Occupational Segregation Measures:

A Role for Status*

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Abstract

This paper extends recent local segregation measures by incorporating status differences across occupations. These new measures are intended to be used to assess, from a normative point of view, the segregation of a target group. They seem appropriate to complement, rather than substitute, other measures by quantifying how things change when taking into account the status of occupations. The usefulness of these tools is shown in the case of occupational segregation of immigrants and natives in Spain.

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1. Introduction

The literature on segregation has devoted a great deal of attention to analyzing segregation in the case of two population subgroups (blacks/whites, high/low social position, and women/men).[1] According to this literature, segregation exists so long as one distribution departs from the other, which should be better interpreted as overall or aggregate segregation since both demographic groups are jointly considered. In recent years, the study of overall segregation in a multigroup context has received increasing attention among scholars and several indices have been proposed (Silber, 1992; Boisso et al., 1994; Reardon and Firebaugh, 2002; Frankel and Volij, 2007, 2008). Nevertheless, one may be interested in measuring not only overall segregation, which involves simultaneous comparisons among all groups, but also the segregation of a target population subgroup, an issue that gains special relevance in a multigroup context. This matter was tackled recently by Alonso-Villar and Del Río (2010a), who offered an axiomatic set-up within which the segregation measurement of target groups (which can be labeled as local segregation) can be addressed. The measurement of the segregation of each population subgroup in which the economy can be partitioned allows one to delve deeper into the segregation phenomenon since the distribution of a demographic group across occupations can be rather different from that concerning other population groups.[2] In addition, these authors showed that several of the overall segregation indexes existing in the literature can be expressed as weighted sums of the corresponding local measures, which allows one to quantify the contribution of each demographic group to overall/aggregated segregation.

However, none of the aforementioned works consider the fact that occupations have different status. Therefore, their view of segregation does not take account whether demographic groups tend to occupy high or low status jobs, even though wage earnings vary considerably among occupations.[3] On the contrary, a segregation measure taking into account the status of occupations explicitly assumes that it is important not only to determine how uneven the

[1] See classical works by Duncan and Duncan (1955), Karmel and MacLachlan (1988), and Silber (1989). For more recent proposals, see Hutchens (1991, 2004) and Chakravarty and Silber (2007).
[2] Recent studies using this approach to analyze the occupational segregation of several demographic groups are Del Río and Alonso-Villar (2010a, b) and Alonso-Villar and Del Río (2010b).
[3] In this study, we use wage as a proxy for status, although, this must not be the only relevant variable in defining job status.

distribution of a group across occupations is with respect to others but also to identify the direction of these differences. Let us think of this in the case of local measures. Considering the salary level of occupations in the segregation measurement of a target group means, on one hand, placing emphasis on the different levels of individuals' well-being, since well-being is not be the same for those who are strongly concentrated in high-paid occupations rather than in low-paid occupations. On the other hand, identifying the direction of the differences in the occupational distribution of a group helps one to determine the causes of both types of segregation. In fact, the reasons behind the segregation of native male workers with a high educational level are not the same as those explaining the segregation of immigrant men with a low educational level, even though both groups may have high occupational segregation levels. In order to illustrate the relevance of these questions in the measurement of local occupational segregation, consider the following economy with two demographic groups (*A* and *B*) of equal size and two occupations (*j* and *k*). Table 1 presents the distribution of both groups between occupations together with the corresponding wages.

	Group A	Group B	Wage
Occupation j	20	80	3
Occupation k	80	20	7

Table 1. Example

Any of the local segregation measures proposed by Alonso-Villar and Del Río (2010a) would conclude that both demographic groups share identical segregation levels. However, some researchers would agree that the segregation suffered by group *B* is of a different nature, and more disturbing, than that of group *A*, since its employment is strongly concentrated in the low-paid occupation. In this regard, one might reasonably wonder whether it is possible to develop measures that allow one to include the status of organizational units (occupations, branches of activity, etc.) in the segregation measurement of a demographic group. These tools should give a higher segregation value to group $B \equiv (80,20)$ than to $A \equiv (20,80)$. Even though the discrepancy between the distribution of each of them and that of total employment $(100,100)$ is of the same magnitude, it does not have the same repercussion.

Two recent papers have tackled the inclusion of status/prestige in the measurement of overall segregation. Thus, Reardon (2009) offered overall measures in a multigroup context, which are useful when organizational units can be defined by ordered categories. In doing so, he established a set of desirable properties that any ordinal segregation measure should satisfy and developed a general procedure with which to build these kind of measures.[4] In addition, by following an approach more closely related to that of the literature on inequality, Hutchens (2006) proposed overall segregation measures in the binary case taking into account differences in the prestige of organizational units. In some cases, these disparities are addressed by following a cardinal scale of prestige, while other measures use ordinal classifications. Both studies have opened the axiomatic debate, offering valued proposals for empirical research. However, none of them have tackled the inclusion of status in local segregation.

To close that gap somewhat, this paper extends the local measures proposed by Alonso-Villar and Del Río (2010a) by incorporating the status of occupations (cardinally measured). These new measures are intended to be used to assess, from a normative point of view, the occupational segregation of a target group. For that purpose, Section 2 offers a reflection about the properties that a local segregation measure taking into account the status of organizational units should satisfy and offers several measures (indexes and curves) consistent with them. These tools are later used, in Section 3, to analyze the occupational segregation of immigrants and natives in Spain. This illustration shows the potential of this approach, which offers useful hints in distinguishing between occupational distributions that are similar in terms of shares but differ regarding the assessment of those shares. In this vein, we propose to complement, rather than substitute, standard approaches with new tools that permit the assessment of segregation by quantifying how things change when taking into account the status of occupations. Finally, Section 4 offers the main conclusions.

2. Local segregation measures: The status of organizational units

This paper considers an economy with $J>1$ organizational units among which total population, denoted by *T*, is distributed according to distribution $t \equiv \left(t_1, t_2, ..., t_J\right)$, where

[4] The mentioned paper also offers a reflection on previous proposals existing in the literature regarding ordinal segregation following alternative approaches, as is the case of Meng et al. (2006).

