 defines a family of such indices and proves that it satisfies all the properties proposed in Section 2. The relationship between one member of this family and local and status-sensitive (local) segregation measures is also shown. In addition, this section explains how to build the total well-being gain/loss of a group derived from both segregation and within-occupation disparities. The usefulness of our well-being indices associated with segregation is illustrated in Section 4 using U.S. data for the period 1980-2010 to explore the situation of several gender-racial/ethnic groups. The differences and similarities between our indices and the one proposed by DR-AV are also shown. Finally, Section 5 offers the main conclusions.

2. Measuring the Well-Being Loss/Gain of a Group Associated with its Segregation: Some Properties

To know if a measure works to quantify the well-being loss/gain of a group associated with its segregation, one should think about the properties that such an index, broadly denoted by Ψ, should verify. In what follows, we introduce these properties, both mathematically and intuitively. These properties are important because they will permit us to give shape to a concept that, as far as we know, has not been previously delimited in the literature.

Let's denote by $t \equiv (t_1, t_2, ..., t_J)$ the distribution of total employment across J occupations, by $c \equiv (c_1, c_2, ..., c_J)$ the distribution of the target group across these occupations (where $c_j \leq t_j \ \forall j$), and by $(w_1, ..., w_J)$ the occupational wage distribution.[1] $T = \sum_j t_j$ 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.

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

In other words, index Ψ rises (respectively, diminishes) when individuals of the target group move from an occupation to another with a higher (respectively, lower) wage. This seems a suitable property because the index is intended to measure a target group's well-being loss/ gain and not its change in segregation. Thus, if the group's segregation

[1] The wage of an occupation could be, for example, the average wage of that occupation.

increases in consequence of a higher concentration in highly paid occupations, we want the 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 $(c;t;w)$ 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 $c_j' = c_j \;\; \forall j \neq i,k$. Let $(c'';t;w)$ be another vector obtained from $(c;t;w)$ 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 $c_j'' = c_j \;\; \forall j \neq h,l \left(0 < n \leq \min\{c_i, c_h\}\right)$. Then, $\Psi(c';t;w) - \Psi(c;t;w) > \Psi(c'';t;w) - \Psi(c;t;w) > 0$.

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 the occupation being left behind, the higher the rise in the index. In other words, we want our index to care more for the individuals who work in the least paid occupations.

Property 3. *Preference for Egalitarian Improvements*: Let $(c';t;w)$ be a vector obtained from $(c;t;w)$ where $c_i' = c_i - n$, $c_k' = c_k + n \left(0 < n \leq c_i\right)$, $c_j' = c_j \;\; \forall j \neq i,k$, and 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, $\Psi(c';t;w) - \Psi(c;t;w) > \Psi(c'';t;w) - \Psi(c;t;w) > 0$.

When n target individuals move from an occupation to another which has an extra wage of x monetary units, the index should increase 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.

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, $\Psi(c';t;w) - \Psi(c;t;w) = \Psi(c'';t;w) - \Psi(c;t;w) + \Psi(c''';t;w) - \Psi(c'';t;w)$.

This property is a kind *of path-independence* property (Moulin, 1987; Zoli, 2003). It means that the change in the index 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.

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

In other words, if the group has no segregation or if all occupations are equally good, the group has no advantages or disadvantages.

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, our 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.[2]

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 $\Psi(\alpha c; \beta t; w) = \Psi(c;t;w)$.

This property means that the 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

[2] 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. However, for this to be the case, the upgrading movements have to be large enough to balance the downgrading ones since, because of property 2, the well-being derived from a monetary increase involving a highly paid occupation is not exactly offset by a monetary decrease of the same magnitude involving a low-paid occupation.

replication of initial distributions, the well-being loss/gain 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 $\Psi(\alpha c;\alpha t;w)=\Psi(c;t;w)$

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

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 loss/gain 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 $\Psi(c';t';w')=\Psi(c;t;w)$.

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 loss/gain.

3. A Family of Indices Measuring the Well-Being Loss/Gain Associated with Segregation

The literature has focused on quantifying the extent of segregation while its consequences in terms of well-being have received little consideration. There are a few proposals that include cardinally the status of occupations to measure either overall segregation in a two-group context (Hutchens, 2006, 2009) or the segregation of a group in a multigroup context (Del Río and Alonso-Villar, 2012).[3] These measures, which penalize the concentration of a group in low-status occupations, cannot be used to rank demographic groups according to the well-being loss/gain associated with their

[3] Reardon (2009) offers ordinal overall measures in a multigroup context. A different ordinal approach is followed by Meng et al. (2006).

segregation because they measure the extent of segregation but not the well-being associated with this phenomenon, which implies satisfying a different set of properties.

