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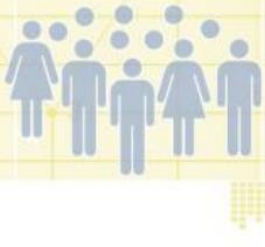

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Segregation and Social Welfare

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Segregation and Social Welfare*

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Abstract

The aim of this paper is twofold: a) to define a new concept, the welfare loss that a society experiences due to the segregation of the demographic groups that comprise it and b) to propose measures that quantify this phenomenon satisfying a set of desirable normative properties. For that purpose, it offers a framework that involves, firstly, to deal with the well-being losses (gains) that the groups have due to their sorting across organizational units and, secondly, to aggregate those losses (gains) in a proper manner. To tackle the aggregation issue, this paper embraces the distributive approach adopted in the literature on economic deprivation and poverty. The advantages of these measures are shown by exploring the welfare losses that the United States has experienced from 1980 to 2012 due to occupational segregation by both gender and race/ethnicity.

JEL Classification: D63; J15; J71

Keywords: Segregation measures; social welfare; occupations; wages; gender/race

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1. Introduction

The analysis of segregation has played an important role in studies conducted over decades by sociologists and economists concerned about the consequences of a low level of integration in society for the demographic groups that suffer it. Most segregation studies quantify the unevenness of the distribution of a demographic group across organizational units (occupations, schools, neighborhoods, etc.) with respect to those of other groups. The literature offers a number of measures that allow quantifying overall segregation either in an economy with only two demographic groups or in a multigroup context (Duncan and Duncan, 1955; Silber, 1992; Frankel and Volij, 2011; see Silber, 2012, for a recent survey). But if one is interested in exploring the effects of segregation, one should move beyond the measurement of unevenness to approach a different concept, that of well-being. For example, in the context of occupational segregation, the concentration of a group in a few occupations may bring it advantages or disadvantages depending on whether those occupations are highly or low paid. Therefore, a question of interest is: what are the consequences of segregation in terms of welfare? This was precisely the question raised by François Bourguignon in a plenary session of the fourth meeting of the Society for the Study of Economic Inequality (ECINEQ) that took place in Catania, Italy, in 2011.

The literature on segregation, however, has barely paid attention to the link between segregation and well-being (Philipson, 1993; Alonso-Villar and Del Río, 2016a). There are a few proposals that measure unevenness while accounting for the status or "quality" of organizational units, but they measure segregation, not the social welfare associated with that situation.[1] The goal of this paper is precisely to fill this gap by defining a new concept, the welfare loss that the whole society derives from the segregation of the demographic groups that comprise it. It offers a setup within which this phenomenon can be quantified and develops measures that satisfy a set of desirable normative properties.[2]

[1] Hutchens (2009) and Del Río and Alonso-Villar (2012) include the status of occupations cardinally to quantify, respectively, overall segregation in a two-group context and the segregation of a group in a multigroup context. Reardon (2009) offers ordinal overall measures in a multigroup context.

[2] Philipson (1993) also explores the link between segregation and social welfare but he follows a different approach. He studies how individuals' preferences should be for segregation measures being consistent with a social welfare criterion such as Pareto optimality. In his analysis, individuals' preferences are assumed to depend on the demographic composition of organizational units. Our approach is different. We think of the welfare of a society associated with the segregation of its members in a way similar to

To address this issue, this paper builds on some recent proposals that have been made to measure either the well-being or monetary losses (gains) of a group associated with its occupational sorting (Del Río and Alonso-Villar, 2015; Alonso-Villar and Del Río, 2016a). These measures allow focusing the lens on the consequences of segregation for any demographic group in which one is interested. But, the question that remains unanswered is how to determine the welfare loss that the whole society experiences due to segregation. Note that this is not obvious, since some groups may have advantages derived from their uneven distribution across organizational units whereas other groups may face disadvantages. Thus, for example, in the first decade of the 21st century, white and Asian men in the United States had gains associated with their occupational sorting while white women and all minority women, except Asians, had losses (Del Río and Alonso-Villar, 2015).

To determine the welfare loss that a society derives from the segregation of the mutually exclusive groups into which that society has been partitioned, we propose to sum up the well-being losses of the groups in a way that is consistent with the value judgements conducted in the literature on economic deprivation (Shorrocks, 1998). In other words, the way we aggregate these losses goes beyond the simple average value by proposing measures that satisfy good normative properties. Our approach has sense because the well-being losses that groups have associated with their segregation can be considered as deprivation gaps, a perspective in line, *inter alia*, with the income gaps considered in the field of poverty (Sen, 1976; Atkinson, 1987; Foster and Shorrocks, 1988; Spencer and Fisher, 1992; Jenkins and Lambert, 1993), the employment gaps contemplated in the study of unemployment (Paul, 1992; Sengupta, 2009; Shorrocks, 2009), and the wage gaps dealt with in the field of wage discrimination (Jenkins, 1994; Del Río et al., 2011).