$T = \sum_j t_j$. Assume that the status of each organizational unit is represented by distribution $s = (s_1, ..., s_J)$, where each s_j is a cardinal measure of the status of occupation j and $\sum_j \frac{t_j}{T} s_j = 1$. Denote by $c^g \equiv \left(c_1^g, c_2^g, ..., c_J^g\right)$ the distribution of target group g, where $c_j^g \le t_j$ $(g = 1, ..., G)$. Distribution c^g could represent, for example, the number of individuals of an ethnic/racial group or any other group of citizens in each occupation. Therefore, the economy can be summarized by status vector s and matrix *E*, which represents the number of individuals of each population subgroup in each organizational unit, where rows and columns correspond to population subgroups and organizational units, respectively. The total number of individuals in unit j is $t_j = \sum_g c_j^g$, and the total number of individuals of target group g is $C^g = \sum_j c_j^g$.

$$
\begin{array}{c}
G \text{ subgroups} \times J \text{ organizational units} \\
E = \begin{bmatrix} c_1^1 & \cdots & c_J^1 \\ \vdots & & \vdots \\ c_1^G & \cdots & c_J^G \end{bmatrix} \rightarrow \begin{bmatrix} \sum_j c_j^1 = C^1 \\ \vdots \\ \sum_j c_j^G = C^G \end{bmatrix} \\
\downarrow \\
\begin{bmatrix} \sum_g c_1^g = t_1 & \cdots & \sum_g c_J^g = t_J \end{bmatrix}
\end{array}
$$

A measure of local segregation taking into account status is a function, Φ_s, that allocates a real number to each vector $\left(c^g; t; s\right)$ by measuring the differences between the distribution of target group g among organizational units, c^g, and the distribution of reference, t, both distributions expressed in proportions, taking into account the status of occupations. In other words, distribution $\left(\frac{c_1^g}{C^g}, ..., \frac{c_J^g}{C^g}\right)$ is compared with $\left(\frac{t_1}{T}, ..., \frac{t_J}{T}\right)$ according to *s*. Namely, $\Phi_s : D \rightarrow \mathbb{R}$, where $D = \bigcup_{J>1} \left\{\left(c^g; t; s\right) \in \mathbb{R}_+^J \times \mathbb{R}_{++}^J \times \mathbb{R}_{++}^J : c_j^g \le t_j \forall j\right\}$.

2.1 Basic properties

Following Alonso-Villar and Del Río (2010a) (henceforth AV-DR), we propose the following four basic properties for measuring local segregation in a hierarchical context:

Property 1. *Scale Invariance*: Let α and β be two positive scalars such that when $\left(c^g;t;s\right)\in D$ vector $\left(\alpha c^g;\beta t;s\right)\in D$, then $\Phi_s\left(\alpha c^g;\beta t;s\right)=\Phi_s\left(c^g;t;s\right)$.

Property 2. *Symmetry in Groups*: If $\left(\Pi(1),...,\Pi(J)\right)$ represents a permutation of occupations $\left(1,...,J\right)$ and $\left(c^g;t;s\right)\in D$, then $\Phi_s\left(c^g\Pi;t\Pi;s\Pi\right)=\Phi_s\left(c^g;t;s\right)$, where $c^g\Pi=\left(c^g_{\Pi(1)},...,c^g_{\Pi(J)}\right)$, $t\Pi=\left(t_{\Pi(1)},...,t_{\Pi(J)}\right)$, and $s\Pi=\left(s_{\Pi(1)},...,s_{\Pi(J)}\right)$.

Property 3. *Insensitivity to Proportional Divisions*: If vector $\left(c^g{}';t';s'\right)\in D$ is obtained from vector $\left(c^g;t;s\right)\in D$ in such a way that **a)** $c^g{}'_j=c^g{}_j$, $t'_j=t_j$, $s'_j=s_j$ for any $j=1,...,J-1$ and **b)** $c^g{}'_j=c^g_J/M$, $t'_j=t_J/M$ and $s'_j=s_J$, for any $j=J,...,J+M-1$, then $\Phi_s\left(c^g{}';t';s'\right)=\Phi_s\left(c^g;t;s\right)$.

The first property means that the segregation index does not change when the total number of jobs in the economy and/or the total number of individuals of target group g vary so long as their respective shares in each occupation remain unaltered. In other words, in measuring local segregation, only employment shares matter, not employment levels. The second property means that the "occupation's name" is irrelevant so that if we enumerate occupations in a different order, the segregation level remains unchanged. The third property states that subdividing an occupation into several categories of equal size, both in terms of total employment and in terms of individuals of the target group, does not affect the segregation measurement so long as the status of the new categories coincides with that of the original occupation.

Property 4. *Sensitivity to Disequalizing Movements between Organizational Units*: Consider two occupations, i and h, satisfying $\frac{c_i^g}{t_i s_i}<\frac{c_h^g}{t_h s_h}$. If vector $\left(c^g{}';t';s\right)\in D$ is obtained from vector $\left(c^g;t;s\right)\in D$ in such a way that either **a)** $c_i^g{}'=c_i^g-d$ and $c_h^g{}'=c_h^g+d$ $\left(0<d\le c_i^g\right)$, other things being equal (i.e., $c_j^g{}'=c_j^g$ $\forall j\ne i,h$ and $t_j{}'=t_j$ $\forall j$), or **b)** $t_i{}'=t_i+e$ and $t_h{}'=t_h-e$ $(0<e\le t_h;\ s_i=s_h)$, other things being equal (i.e., $c_j^g{}'=c_j^g$ $\forall j$ and $t_j{}'=t_j$ $\forall j\ne i,h$), then $\Phi_s\left(c^g{}';t';s\right)>\Phi_s\left(c^g;t;s\right)$.

This property requires the local segregation to increase when there are disequalizing movements between occupations. It implies, for example, that if occupation *i* has the same number of jobs and status as occupation *h* (i.e., $t_i=t_h$ and $s_i=s_h$) but a lower number of positions for the target group (i.e., $c_i^g<c_h^g$), a movement of target individuals from *i* to *h* is a disequalizing movement fostering the segregation of that group. In this case, there would be no difference between this property and that of "movement between groups" proposed by AV-DR, since both occupations are considered to have the same status and, therefore, the target group has a lower presence in occupation *i* regarding not only employment in that occupation, t_i, but also regarding employment weighted by status, t_is_i. But property 4 also refers to disequalizing movements between occupations with different status, which are not considered in AV-DR. Thus, for example, if there is a movement of target individuals from *i* to *h*, segregation increases when occupation *i* has the same number of jobs as occupation *h* (i.e., $t_i=t_h$) but a higher status and a lower number of positions for the target group (i.e., $s_i>s_h$ and $c_i^g<c_h^g$). In addition, a disequalizing movement between two occupations with the same status can be found if the employment structure of the economy changes in such a way that the number of jobs increases in occupation *i* and decreases in *h* (in the same amount), the former having lower employment positions for the target group and higher (or equal) employment level weighed by status (i.e., $c_i^g<c_h^g$ and $t_is_i\ge t_hs_h$).