In this section, we develop a procedure to build indices with which to quantify the well-being loss/gain of a target group derived from its segregation and propose a family of such indices. This family, which is characterized in terms of standard assumptions of social welfare functions, is later shown to satisfy all the properties defined in Section 2. The members of this family can be used to rank demographic groups according to the consequences of segregation for each of them, as we display in our empirical illustration (Section 4).

3.1 Well-Being Indices Associated with Segregation

We define the well-being loss/gain of a demographic group associated with its occupational segregation as the *per capita* gap that exists between the social welfare of the group derived from its distribution across occupations and the social welfare it would have in the case of no segregation. Therefore, our proposal is to quantify the extent to which the well-being of the group departs from the one it would obtain in an egalitarian situation in which the proportion of jobs in each occupation filled by the target group were equal to the share of the group in the economy (i.e., $\frac{c_j}{t_j}=\frac{C}{T}$). If the group represents, for example, 20% of total workers in the economy, the egalitarian distribution would be that in which the group accounts for 20% of each occupation's employment. By dividing the gap in well-being by the number of individuals of the target group, the well-being loss/gain of the group does not depend on its demographic size, which allows comparisons among different groups. Therefore, our well-being index associated with segregation, $\Psi(c;t;w)$, takes this general form:

$$\Psi(c;t;w)=\frac{1}{C}[W(c;t;w)\text{ - }W(\frac{C}{T}t;t;w)\ ], \qquad (1)$$

where *W*(.) denotes the social welfare function (SWF henceforth). We define the social welfare associated with state $(c;t;w)$ by the social welfare of an artificial "income" distribution consisting of *C* individuals, each of them having an "income" equal to the relative wage of the occupation in which that individual works, given by $\frac{w_j}{\overline{w}}$ in occupation *j*, where $\bar{w} = \sum_j \frac{t_j}{T} w_j$ is the average wage of the economy. In what follows, we will derive our family of indices Ψ by imposing several conditions on *W*.

To start with, we assume some standard properties: our SWF is individualistic, strictly increasing, symmetric, and additive (see *inter alia* Lambert, 1993; Cowell, 1995). Individualistic means that our SWF depends on individuals' utilities and on nothing else.[4] Given that our SWF is strictly increasing, the social welfare increases when, *ceteris paribus*, any individual's income rises. Our SWF is symmetric and, therefore, any permutation of individuals does not change the social welfare (i.e., individuals play identical roles). Additivity implies that our SWF can be expressed as the summation of individuals' utilities, each individual having his/her own utility function, which only depends on his/her income.

As a consequence of these properties, our SWF can be written as the summation of individuals' utilities using an increasing social utility function, *U*(.), which is shared by all of them and only depends on individuals' own income (Cowell, 1995). Given that in our artificial income distribution all individuals working in the same occupation have the same "income," then our SWF takes the form $W(c;t;w) = \sum_j c_j \ \mathrm{U}\left(\frac{w_j}{\bar{w}}\right)$.

To fully characterize our indices Ψ, we need to impose two additional conditions on *U*(.). First, we assume that *U*(.) is strictly concave—which is also a standard condition—so that the social marginal utility, *U'*, decreases with income. In other words, an increase in an individual's income, all else equal, entails a larger change in *U* (and, therefore, in *W*) the lower the initial income of that individual is.

How much does *U'* decrease as income rises? This leads us to the second condition. We assume that *U'* has constant elasticity, given by the parameter ε, so that if an individual's income increases by 1%, then *U'* drops by $\varepsilon\%$ no matter her/his initial income level. As discussed by Lambert (1993), the parameter ε reflects how sharply curved function *U* is and, therefore, it can be interpreted as a (relative) inequality aversion. The assumption of constant (relative) inequality aversion is often used in the

[4] Individuals' preferences are also assumed to be individualistic. Therefore, the utility level of each individual only depends on his/her own income (Lambert, 1993). This implies that there are no externalities.

literature on income inequality. Thus, for example, it is required to warrant that Atkinson's inequality index is scale invariant. Although this condition is not necessary to define a reasonable $\Psi(.)$, we impose it to restrict the class of possible measures to a family parameterized by an inequality aversion parameter, which seems especially appealing given its intuitive interpretation.