Apart from developing several measures, this paper applies these measures to explore the welfare loss that the U.S. has derived over the last decades due to overall occupational segregation by both gender and race/ethnicity. The U.S. is a racially/ethnically diverse country, which makes it an especially interesting case of study, since gender and race/ethnicity are two important traits that affect the integration

how social welfare is accounted for when assessing income distributions. In our case, the utility function of each individual only depends on its own situation, i.e., on the "quality" of the organizational unit (occupation, school, neighborhood, etc.) in which she/he is (for example, whether she/he works in a highly or low-paid occupation). Thus, changes in segregation can be assessed in terms of social welfare in a similar way to changes in income inequality.

of workers in the labor market (Reskin and Bielby, 2005; Kurtulus 2012; Del Río and Alonso-Villar, 2015; Gradín et al., 2015; Alonso-Villar and Del Río, 2016b). Segregation in this multigroup context implies accounting not only for disparities between women and men of the same race/ethnicity but also for differences between women of a given race/ethnicity and men of a different race/ethnicity and for differences within the same gender group across races/ethnicities. By quantifying the losses that this society derives from the occupational sorting of its gender-race/ethnicity groups, this paper moves beyond the mere measurement of unevenness to focus attention on the economic consequences of that unevenness, which is where the main problem lies.

This paper is structured as follows. Section 2 develops the framework to measure the social welfare loss that a society has associated with its segregation. After offering a brief empirical background on occupational segregation in the U.S., Section 3 presents the dataset used and offers the evolution of the welfare losses of this country due to occupational segregation by both gender and race/ethnicity from 1980 to 2012. Finally, Section 4 shows the main conclusions.

2. Aggregating the Well-Being Losses of Groups

As mentioned above, the literature on segregation has barely tackled the assessment of segregation in terms of well-being. As far as we know, Alonso-Villar and Del Río (2016a) present the only proposal in this respect, although their paper focuses on the well-being of a group associated with its segregation rather than the welfare of the whole society.[3] The question this paper poses is how to aggregate the well-being losses (gains) of the mutually exclusive groups into which a society can be partitioned.

The first indicator one may think of is the average well-being of the groups involved. Despite its simplicity, however, this indicator does not seem a sensible way of aggregating the well-being losses (gains) of the groups. In particular, it would imply to assume that the gains of advantaged groups necessarily offset losses of the same magnitude suffered by disadvantaged groups, which might be judged as an inadequate property by those who exhibit inequality aversion. For this reason, the question we raise

[3] Del Río and Alonso-Villar (2015) also deal with the consequences of the segregation of a group but assuming inequality neutrality rather than inequality aversion, the latter being the standard assumption when one aims at approaching well-being.

here is how to construct a measure that satisfies good normative properties. In doing so, we adopt an approach that started in the 1990s when trying to evaluate distributions of variables that embodies "bads" (deprivation, poverty, unemployment, discrimination, etc.) rather than "goods," see Shorrocks (1998, 2009), Spencer and Fisher (1992), Jenkins and Lambert (1993), and Jenkins (1994), *inter alia*. This literature offers not only indices with which to quantify each of these particular phenomena but also curves that, apart from having the advantage of being easy to interpret, have associated a dominance criterion. We consider that the same line of reasoning can also be applied in our context.

To measure the consequences of overall segregation in terms of social welfare, first, we present the approach developed by Alonso-Villar and Del Río (2016a) to measure the well-being loss (gain) of a group associated with its segregation. Second, we build a curve that accumulates the well-being losses of the groups, and we develop a dominance criterion that allows ranking of different scenarios. In doing so, we make use of the literature on deprivation (Shorrocks, 1998) and poverty (Jenkins and Lambert, 1993, 1998) and adapt them to our context. Then, we discuss the properties that underlie our dominance criterion, which are the minimal set of value judgements necessary to establish it. Finally, based on the well-known FGT poverty indices (Foster et al., 1984), we propose a family of social welfare loss indices that are consistent with our dominance criterion.

Although for the sake of simplicity, this paper will focus on occupational segregation, this theoretical framework can also be used to assess the social welfare loss due to other kinds of segregation (e.g., school and residential segregation) by using indicators of the status of the organizational units under consideration.