One might consider it necessary to include an additional property to compare disequalizing movements that differ in the status of the "receiving" occupation. Thus, it seems reasonable that a disequalizing movement toward an occupation with a lower status fosters segregation to a higher extent than a movement toward an occupation with the same status. Following the property of "movements between groups with different prestige" established by Hutchens (2006) to measure overall segregation in a binary context, the next property can be defined.

Property 5. *Sensitivity to Disequalizing Movements between Organizational Units with Different Status:* Consider three occupations, *i*, *h*, and *k*, such that $\frac{c_i^g}{t_i} < \frac{c_h^g}{t_h} = \frac{c_k^g}{t_k}$ and $s_i = s_h > s_k$. If vectors $\left(c^{g}{}';t;s\right),\left(c^{g}{}'';t;s\right) \in D$ are obtained from vector $\left(c^{g};t;s\right) \in D$ in such a way that $c_i^g{}' = c_i^g - d$ and $c_h^g{}' = c_h^g + d$, and $c_i^g{}'' = c_i^g - d$ and $c_k^g{}'' = c_k^g + d$ with $\left(0 < d \le c_i^g\right)$, other things being equal, then $\Phi_s\left(c^{g}{}'';t;s\right) - \Phi_s\left(c^{g};t;s\right) > \Phi_s\left(c^{g}{}';t;s\right) - \Phi_s\left(c^{g};t;s\right) > 0$.

Note, however, that property 5 is a particular case of property 4, and, therefore, if the latter is required, there is no need for the former.

2.2 Local segregation curves

Keeping in mind properties 1-4, we now define local segregation curves that are sensible to differences among occupations' status. The dominance criterion of these curves is later shown to be consistent with these properties. In order to propose measures that can be easily implemented, we use wage as a proxy for occupational status. Namely, we assume that the distribution of status across occupations is equal to $s \equiv \left(\frac{w_1}{\overline{w}},...,\frac{w_J}{\overline{w}}\right)$, where w_j is the wage of occupation *j* and $\overline{w} = \sum_j \frac{t_j w_j}{T}$. In building the new local curves, we modify the distribution of reference against which to compare that of the target group used in AV-DR--that of total employment $t \equiv \left(t_1, t_2, ..., t_J\right)$--so as to incorporate the importance of each occupation in terms of status/wages. Thus, the weight of each occupation in the new distribution of reference is now equal to its employment level weighted by its relative wage ($\frac{w_j}{\overline{w}}$). Consequently, if occupation j has a wage above the average ($w_j > \overline{w}$), it has a high status, and, therefore, the employment benchmark against which to compare that of the target group gains relevance ($t_j \frac{w_j}{\overline{w}} > t_j$). Later on, we will see that this change allows the new local measures to satisfy the aforementioned basic properties.

As opposed to AV-DR, a segregation curve for target group g is now obtained by comparing the distribution of that group with distribution $\left(t_1\frac{w_1}{\overline{w}},...,t_J\frac{w_J}{\overline{w}}\right)$ rather than $(t_1,...,t_J)$. Thus, we plot the cumulative proportion of employment, $\sum_{i\leq j}\frac{t_i\frac{w_i}{\overline{w}}}{T}$, on the horizontal axis and the cumulative proportion of individuals of the target group, $\sum_{i\leq j}\frac{c_i^g}{C^g}$, on the vertical axis, once occupations are lined up in ascending order of the ratio $\frac{c_j^g/C^g}{(t_j\frac{w_j}{\overline{w}})/T}$, which is equivalent to ranking according to $\frac{c_j^g}{t_j\frac{w_j}{\overline{w}}}$[5]. This local segregation-status curve generalizes that previously proposed by AV-DR, since the latter can be obtained as a particular case where all of the occupations have the same wage.

Definition*:* We say that the local segregation curve of $\left(c^g;t;\frac{w}{\overline{w}}\right)\in D$ *dominates in segregation that of* $\left(c^g{}';t';\frac{w'}{\overline{w}'}\right)\in D$, where $w\equiv(w_1,...,w_J)$, if the segregation curve of the former lies at no point below the latter and at some point above. Next, we show the relationship between our segregation curves and segregation indexes satisfying the aforementioned basic properties.

Proposition 1. *Given vectors* $\left(c^g;t;\frac{w}{\overline{w}}\right),\left(c^g{}';t';\frac{w'}{\overline{w}'}\right)\in D$, *the local segregation curve of* $\left(c^g;t;\frac{w}{\overline{w}}\right)$ *dominates that of* $\left(c^g{}';t';\frac{w'}{\overline{w}'}\right)$ *if and only if* $\Phi_s\left(c^g;t;\frac{w}{\overline{w}}\right)<\Phi_s\left(c^g{}';t';\frac{w'}{\overline{w}'}\right)$ *for any local segregation index* Φ_s *satisfying properties 1-4.*

Proof: See Appendix

[5] Note that considering $s\equiv\left(\frac{w_1}{\overline{w}},...,\frac{w_J}{\overline{w}}\right)$ warranties that $\sum_j t_j s_j=\sum_j t_j\frac{w_j}{\overline{w}}=\sum_j t_j=T$.

This result shows the robustness of the dominance criterion for measuring the segregation of a demographic group when taking into account the status of occupations, since when a curve dominates in segregation another curve, any local segregation index satisfying the above properties will be necessarily consistent with this criterion. This makes the use of these curves a powerful procedure for empirical analysis. However, if curves cross or if one is interested in quantifying the extent of segregation, the use of indexes satisfying the basic properties seems most appropriate. In what follows, we extend several local segregation measures existing in the literature by incorporating the status of occupations.

2.3 Local segregation indexes

The segregation Gini index of a target group can be written as the weighted sum of the differences between pairs of occupations according to the relative presence of the target group--all ratios being expressed in terms of weighted-status employment--divided by twice the demographic weight of the group:

$$G_s^g = \frac{\sum_{i,j} \frac{t_i}{T} \frac{t_j}{T} \frac{w_i}{\overline{w}} \frac{w_j}{\overline{w}} \left| \frac{c_i^g}{t_i \frac{w_i}{\overline{w}}} - \frac{c_j^g}{t_j \frac{w_j}{\overline{w}}} \right|}{2 \frac{C^g}{T}}.$$

Given the parallelism between the classical Gini index and the Lorenz curve, one can easily observe that this measure is equal to twice the area between the above local segregation curve and the 45º-line.