This leads us to the following family of social utility functions (see Lambert, 1993):

$$U_{\varepsilon}\left(\frac{w_j}{\overline{w}}\right)=\begin{cases} a_1+b_1\dfrac{\left(\dfrac{w_j}{\overline{w}}\right)^{1-\varepsilon}}{1-\varepsilon} & \varepsilon\neq 1 \\ a_2+b_2\ln\dfrac{w_j}{\overline{w}} & \varepsilon=1 \end{cases}$$

where the inequality aversion parameter, ε, is a positive number (a_1, a_2, $b_1>0$, and $b_2>0$ are constants). Given that a_1, a_2, b_1, and b_2 can be changed without altering substantial properties of $U(.)$, we use a common normalization of those parameters that leads us to the following family of social utility functions (Cowell, 1995):

$$U_{\varepsilon}\left(\frac{w_j}{\overline{w}}\right)=\begin{cases} \dfrac{\left(\dfrac{w_j}{\overline{w}}\right)^{1-\varepsilon}-1}{1-\varepsilon} & \varepsilon\neq 1 \\ \ln\dfrac{w_j}{\overline{w}} & \varepsilon=1 \end{cases} \qquad (2)$$

Therefore, the SWF associated with the distribution of the target group across occupations has the form

$$W(c;t;w)=\sum_j c_j\ \mathrm{U}_{\varepsilon}\left(\frac{w_j}{\overline{w}}\right), \qquad (3)$$

where U_{ε} is given by expression (2).

As a consequence of all of the above, the family of indices with which to measure the well-being gain/loss of a group associated with its occupational segregation is:

$$\Psi_{\varepsilon}(c;t;w) = \begin{cases} \sum_j \left(\frac{c_j}{C} - \frac{t_j}{T} \right) \frac{\left(\frac{w_j}{\overline{w}} \right)^{1-\varepsilon} - 1}{1-\varepsilon} & \varepsilon \neq 1 \\ \sum_j \left(\frac{c_j}{C} - \frac{t_j}{T} \right) \ln \frac{w_j}{\overline{w}} & \varepsilon = 1 \end{cases} \quad (4)$$

where $\varepsilon > 0$ is the inequality aversion parameter.[5] Note that the contribution to $\Psi_{\varepsilon}(c;t;w)$ of any occupation in which the group is overrepresented is positive if and only if that occupation's wage is higher than the average wage of the economy. Likewise, the contribution of any occupation in which the group is underrepresented is negative if and only if it offers a wage above the average. This is so because when $\varepsilon = 1$ and $c_j > C\frac{t_j}{T}$, the sign of $\Psi_{\varepsilon}(c;t;w)$ coincides with that of $\ln(\frac{w_j}{\overline{w}})$, which is positive if and only if $\frac{w_j}{\overline{w}} > 1$. Analogously, when $\varepsilon \neq 1$ and $c_j > C\frac{t_j}{T}$, the sign of $\Psi_{\varepsilon}(c;t;w)$ coincides with that of $\frac{\left(\frac{w_j}{\overline{w}} \right)^{1-\varepsilon} - 1}{1-\varepsilon}$, which is positive if and only if $\frac{w_j}{\overline{w}} > 1$. Therefore, underrepresentation in an occupation only penalizes the index when it occurs in highly paid occupations while overrepresentation does so when it takes place in the lower-paid jobs.

Note that in the limit case where $\varepsilon = 0$, $\Psi_0(c;t;w) = \sum_j \left(\frac{c_j}{C} - \frac{t_j}{T} \right) \frac{w_j}{\overline{w}}$ is actually the Γ index defined by DR-AV to measure the monetary—rather than the well-being—gain/loss of a group associated with its segregation. We will come back to this issue later on when we discuss the implications of assuming inequality neutrality (i.e., $\varepsilon = 0$) rather than inequality aversion (i.e., $\varepsilon > 0$) in Section 3.3.

Finally, note that by following our procedure to obtain well-being indices we could define the total well-being advantage/disadvantage that a group faces in the labor market due to both its uneven distribution across occupations and its within-occupation

[5] Index Ψ_1 can be interpreted in terms of wage inequality (see Appendix A). This index can also be obtained following another line of reasoning based on status-sensitive segregation measures (see Appendix B).

wage disparities with respect to other groups. It can be shown that $\Psi_{\varepsilon}(c;t;w)$ represents the part of that total that is due to the occupational segregation of the group (see Appendix C).

It is important to keep in mind that, although our family of indices is interpreted in this paper in the case of occupational segregation, it can also be used to quantify the consequences of other types of segregation phenomena so long as the status of organizational units (schools, neighborhoods, etc.) can be measured cardinally.