2.1 Defining the Well-Being Loss (Gain) of a Group

Let us denote by n the number of mutually exclusive groups into which the economy has been partitioned. Vector $t \equiv (t_1, t_2, ..., t_J)$ represents the distribution of total employment across J occupations, and $g^i \equiv (g_1^i, g_2^i, ..., g_J^i)$ is the distribution of group i ($i = 1, ..., n$) across these occupations. Vector $w \equiv (w_1, ..., w_J)$ denotes the occupational

wage distribution. $G^i = \sum_{j=1}^{J} g_j^i$ is the total number of workers of group *i* and $T = \sum_{j=1}^{J} t_j$ is the total number of workers in the economy ($\sum_{i=1}^{n} g_j^i = t_j \ \forall j$).

Following Alonso-Villar and Del Río (2016a), the well-being loss (gain) of group *i* associated with its occupational segregation can be defined as the gap that exists between the well-being of the group associated with state $(g^i;t;w)$ and the well-being it would have in case of no segregation (i.e., if $g_j^i = \frac{G^i}{T} t_j \ \forall j$ or, equivalently, if the state were $(\frac{G^i}{T}t;t;w)$). This idea, which is analogous to that of normative inequality measures, is also behind recent indices of the United Nations Development Program (Foster et al., 2005; Seth, 2009). Note, however, that in our case the egalitarian situation is that in which the proportion of jobs in each occupation filled by group *i* is equal to the share of the group in the economy (i.e., $\frac{g_j^i}{t_j} = \frac{G^i}{T}$). Not all occupations have the same size and, therefore, if group *i* represents, for example, 10% of total workers in the economy, the egalitarian distribution will be that in which the group accounts for 10% of each occupation's employment. Therefore, the (per capita) well-being loss (gain) of group *i* associated with its occupational segregation, denoted by $\Psi(g^i;t;w)$, takes this general form:

$$\Psi(g^i;t;w) = \frac{1}{G^i}[SWF(g^i;t;w) - SWF(\frac{G^i}{T}t;t;w)\ ],$$

where SWF(.) denotes the social welfare function. The social welfare associated with state $(g^i;t;w)$ is defined as the social welfare corresponding to an artificial distribution consisting of G^i 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 $\overline{w} = \sum_j \frac{t_j}{T} w_j$.[4] Assuming some properties on SWF(.), Alonso-Villar and Del Río (2016a)

[4] If occupations' wages, w_j, are measured by their average wages, $\overline{w}$ will be equal to the average wage of the economy.

propose the following family of indices to quantify the well-being loss (gain) of group *i* associated with its occupational sorting:

$$\Psi_{\varepsilon}(g^i;t;w)=\begin{cases}\sum_j\left(\frac{g^i_j}{G^i}-\frac{t_j}{T}\right)\frac{\left(\frac{w_j}{\overline{w}}\right)^{1-\varepsilon}-1}{1-\varepsilon} & \varepsilon\neq 1\\ \sum_j\left(\frac{g^i_j}{G^i}-\frac{t_j}{T}\right)\ln\frac{w_j}{\overline{w}} & \varepsilon=1\end{cases} \quad (1)$$

The properties these authors assume on the SWF are standard: this function is individualistic, strictly increasing, symmetric, and additive. The first property means that the SWF depends on individuals' utilities and on nothing else. Individuals' preferences are also assumed to be individualistic and, therefore, the utility level of each individual only depends on her/his own income. Strictly increasing monotonicity entails that the social welfare increases when, *ceteris paribus*, any individual's income rises. Symmetry means individuals play identical roles. Additivity implies that the SWF can be expressed as the summation of individuals' utilities which, as mentioned above, only depends on her/his income.

These properties imply that the individuals' utility function is shared by all of them. This utility function, *U*(.), is also assumed to be strictly concave—which is also a standard condition—so that an increase in an individual's income,[5] all else equal, entails a larger change in *U* (and, therefore, in SWF) the lower the initial income of that individual is. In addition, *U'* is assumed to have constant elasticity, given by the parameter ε, so that if an individual's income increases by 1%, then *U'* drops by ε% no matter her/his initial income level. This parameter reflects how sharply curved function *U* is and, therefore, it can be interpreted as a (relative) inequality aversion parameter. The assumption of constant (relative) inequality aversion is also often used in the literature on income inequality.