The generalized entropy family of local segregation indexes proposed by AV-DR can also be conveniently modified in order to take into account the status of occupations:

$$\Psi_{s,\alpha} \equiv \Psi_\alpha(c^g; t; \frac{w}{\overline{w}}) = \begin{cases} \frac{1}{\alpha(\alpha-1)} \sum_j \frac{t_j \frac{w_j}{\overline{w}}}{T} \left[\left(\frac{c_j^g / C^g}{\left(t_j \frac{w_j}{\overline{w}} \right) / T} \right)^\alpha - 1 \right] & \text{if } \alpha \neq 0,1 \\ \sum_j \frac{c_j^g}{C^g} \ln \left(\frac{c_j^g / C^g}{\left(t_j \frac{w_j}{\overline{w}} \right) / T} \right) & \text{if } \alpha = 1 \end{cases}$$

where α is a sensitivity parameter.[6] Note that when $\alpha = 0.5$, the above index is a variation of the square root index proposed by Hutchens (2006) to measure overall segregation in the binary case when taking the prestige of occupations into account:

$$\Psi_{s,0.5} = \frac{1}{4}\left(1 - \sum_j \sqrt{\frac{w_j}{\overline{w}}}\sqrt{\frac{c_j^g}{C^g}\frac{t_j}{T}}\right).$$

Moreover, the index of dissimilarity proposed by Duncan and Duncan (1955), the most popular segregation measure, can also be conveniently adapted to measure the segregation of target group *g* when taking status into account:

$$D_s^g = \frac{1}{2}\sum_j \left|\frac{c_j^g}{C^g} - \frac{t_j}{T}\frac{w_j}{\overline{w}}\right|.$$

Given the parallelism between the local segregation curve of vector $\left(c^g; t; \frac{w}{\overline{w}}\right)$ and the Lorenz curve of fictitious income distribution $\left(\underbrace{\frac{c_1^g}{t_1\frac{w_1}{\overline{w}}}, \ldots, \frac{c_1^g}{t_1\frac{w_1}{\overline{w}}}}_{t_1\frac{w_1}{\overline{w}}}, \ldots, \underbrace{\frac{c_J^g}{t_J\frac{w_J}{\overline{w}}}, \ldots, \frac{c_J^g}{t_J\frac{w_J}{\overline{w}}}}_{t_J\frac{w_J}{\overline{w}}}\right)$ defined in the proof of the above proposition, demonstrating that the Gini index of target group *g*, G_s^g, and the family of indexes $\Psi_{s,\alpha}$ satisfy properties 1-4 is easy. For the same reason, it follows that local index D_s^g only satisfies properties 1-3, since the classical index of dissimilarity is not consistent with the Lorenz dominance criterion.

All these measures are especially useful in quantifying how the segregation level of a target group changes when taking into consideration status differences among occupations. In this

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[6] If we had considered local segregation indexes defined on the space of distributions $(c^g; t; s)$, where all components of vector c^g were strictly positive, rather than positive, then another index could be defined: $\Psi_\alpha(c^g; t; \frac{w}{\overline{w}}) = \sum_j \frac{t_j \frac{w_j}{\overline{w}}}{T} \ln\left(\frac{(t_j \frac{w_j}{\overline{w}})/T}{c_j^g / C^g}\right)$ if $\alpha = 0$.

vein, we propose to use these tools to complement, rather than substitute, indexes that do not take status into account, since this approach can be helpful to assess, from a normative point of view, the type of segregation experienced by the target group.

3. An illustration: Occupational segregation of immigrants and natives in Spain

In order to illustrate the usefulness of the above measures, in this section, we analyze the distribution of immigrant and native workers across occupations in the case of Spain, which is a country that has experienced an extraordinary expansion of its immigrant population in the last few years. Thus, according to the Municipal Census offered by the Spanish Institute of Statistics (INE), Spain had, in 1996, half a million immigrants, while, in 2009, this number reached 5.6 million. This has caused Spain to achieve an immigration rate similar to that of countries with much longer migrant traditions, such as the United Kingdom, France, Germany, and the United States (see Figure 1, in which the estimations of the Population Division of United Nations for 2010 are given).

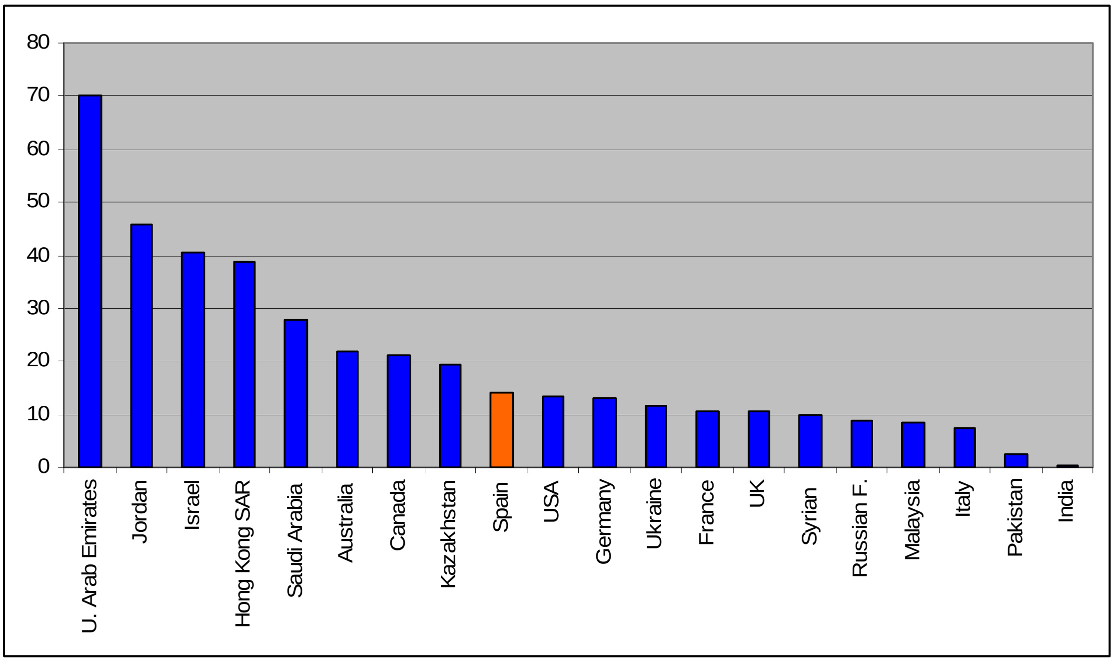

Figure 1: Migrant stock as a percentage of total population in 2010 for the countries with the highest migrant stocks. Source: United Nations (2009).