3.2 Does Ψ_{ε} Satisfies Our Basic Properties?

The properties that we have imposed on our SWF are consistent with the properties we want our family of indices $\Psi_{\varepsilon}(c;t;w)$ to satisfy, which were defined in Section 2. In what follows, we show that our family holds all of them.

Property 1 (*monotonicity regarding increasing-wage movements*). To prove that Ψ_{ε} satisfies this property, 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 $\Psi_{\varepsilon}(c';t;w)-\Psi_{\varepsilon}(c;t;w)=\frac{n}{C}\left[U_{\varepsilon}(\frac{w_k}{\overline{w}})-U_{\varepsilon}(\frac{w_i}{\overline{w}})\right]$. Since $U_{\varepsilon}(.)$ is a strictly increasing function, if $w_k > w_i$, the index increases and if $w_k < w_i$, the opposite holds true.[6]

Property 2 (*sensitivity against increasing-wage movements*). Ψ_{ε} satisfies this property because $\Psi_{\varepsilon}(c';t;w)-\Psi_{\varepsilon}(c;t;w)=\frac{n}{C}\left[U_{\varepsilon}(\frac{w_k}{\overline{w}})-U_{\varepsilon}(\frac{w_i}{\overline{w}})\right]$ and $U_{\varepsilon}(.)$ is a strictly concave and increasing 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*). To proof it, note that, on the one hand, $\Psi_{\varepsilon}\left(c';t;w\right)-\Psi_{\varepsilon}\left(c;t;w\right)=\frac{n}{C}\left[U_{\varepsilon}\left(\frac{w_i+x}{\overline{w}}\right)-U_{\varepsilon}\left(\frac{w_i}{\overline{w}}\right)\right]$ and, on the other hand,

[6] 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.

$\Psi_{\varepsilon}(c'';t;w)-\Psi_{\varepsilon}(c;t;w)=\frac{1}{C}\left[U_{\varepsilon}\left(\frac{w_i+nx}{\overline{w}}\right)-U_{\varepsilon}\left(\frac{w_i}{\overline{w}}\right)\right]$. Given that $U_{\varepsilon}(.)$ is a strictly concave function and also that $\frac{w_i+x}{\overline{w}}$ can be rewritten as $\frac{n-1}{n}\frac{w_i}{\overline{w}}+\frac{1}{n}(\frac{w_i+nx}{\overline{w}})$, it follows that $U_{\varepsilon}\left(\frac{w_i+x}{\overline{w}}\right)>\frac{n-1}{n}U_{\varepsilon}\left(\frac{w_i}{\overline{w}}\right)+\frac{1}{n}U_{\varepsilon}\left(\frac{w_i+x}{\overline{w}}\right)$. After some arithmetic, we have that $\frac{n}{C}\left[U_{\varepsilon}\left(\frac{w_i+x}{\overline{w}}\right)-U_{\varepsilon}\left(\frac{w_i}{\overline{w}}\right)\right]>\frac{1}{C}\left[U_{\varepsilon}\left(\frac{w_i+nx}{\overline{w}}\right)-U_{\varepsilon}\left(\frac{w_i}{\overline{w}}\right)\right]$, which completes the proof.

Property 4 (*path-independence*). To prove that our index satisfies this property, note that, on the one hand, $\Psi_{\varepsilon}(c';t;w)-\Psi_{\varepsilon}(c;t;w)=\frac{1}{C}\left[U_{\varepsilon}\left(\frac{w_i+x_1+x_2}{\overline{w}}\right)-U_{\varepsilon}\left(\frac{w_i}{\overline{w}}\right)\right]$ and, on the other hand, $\Psi_{\varepsilon}(c'';t;w)-\Psi_{\varepsilon}(c;t;w)=\frac{1}{C}\left[U_{\varepsilon}\left(\frac{w_i+x_1}{\overline{w}}\right)-U_{\varepsilon}\left(\frac{w_i}{\overline{w}}\right)\right]$ and

$$\Psi_{\varepsilon}(c''';t;w)-\Psi_{\varepsilon}(c'';t;w)=\frac{1}{C}\left[U_{\varepsilon}\left(\frac{w_i+x_1+x_2}{\overline{w}}\right)-U_{\varepsilon}\left(\frac{w_i+x_1}{\overline{w}}\right)\right].$$

Property 5 (*normalization*). This property holds in the case of our family of indices because, on the one hand, when the group has zero segregation, $\frac{c_j}{C}=\frac{t_j}{T}$ and, on the other hand, when there are no wage disparities across occupations, $w_j=\overline{w}$.