Note that Ψ_{ε} is a family parameterized by this inequality aversion parameter, where $\varepsilon>0$ (the higher the value of this parameter, the sharper the utility function behind the

[5] Remember that, in our case, this means an increase in the relative wage of the occupation in which this individual works.

social welfare function and, therefore, the more attention the index pays to differences among individuals of the group).[6] If we instead assumed inequality neutrality, i.e., if $\varepsilon = 0$, the above expression would become $\Psi_0(g^i;t;w) = \sum_j \left(\frac{g^i_j}{G^i} - \frac{t_j}{T} \right) \frac{w_j}{\overline{w}}$, which is the Γ index proposed by Del Río and Alonso-Villar (2015) to measure the monetary, rather than the well-being, loss (gain) of the group.

Note that $\sum_j \left(\frac{g^i_j}{G^i} - \frac{t_j}{T} \right) \frac{w_j}{\overline{w}} = \frac{\sum_j \frac{g^i_j w_j}{G^i} - \overline{w}}{\overline{w}}$. Therefore, Ψ_0 (i.e., Γ) quantifies the difference between the average wage that group i would obtain due to its occupational sorting (disregarding wage differences within occupations) and the average wage of the economy (i.e., the average wage that the group would have if it did not suffer occupational segregation) divided by the latter. Consequently, $\Psi_0(g^i;t;w)$ is a "relative" measure of deprivation, deprivation that arises from the wage gap of the group due to its occupational segregation.

Therefore, using either $\Psi_\varepsilon(g^i;t;w)$ with $\varepsilon > 0$ or $\Psi_0(g^i;t;w)$ (i.e., Γ), we can calculate the losses (gains) that group i ($i = 1,...,n$) derives from its occupational sorting. From now on, we will broadly refer to these losses (gains) as the well-being losses (gains) that a group derives from its occupational segregation, although for $\varepsilon = 0$, the index involves inequality neutrality rather than inequality aversion.

2.2 Building the Social Welfare Loss Curve Associated with Segregation

For simplicity, let us denote by $x \equiv \left(\Psi_\varepsilon(g^1;t;w),...,\Psi_\varepsilon(g^n;t;w) \right)$ the n-dimensional vector displaying the well-being losses (if the values are negative) or gains (if the values are positive) of the n groups into which society is being partitioned (i.e., our vector x is the result of applying index $\Psi_\varepsilon(g^i;t;w)$ to each of the n mutually exclusive demographic groups i into which the whole society is being partitioned).

[6] Loosely speaking, when assuming inequality aversion, we are assuming that the improvement of an individual who is in a better economic position than another does not increase the well-being index as much as it would do an improvement of the same magnitude experienced by the individual who is in a worse position.

The question we pose now is how to aggregate the welfare losses of these groups to calculate the loss of the whole society. Our problem is similar to that dealt with when aggregating individuals' deprivation because disadvantaged groups are deprived of achieving the well-being level that an egalitarian distribution of the group across occupations would imply (as explained in Section 2.1). For this reason, to build our *social welfare loss curve associated with segregation,* we follow the approach developed by Shorrocks (1998), who proposed a general framework in which to construct deprivation profiles and deprivation indices that are consistent with the ranking given by these profiles. In addition, these *social welfare loss curves* will allow offering a simple representation of the consequences that occupational segregation generates in society in terms of social welfare.

Let us now define $d \equiv (d_1,...,d_i,...,d_n)$ as the vector resulting from giving each group the (absolute value of the) minimum between the well-being losses (gains) of the group and zero. In other words, the *i* component of vector d , denoted by d_i, is equal to zero if group *i* is a privileged one and is equal to the absolute value of its losses if it is a disadvantaged one. Namely,

$$d_i = \left| \min\left\{\Psi_\varepsilon(g^i;t;w),0\right\} \right| . \qquad (2)$$

We assume that this vector is ordered so that the groups are ranked from high to low losses (i.e., $d_1 \geq d_2 \geq \ldots \geq d_n$) .[7] Let us denote by $G \equiv (G^1,...,G^n)$ the vector representing the demographic size of the groups ($T = \sum_{i=1}^{n} G^i$) and by $p^k = \frac{G^1 + ... + G^k}{T}$ $(0 \leq p^k \leq 1)$ the demographic share of the first *k* groups, where $k = 1,...,n$.