The distribution of immigrant workers across occupations may depart from that of natives for several reasons (Liu et al., 2004; Parasnis, 2006). Thus, the job opportunities of newly arrived immigrants are likely to depend on migrant networks, which may favor the concentration of immigrants in a few occupations. In addition, differences in educational achievements and/or language may hinder the process of assimilation for immigrants, especially if specific knowledge is required in the receiving country (as in the case of lawyers).[7]

In what follows, we quantify the occupational segregation of immigrant workers in Spain, paying attention to whether education affects the distributions of immigrants and natives across occupations in the same manner and how things change when taking into account the status of occupations (measured in terms of wages). The dataset used in this paper comes from the Spanish Labor Force Survey (EPA) conducted by the INE following EUROSTAT's guidelines. This survey offers labor market information for a representative sample of households and is commonly used for international comparisons. Our data corresponds to the second quarter of 2007,[8] which is the year with the lowest unemployment rate of the whole demographic period (from 1978-2009). Occupations are considered at a two-digit level of the CNO-1994 (*National Classification of Occupations*), and the list includes 66 occupations. The Spanish Structure Earnings Survey for 2002 has also been used to estimate the average wage of occupations since the aforementioned survey did not gather any information on wages. [9]

In a recent paper, Alonso-Villar and Del Río (2010b) considered three educational groups in the populations of native and immigrant workers: low-educated (those who have not finished secondary school); intermediate-educated (those who have completed secondary school); and high-educated (those who have a college degree).[10] They concluded that, by using the tools proposed by AV-DR, the occupational segregation of immigrants decreases with their educational level. That analysis has been reproduced here for the list of occupations for which

[7] The residential segregation of immigrants may also affect their job opportunities since the characteristics of neighborhoods affect the provision of basic goods, such as education, healthcare, and transportation (Card and Rothstein, 2007; Joassart-Marcelli, 2009).

[8] The survey includes 70,506 workers above 16 years old.

[9] We have eliminated 8 occupations from the study because the Structure Earnings Survey did not gather information about them. These occupations are management of companies without wage earners or with less than 10 employees, fishermen and skilled fish farm workers, and members of the armed forces. Thus, the study considers 58 out of 66 occupations.

[10] It also includes those who have obtained a degree in "Formación Profesional Superior" (vocational training, 2nd technical college).

the Spanish Earnings Survey provides information. The corresponding segregation curves for immigrants (denoted by I) and natives (denoted by N) are offered in Figure 2, and several of their local segregation measures are given at the top of Table 1 (Ψ_α, $\alpha = 0.1, 0.5, 1,$ and 2, D^g, and G^g).

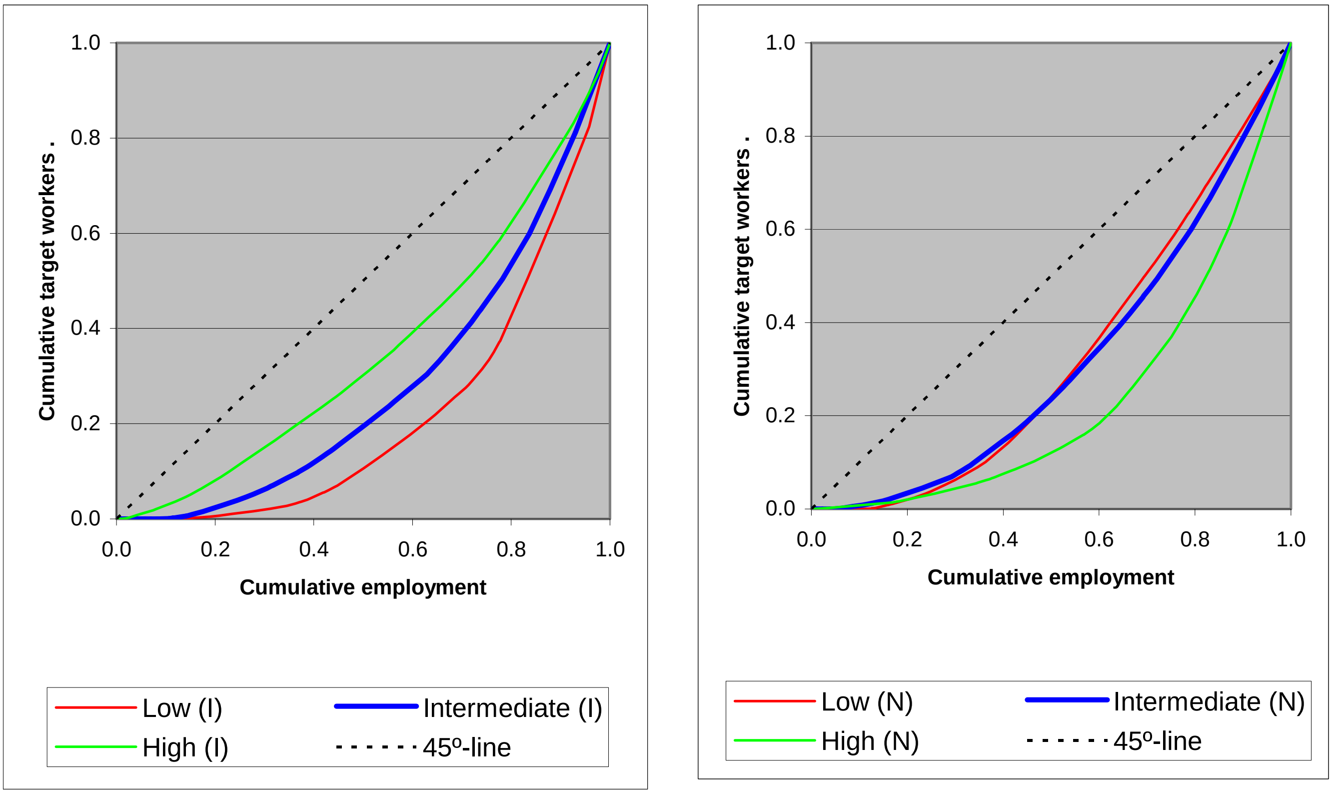

Figure 2. Segregation curves for immigrants and natives by educational level (58 occupations).

We see that the segregation curve for immigrants approaches the 45º-line when education augments, which implies a reduction in segregation. However, the effects of education are not the same for immigrants and natives since the segregation curve for low-educated natives is closer to the 45º-line than that of high-educated natives. The higher segregation of high-educated natives is perhaps a consequence of the nature of the occupations requiring that kind of skill, while the lower segregation of high-skilled immigrants is perhaps the result of their worst matching between qualification and job. In addition, there is a notorious resemblance between the segregation curve for low-educated immigrants across occupations and that of high-educated natives, as corroborated in Figure 3 (where the segregation curves for both groups without wages are shown).[11]

Without considering the important differences between the kinds of occupations in which each demographic group tends to work, one would conclude that high-educated natives and low-educated immigrants are similar in terms of segregation. However, when taking into account the status of occupations, the performances of both groups clearly depart, as shown in Figure 3 (see segregation curves with wages).