With respect to properties 6 (*scale invariance*), 7 (*replication invariance*), 8 (*symmetry in occupations*), and 9 (*insensitivity to proportional divisions*), it is easy to see that they follow immediately from the definition of our family of indices.

3.3 Differences with respect to DR-AV

As mentioned above, to measure the monetary gain/loss of a target group associated with its occupational segregation, DR-AV have recently proposed an index, Γ, that can be obtained as a limit case of our family of indices when $\varepsilon=0$, $\Psi_0(c;t;w)=\sum_j\left(\frac{c_j}{C}-\frac{t_j}{T}\right)\frac{w_j}{\overline{w}}=\Gamma$. This index has a clear economic interpretation: it measures the *per capita* monetary loss or gain of a group derived from its overrepresentation in some occupations and underrepresentation in others. To see this, first, note that $\sum_j C\left(\frac{c_j}{C}-\frac{t_j}{T}\right)w_j$ can be thought of as the monetary gain or loss that the target group has as a consequence of its uneven distribution across occupations. This expression 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* loss/gain of each member of the group in monetary terms. This expression 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 loss/gain of each member of the group as a proportion of that average wage, which makes it possible to compare not only the monetary gains/losses of different groups in an economy but also the monetary gains/losses of groups in different economies. This expression is precisely $\Psi_0(c;t;w)$.

Despite its intuitive interpretation, index $\Psi_0(c;t;w)$ does not show inequality aversion and, therefore, does not capture distributive issues, which makes it to violate some of the basic properties established in Section 2. 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 $\Psi_0(c';t;w)-\Psi_0(c;t;w)=\frac{n}{C}\frac{w_k-w_i}{\overline{w}}$. This means that, according to $\Psi_0(c;t;w)$, 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, $\Psi_0(c;t;w)$ index does not satisfy properties 2 and 3. On the contrary, it is easy to see that properties 1 and 4 through 9 do hold.

Consequently, index $\Psi_0(c;t;w)$ measures the monetary gain/loss of a target group associated with its occupational segregation while the family Ψ_ε with $\varepsilon>0$ quantifies the well-being gain/loss of the group assuming that there is inequality aversion toward inequality, which is the standard assumption in the literature on economic inequality. We consider that both types of indices can be used to assess the position of a group associated its occupational segregation bringing complementary points of view.

4. The Consequences of Segregation: An Illustration

To illustrate the usefulness of our family of indices, this section assesses 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 our indices for these six groups from 1980 to 2010. Our data come from the Integrated Public Use Microdata Series (IPUMS-USA) provided by the Minnesota Population Center of the University of Minnesota (Ruggles et al., 2010). The IPUMS-USA data are drawn from the U.S. decennial censuses and the American Community Surveys (ACS)—which replaced the census long form and which includes occupation information from 2000 on—while assigning uniform codes to variables. The advantage of this dataset is precisely the harmonization of variables and codes of the different datasets, which facilitates analysis over time. In our case, the IPUMS-USA corresponds to the decennial censuses for the period 1980-2000 and the three-year sample of the ACS for 2008-10.

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 (2015), 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 1).

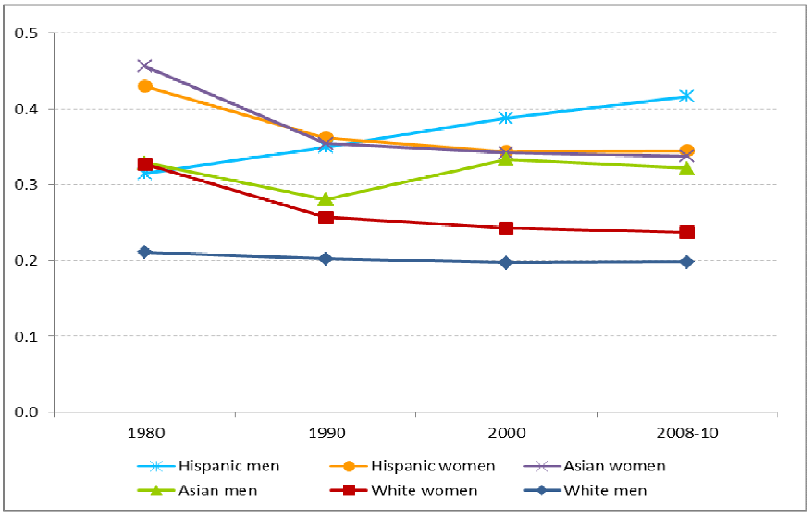


Figure 1. Local segregation index Φ_1 for several demographic groups, 1980-2010
Source: Del Río and Alonso-Villar (2015)