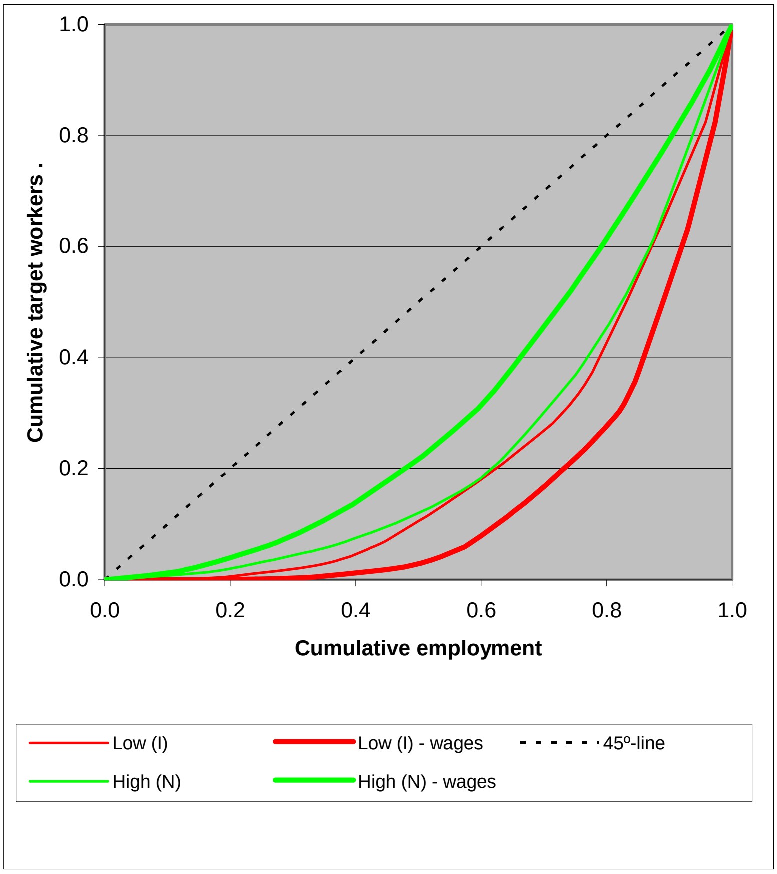

Figure 3. Segregation curves for low-educated immigrants and high-educated natives with and without status (58 occupations).

Therefore, the introduction of status into the analysis of segregation allows one to discriminate between distributions that are apparently similar. Moreover, the inclusion of status makes the relationship between segregation and education monotonic not only for

[11] For a study of over-education of immigrants in Spain, see Fernández and Ortega (2006).

immigrants (as already happened in the case without status) but also for natives (see Table 1, bottom rows).

In addition, we find that the segregation of high-educated immigrants barely changes when considering wages, which suggests that they work both in low-paid and high-paid jobs. However, the segregation of other immigrants increases notably. Regarding natives, we observe that the introduction of wages notably reduces the segregation of the high educated, while it increases the segregation of the rest, which is particularly manifest in the group of natives with a low education level.

LOCAL SEGREGATION without wages	$\Psi_{0.1}$	$\Psi_{0.5}$	Ψ_{1}	Ψ_{2}	D^g	G^g
Low-educated immigrants	1.57	0.68	0.56	0.59	0.43	0.56
Intermediate-educated immigrants	1.13	0.42	0.33	0.31	0.32	0.44
High-educated immigrants	0.21	0.15	0.14	0.15	0.21	0.29
Low-educated natives	1.01	0.36	0.24	0.18	0.27	0.34
Intermediate-educated natives	0.68	0.29	0.23	0.20	0.26	0.36
High-educated natives	0.58	0.50	0.46	0.50	0.42	0.53
LOCAL SEGREGATION with wages	$\Psi_{s,0.1}$	$\Psi_{s,0.5}$	$\Psi_{s,1}$	$\Psi_{s,2}$	D_s^g	G_s^g
Low-educated immigrants	2.64	1.08	0.89	1.13	0.53	0.69
Intermediate-educated immigrants	2.00	0.75	0.61	0.68	0.44	0.59
High-educated immigrants	0.21	0.15	0.15	0.17	0.21	0.29
Low-educated natives	1.91	0.68	0.48	0.40	0.41	0.50
Intermediate-educated natives	1.16	0.44	0.33	0.30	0.31	0.43
High-educated natives	0.29	0.25	0.23	0.21	0.29	0.37

Table 1. Local segregation indexes with and without wages (58 occupations).

4. Conclusions

Segregation analyses have mainly focused on measuring the disparities among the occupational distributions of the demographic groups into which total population is partitioned (overall segregation). However, one might be interested not only in this matter but also in exploring the segregation of a target group (local segregation). In this context, the introduction of occupational status into the analysis becomes especially relevant, since the tendency of some demographic groups to concentrate in low pay/status jobs has an important impact on their well-being levels. The present paper has tackled this topic in a multigroup context by proposing an axiomatic framework through which to study the segregation of any population subgroup when taking into account the status of occupations (cardinally measured). This allows one to determine differences among demographic groups in terms of not only employment shares in each occupation but also status. In doing so, this paper has generalized the local segregation curves and indexes proposed by Alonso-Villar and Del Río (2010a).

Finally, the usefulness of these measures has been illustrated in our study of occupational segregation in Spain, where these tools were used to analyze disparities in the distributive patterns of immigrant and native workers depending on their educational levels. This analysis has shown that the performance of low-educated immigrants in the Spanish labor market clearly departs from that of high-educated natives, even though the occupational segregation levels of both groups are similar according to indexes that do not take into consideration salary disparities among occupations. The extent of the differences between both groups has been quantified using the tools proposed in this paper.

Appendix

PROOF OF PROPOSITION 1

First Implication

Assume that Φ_s satisfies properties 1-4 and consider distributions $\left(c^g;t;\frac{w}{\overline{w}}\right)$, $\left(c^g{}';t';\frac{w}{\overline{w}'}\right)\in D$. In what follows, we first transform vector $\left(c^g;t;\frac{w}{\overline{w}}\right)$ into a hypothetical "income" distribution whose Lorenz curve is equal to the segregation curve corresponding to $\left(c^g;t;\frac{w}{\overline{w}}\right)$, which allows us to use some well-known results from the literature on income distribution. Next, by following steps analogous to those followed by Foster (1985) in a context of income distribution, we multiply distributions $\left(c^g;t;\frac{w}{\overline{w}}\right)$ and $\left(c^g{}';t';\frac{w}{\overline{w}'}\right)$ by positive scalars in such a way that their corresponding "income" distributions share the same dimension and mean, while keeping segregation unaltered.

It is easy to verify that the local segregation curve corresponding to $\left(c^g;t;\frac{w}{\overline{w}}\right)$ is equal to the Lorenz curve corresponding to fictitious income distribution $\left(\underbrace{\frac{c_1^g}{t_1\frac{w_1}{\overline{w}}},\ldots,\frac{c_1^g}{t_1\frac{w_1}{\overline{w}}}}_{t_1\frac{w_1}{\overline{w}}},\ldots,\underbrace{\frac{c_J^g}{t_J\frac{w_J}{\overline{w}}},\ldots,\frac{c_J^g}{t_J\frac{w_J}{\overline{w}}}}_{t_J\frac{w_J}{\overline{w}}}\right)$. The same relationship can be established between $\left(Tc^g{}';Tt';\frac{w}{\overline{w}'}\right)$ and $y\equiv\left(\underbrace{\frac{Tc_1^g{}'}{Tt_1{}'\frac{w_1}{\overline{w}'}},\ldots,\frac{Tc_1^g{}'}{Tt_1{}'\frac{w_1}{\overline{w}'}}}_{Tt_1{}'\frac{w_1}{\overline{w}'}},\ldots,\underbrace{\frac{Tc_J^g{}'}{Tt_J{}'\frac{w_1}{\overline{w}'}},\ldots,\frac{Tc_J^g{}'}{Tt_J{}'\frac{w_1}{\overline{w}'}}}_{Tt_J{}'\frac{w_J}{\overline{w}'}}\right)$, and between

$$\left(T'\frac{\frac{C^{g}{}'}{T'}}{\frac{C^{g}}{T}} c^{g}; T't; \frac{w}{\overline{w}} \right) \quad \text{and} \quad z \equiv \left(\underbrace{T\frac{C^{g}{}'}{C^{g}}\frac{c_1^{g}}{T't_1\frac{w_1}{\overline{w}}}, \ldots, T\frac{C^{g}{}'}{C^{g}}\frac{c_1^{g}}{T't_1\frac{w_1}{\overline{w}}}}_{T't_1\frac{w_1}{\overline{w}}}, \ldots, \underbrace{T\frac{C^{g}{}'}{C^{g}}\frac{c_J^{g}}{T't_J\frac{w_J}{\overline{w}}}, \ldots, T\frac{C^{g}{}'}{C^{g}}\frac{c_J^{g}}{T't_J\frac{w_J}{\overline{w}}}}_{T't_J\frac{w_J}{\overline{w}}} \right).$$

Note that y and z have the same number of "individuals" (TT') and "income" mean ($\frac{C^{g}{}'}{T'}$).

Without loss of generality in what follows, we assume that $\frac{C^{g}}{T} > \frac{C^{g}{}'}{T'}$.

By using Lemma 2 proposed in Foster (1985), the Lorenz curves of the "income" distributions corresponding to $\left(c^{g}; t; \frac{w}{\overline{w}}\right)$ and $\left(T'\frac{\frac{C^{g}{}'}{T'}}{\frac{C^{g}}{T}} c^{g}; T't; \frac{w}{\overline{w}} \right)$ coincide, since the latter is a (T' times) replication of the former multiplied by a positive scalar ($\frac{C^{g}{}'}{C^{g}}\frac{T}{T'}$). The same applies to distributions $\left(c^{g}{}'; t'; \frac{w}{\overline{w}'}\right)$ and $\left(Tc^{g}{}'; Tt'; \frac{w}{\overline{w}'}\right)$. Consequently, the local segregation curves of $\left(c^{g}; t; \frac{w}{\overline{w}}\right)$ and $\left(T'\frac{\frac{C^{g}{}'}{T'}}{\frac{C^{g}}{T}} c^{g}; T't; \frac{w}{\overline{w}} \right)$ coincide, and also the ones corresponding to $\left(c^{g}{}'; t'; \frac{w}{\overline{w}'}\right)$ and $\left(Tc^{g}{}'; Tt'; \frac{w}{\overline{w}'}\right)$ do.

Assuming that the local segregation curve of $\left(c^{g}; t; \frac{w}{\overline{w}}\right)$ dominates that of $\left(c^{g}{}'; t'; \frac{w}{\overline{w}'}\right)$ (i.e., the local segregation curve of the former is at no point below that of the latter), two cases can be distinguished:

a) The local segregation curve of $\left(c^g;t;\frac{w}{\overline{w}}\right)$ coincides with that of $\left(c^g{}';t';\frac{w}{\overline{w}'}\right)$. Consequently, the local segregation curve of $\left(T'\frac{\frac{C^g{}'}{T'}}{\frac{C^g}{T}}c^g;T't;\frac{w}{\overline{w}}\right)$ coincides with that of $\left(Tc^g{}';Tt';\frac{w}{\overline{w}'}\right)$. By using Lemma 1 proposed in Foster (1985), it follows that the ordered distribution (from low to high values) corresponding to y, labeled $\hat{y}$, majorizes that of z, labeled $\hat{z}$, and vice versa.[12] In other words, distributions $\hat{y}$ and $\hat{z}$ are identical, which implies that $\Phi_s(z;e;s)=\Phi_s(y;e';s')$, where $e\equiv\left(\underbrace{\frac{\overline{w}}{w_1},...,\frac{\overline{w}}{w_1}}_{Tt_1\frac{w_1}{\overline{w}}},...,\underbrace{\frac{\overline{w}}{w_J},...,\frac{\overline{w}}{w_J}}_{Tt_J\frac{w_J}{\overline{w}}}\right)$ and $s\equiv\left(\underbrace{\frac{w_1}{\overline{w}},...,\frac{w_1}{\overline{w}}}_{Tt_1\frac{w_1}{\overline{w}}},...,\underbrace{\frac{w_J}{\overline{w}},...,\frac{w_J}{\overline{w}}}_{Tt_J\frac{w_J}{\overline{w}}}\right)$. Note that, on one hand, Φ_s satisfies the properties of symmetry, insensitivity to proportional subdivisions, and scale invariance, which implies that $\Phi_s(y;e';s')=\Phi_s\left(Tc^g{}';Tt';\frac{w}{\overline{w}'}\right)$ and $\Phi_s(z;e;s)=\Phi_s\left(T'\frac{\frac{C^g{}'}{T'}}{\frac{C^g}{T}}c^g;T't;\frac{w}{\overline{w}}\right)$. On the other hand, by using the scale invariance property, $\Phi_s\left(Tc^g{}';Tt';\frac{w}{\overline{w}'}\right)=\Phi_s\left(c^g{}';t';\frac{w}{\overline{w}'}\right)$ and $\Phi_s\left(T'\frac{\frac{C^g{}'}{T'}}{\frac{C^g}{T}}c^g;T't;\frac{w}{\overline{w}}\right)=\Phi_s\left(c^g;t;\frac{w}{\overline{w}}\right)$ (since $\frac{C^g}{T}>\frac{C^g{}'}{T'}$). Consequently, $\Phi_s\left(c^g;t;\frac{w}{\overline{w}}\right)=\Phi_s\left(c^g{}';t';\frac{w}{\overline{w}'}\right)$.