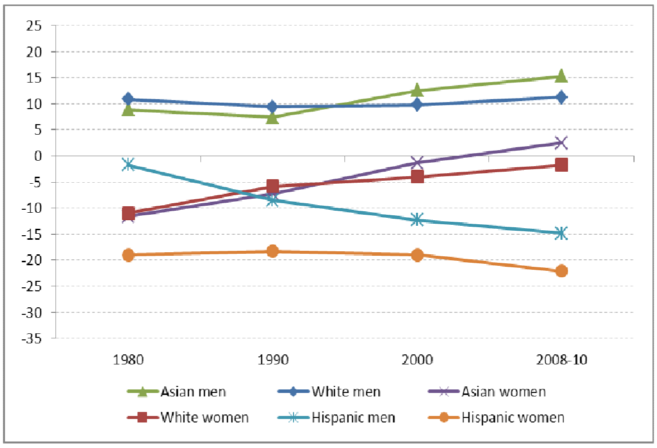
To assess the segregation of these gender-race/ethnic groups in terms of well-being, we now use the tools presented in section 3. The wage of each occupation is proxied by the average wage per hour.[7] Figure 2 shows index Ψ_ε for several values of the inequality aversion parameter ($\varepsilon = 1, 2, 3,$ and 4) for the period 1980-2010.

First of all, Ψ_1 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 1). 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.[8] Second, the kind of segregation experienced by Hispanic women is much worse than that of Asian women

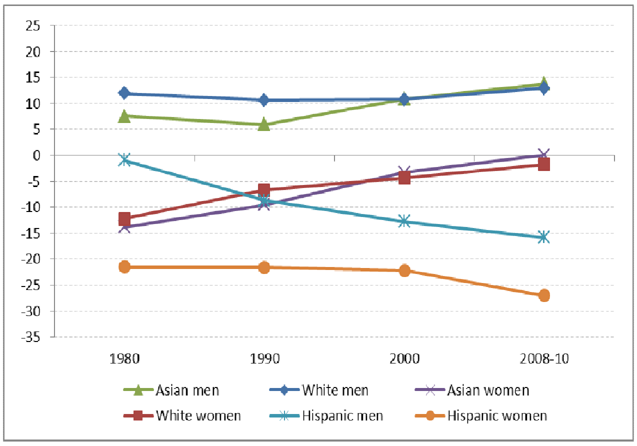
[7] For each occupation, we trim the tails of the hourly wage distribution to prevent data contamination from outliers. Thus, we compute the trimmed average in each occupation eliminating all workers whose wage is either zero or situated below the first or above the 99th percentile of positive values in that occupation.

[8] 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 had already 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).

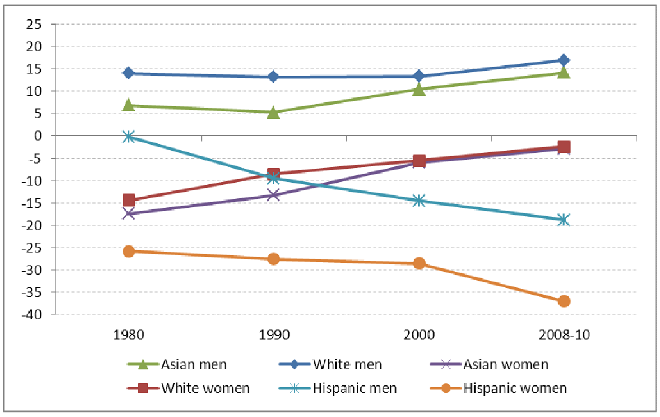
despite their sharing a similar segregation level. In fact, index Ψ_1 in 2008-10 is negative for Hispanics and positive for Asians, which means that the occupational segregation of Asian women brings the group advantages whereas this is not the case for Hispanic women.[9] Third, in the last decade, although 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.



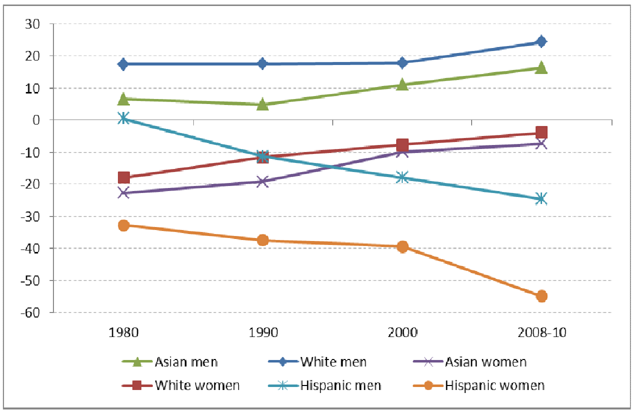
Ψ_1



Ψ_2



Ψ_3



Ψ_4

Figure 2. Indices Ψ_ε (multiplied by 100) for several demographic groups, 1980-2010

Ψ_1 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 advantages given that 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 note

[9] 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*.

that 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.