12 Given two income distributions with the same dimension and ranked in ascending order, one is said to majorize the other if and only if both distributions have the same total income, and the cumulative income level of the former, up to next to last individual, is lower than that of the latter.

b) The local segregation curve of $\left(c^g;t;\frac{w}{\bar{w}}\right)$ is at no point below that of $\left(c^g{}';t';\frac{w}{\bar{w}'}\right)$ and at some above. By following analogous steps to those in case a), it follows that the local segregation curve of distribution $\left(T'\frac{\frac{C^g{}'}{T'}}{\frac{C^g}{T}}c^g;T't;\frac{w}{\bar{w}}\right)$ also dominates that of $\left(Tc^g{}';Tt';\frac{w}{\bar{w}'}\right)$, which implies, by Lemma 3 in Foster (1985), that $\hat{y}$ is obtained from $\hat{z}$ by a finite sequence of regressive transfers. Therefore, since Φ_s satisfies the property of symmetry and that of movement between locations, $\Phi_s\left(y;e';s'\right)>\Phi_s\left(z;e;s\right)$. In addition, the properties of insensitivity to proportional subdivisions of locations and scale invariance mean that $\Phi_s\left(y;e';s'\right)=\Phi_s\left(Tc^g{}';Tt';\frac{w}{\bar{w}'}\right)=\Phi_s\left(c^g{}';t';\frac{w}{\bar{w}'}\right)$ and $\Phi_s\left(z;e;s\right)=\Phi_s\left(T'\frac{\frac{C^g{}'}{T'}}{\frac{C^g}{T}}c^g;T't;\frac{w}{\bar{w}}\right)=\Phi_s\left(c^g;t;\frac{w}{\bar{w}}\right)$. Therefore, $\Phi_s\left(c^g{}';t';\frac{w}{\bar{w}'}\right)>\Phi_s\left(c^g;t;\frac{w}{\bar{w}}\right)$.

Second Implication

Assume now that Φ_s is consistent with the local segregation criterion. As mentioned above, the local segregation curve corresponding to distribution $\left(c^g;t;\frac{w}{\bar{w}}\right)$ coincides with the Lorenz curve of the corresponding hypothetical income distribution $\left(\underbrace{\frac{c_1^g}{t_1\frac{w_1}{\bar{w}}},\ldots,\frac{c_1^g}{t_1\frac{w_1}{\bar{w}}}}_{t_1\frac{w_1}{\bar{w}}},\ldots,\underbrace{\frac{c_J^g}{t_J\frac{w_J}{\bar{w}}},\ldots,\frac{c_J^g}{t_J\frac{w_J}{\bar{w}}}}_{t_J\frac{w_J}{\bar{w}}}\right)$. Therefore, when comparing two occupational distributions, there is consistency between the conclusions reached by using the local segregation curves and those attained with the Lorenz curves of the fictitious income distributions. In what follows, we show that index Φ_s satisfies the four basic properties.

a) Φ_s satisfies scale invariance, since the Lorenz curve of the hypothetical income distribution $\left(\underbrace{\frac{\alpha c_1^g}{\beta t_1 \frac{w_1}{\overline{w}}}, \ldots, \frac{\alpha c_1^g}{\beta t_1 \frac{w_1}{\overline{w}}}}_{\beta t_1 \frac{w_1}{\overline{w}}}, \ldots, \underbrace{\frac{\alpha c_J^g}{\beta t_J \frac{w_J}{\overline{w}}}, \ldots, \frac{\alpha c_J^g}{\beta t_J \frac{w_J}{\overline{w}}}}_{\beta t_J \frac{w_J}{\overline{w}}} \right)$ coincides with that of

$$\left(\underbrace{\frac{c_1^g}{t_1 \frac{w_1}{\overline{w}}}, \ldots, \frac{c_1^g}{t_1 \frac{w_1}{\overline{w}}}}_{t_1 \frac{w_1}{\overline{w}}}, \ldots, \underbrace{\frac{c_J^g}{t_J \frac{w_J}{\overline{w}}}, \ldots, \frac{c_J^g}{t_J \frac{w_J}{\overline{w}}}}_{t_J \frac{w_J}{\overline{w}}} \right).$$

b) Φ_s satisfies symmetry, since "individuals" of the fictitious income distribution play symmetric roles in the Lorenz curves.

c) Φ_s satisfies insensitivity to proportional subdivisions because when an occupation j is subdivided into two occupations (j' and j'') such that $c_{j'}^g = c_{j''}^g = \frac{c_j^g}{2}$ and $t_{j'} = t_{j''} = \frac{t_j}{2}$, the Lorenz curve of the fictitious income distribution does not change.

d) Φ_s satisfies the property of sensitivity to disequalizing movements between organizational units, since any movement from occupation i to h of the types mentioned in property 4 leads to a sequence of regressive transfers in the fictitious income distribution, which results in an increase in inequality according to the Lorenz criterion. As a consequence, the local segregation index Φ_s also increases.[13]

□

[13] Note that Φ_s also satisfies the property of sensitivity to disequalizing movements between organizational units with different status since a movement of target individuals from occupation *i* to *k* involves a sequence of transfers in the fictitious income distribution that are more regressive than those corresponding to the movement between occupations *i* and *h* (observe that $\frac{c_i^g / C^g}{t_i \frac{w_i}{\overline{w}}} < \frac{c_h^g / C^g}{t_h \frac{w_h}{\overline{w}}} < \frac{c_k^g / C^g}{t_k \frac{w_k}{\overline{w}}}$).

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