The evolution of each group across time with the remaining indices is similar. In other words, when a group improves or worsens according to Ψ_1, it also does so with the other indices. What is different among indices is the magnitude of the well-being gains/losses of the groups and also the rankings of Asian and White groups. Thus with index Ψ_2, there were almost no differences between the well-being gains of Asian men during the 2000s and those of White men. Moreover, with a stronger inequality aversion (Ψ_3 and Ψ_4), White men had a higher well-being than Asian men (and this is so not as a consequence of the latter being much worse-off but the former being better-off). Something similar happens to Asian and White women (although in this case Asian women are the group that worsens). When the inequality aversion parameter is equal to 3 or 4, Asian women are no longer better-off than their White counterparts during the 2000s.

For comparative purposes, Figure 3 shows the *per capita* monetary gains/losses 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 evolution remain unaltered. The main differences between indices Ψ_1 and Γ involve Asian women and men. In both cases, we observe that the values of the index are lower with 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 monetary magnitude.

This means that, when inequality aversion is assumed, the position of Asian groups is not as good as index Γ suggests. For Asian male and female groups, this matter seems to be more important than for other demographic groups. In the case of Asians this could be due to their high internal heterogeneity since they are highly overrepresented in both low-paid and highly paid occupations.[10] In consequence, the 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). The differences with respect to Γ are more evident when using Ψ_ε with $\varepsilon > 1$ because, when the inequality aversion is large enough, White men and women are never surpassed by their Asian counterparts.

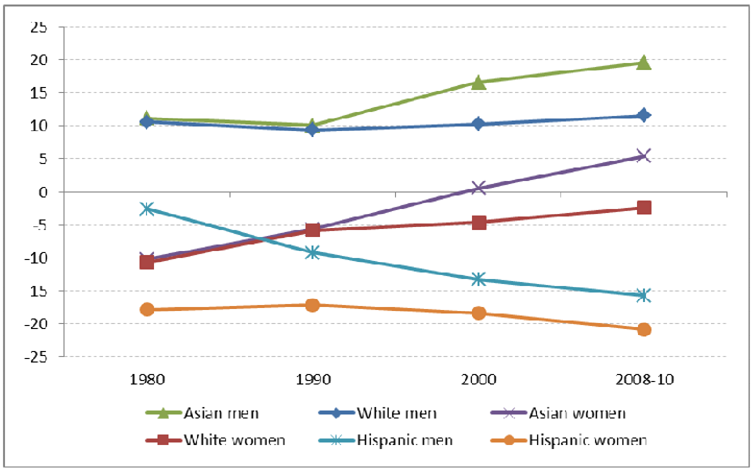


Figure 3. Index Γ (multiplied by 100) for several demographic groups, 1980-2010
Source: Del Río and Alonso-Villar (2015)

Another group whose well-being losses augment significantly when the inequality aversion parameter rises is that of Hispanic women because of their high concentration in low-paid occupations.

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

[10] 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 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.

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 terms of well-being, a phenomenon which, as far as we know, has not been formally addressed in the literature.

This paper has proposed a family of indices that measure the well-being gain/loss of a target group associated with its occupational segregation, accounting for the "quality" of occupations (here measured by the average wage) that the group tends to fill or not to fill. This family, which satisfies several good properties, 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 segregation levels, differ from each other in the nature of that segregation. One should keep in mind that this family could also be expressed in terms of alternative indicators of occupations' "quality," such as social status or prestige. Moreover, one can also use this family to quantify the well-being gain/loss associated with other types of segregation (e.g., residential and school segregation) considering other quality indicators (e.g., services offered in each neighborhood or expenditure per pupil).

To illustrate our proposal, this paper has calculated several of our indices for 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. Moreover, in the last decade, although the monetary gains of White women and men associated with their segregation were lower than that of Asians, the well-being associated with that segregation was higher for the former when one assumes that inequality aversion is high enough.

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Appendix

A. Interpreting Ψ_1 in terms of wage inequality

$\Psi_1(c;t;w)$ can be interpreted in terms of wage inequality when inequality is measured using Theil 0 index. Note that $\Psi_1(c;t;w)$ can be expressed as

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

The first term of the above expression is the *between component* of individuals' wage inequality (according to the decomposability property of Theil 0 inequality index) when individuals are grouped by occupation. Therefore, it can be interpreted as the individuals' wage inequality (including all individuals in the economy) that arises from working in different occupations (while overlooking within-occupation wage inequality). The second term also represents a kind of *between component*; it would be the *between component* of the target group's wage inequality assuming that, within each occupation, there are no wage discrepancies between the target group and other groups. This term could be, therefore, interpreted as the "target group's wage inequality" derived from its distribution across occupations that offer different wages.

B. Obtaining Ψ_1 through Local and Status-sensitive Local Segregation Indices

Alonso-Villar and Del Río (2010) proposed several indices with which to quantify the segregation of a target group in a multigroup context, and labeled them as local segregation measures to distinguish them from overall segregation measures. These measures result from comparing the distribution of a target group across occupations, $(c_1,...,c_J)$, with the distribution of total employment across these occupations, $(t_1,...,t_J)$. 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:

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

the one through which our well-being measure can be obtained, as we will show later on.[11]

Del Río and Alonso-Villar (2012) took a step further and defined several status-sensitive local segregation indices that measure the discrepancy between the employment distribution of the target group $\left(c_1,...,c_J\right)$ and the distribution it would have if it followed the distribution of wage revenues $\left(t_1 w_1,...,t_J w_J\right)$ across occupations (wage differences within occupations being neglected). The corresponding status-sensitive local segregation index in the case of index Φ_1 is:

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

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 this measure, determine the economic position of the target group in the labor market. However, this index does not allow us to quantify the group's well-being gain/loss associated with its segregation. The fact that the index for a group is higher than 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 index can take a high value.

[11] This index is related to the Theil index used in the literature of income distribution and is consistent with the mutual information index used to quantify overall segregation in a multigroup context (Frankel and Volij, 2011). 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.

Contrasting Φ_1^w with Φ_1 seems, however, a good way of distinguishing both cases since it allows assessing whether taking occupational wages into account intensifies the unevenness of the group. If we adjust this difference by the wage inequality across occupations, given by $\Phi_1^w(t;t)$,[12] we can obtain one of the members of our family. In fact, after some calculations, we can show that

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

The difference between the first two terms allows us to quantify how much the status-sensitive segregation departs from the local segregation, making the uneven distribution of the group be more or less problematic depending on whether overrepresentation occurs in low- or high-paid occupations. The third term corrects for the wage inequality that exists among occupations and makes the index equal to zero when the group has no segregation (if $\Phi_1(c;t) = 0$ then $\Phi_1^w(c;t) = \Phi_1^w(t;t)$).

C. Total Well-being Advantage/Disadvantage of a Group

Apart from quantifying the well-being gain/loss of a group associated with its segregation, one may also be interested in quantifying the total well-being advantage/disadvantage (WAD) that the group faces in the labor market, as consequence of both occupational segregation and within-occupation wage disparities with respect to other groups. Following the same line of reasoning of Section 3.1, this total well-being can be measured by the following index:

$$\text{WAD}_\varepsilon = \sum_j \frac{c_j}{C} U_\varepsilon\left(\frac{w_j'}{\bar{w}}\right) - \sum_j \frac{t_j}{T} U_\varepsilon\left(\frac{w_j}{\bar{w}}\right),$$

where w_j' denotes the average wage that the group has within occupation *j* (unlike w_j, which is the average wage in that occupation) and U_ε is given by expression (2). In other words, *WAD* is the difference between the well-being the group really has and the

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

well-being it would have if there were no segregation ($c_j = C\frac{t_j}{T}$) and in each occupation the group received its average wage ($w_j' = w_j$).

By adding and subtracting the term $\sum_j \frac{c_j}{C} U_\varepsilon\left(\frac{w_j}{\overline{w}}\right)$, we get

$$\mathrm{WAD}_\varepsilon = \Psi_\varepsilon(c;t;w) + \sum_j \frac{c_j}{C}\left[U_\varepsilon\left(\frac{w_j'}{\overline{w}}\right) - U_\varepsilon\left(\frac{w_j}{\overline{w}}\right)\right].$$

By using this decomposition, one can determine the proportion of the total well-being advantage/disadvantage of the group that is due to occupational segregation and the proportion due to within-occupation wage disparities with respect to other groups. In other words, one can find out whether segregation is an important component of the total well-being advantage/disadvantage of the group.