Definition. We define the *social welfare loss curve associated with segregation* (labeled for simplicity the WLAS curve and denoted by W^{ε}_{dG}) at point p^k as the sum

[7] Expression (2) can be generalized by defining a threshold $z \geq 0$ which determines the level of losses that can be considered high enough so as to take them into account. Thus, we could define d_i as follows:

$$d_i = \begin{cases} 0 & \text{if } \left|\min\left\{\Psi_\varepsilon(g^i;t;w),0\right\}\right| \leq z \\ \left|\Psi_\varepsilon(g^i;t;w)\right| & \text{if } \left|\min\left\{\Psi_\varepsilon(g^i;t;w),0\right\}\right| > z \end{cases}$$

The role played by *z* would be similar to that of the poverty line in poverty analyses: If $z = 0$, all groups with losses, even if they were really small, would have a positive value of d_i ; if $z > 0$ only the groups whose losses were above that threshold would be considered in the analysis.

of the welfare losses of the first *k* groups, each group, *i*, weighted by its population share ($\frac{G^i}{T}$). Namely:

$$W_{dG}^{\varepsilon}(p^k) = \sum_{i=1}^{k} \frac{G^i}{T} d_i \,, \tag{3}$$

where ε is the inequality aversion parameter used above to define the well-being losses of groups (see expression (1)). At intermediate points ($p \in (0,1)$ with $p \neq p^k$) $W_{dG}^{\varepsilon}(p)$ is determined by linear interpolation. Therefore, the WLAS curve accumulates the well-being losses of the groups, weighted by their demographic sizes, from higher to lower losses. Consequently, this curve is positive, increasing, and concave (see Figure 1).

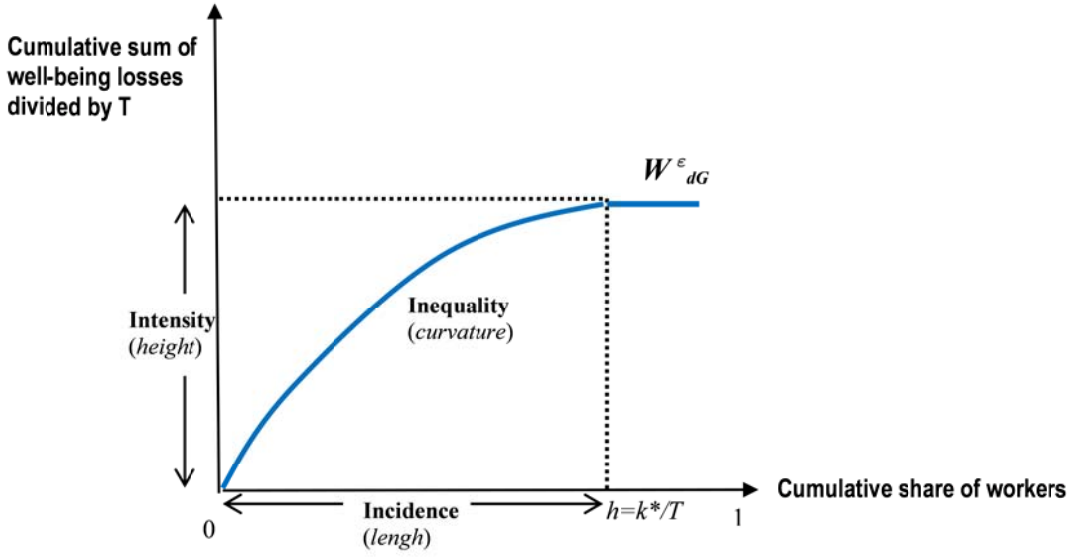

Figure 1. The WLAS curve, W_{dG}^{ε}

Note that the WLAS curve is analogous to the deprivation profile defined by Shorrocks (1998) but considering that all individuals belonging to a group share the same deprivation, i.e., that of the group. In fact, if we define the T-dimension vector $\tilde{d} \equiv \left(\underbrace{d_1,...,d_1}_{G^1},...,\underbrace{d_n,...,d_n}_{G^n} \right) = \left(\tilde{d}_1,...,\tilde{d}_s,...,\tilde{d}_T \right)$ resulting from giving each worker, *s*, a well-being loss equal to the well-being loss of the group to which she/he belongs, it is easy to see that:

$$W_{dG}^{\varepsilon}(p) = W_{\tilde{d}}^{\varepsilon}(p) \quad \text{for all} \quad p \in [0,1],$$

where $W^{\varepsilon}_{\tilde{d}}(p) = \frac{1}{T}\sum_{s=1}^{S} \tilde{d}_s$ for $p = \frac{S}{T}$ and $1 \le S \le T$.

The idea of the deprivation profile is also used in the field of poverty, giving rise to the TIP curves (Jenkins and Lambert, 1993, 1997, and 1998), where TIP stands for the three I's of poverty: Incidence, Intensity, and Inequality.[8] We keep this terminology in our case (see Figure 1).

To see the incidence of the problem, we have to look at the abscissa value, denoted by $h = k^*/T$, at which the curve becomes horizontal. This point stands for the population share that belongs to disadvantaged groups (i.e., those having well-being losses). The intensity of the problem is encapsulated by the maximum height of the curve, which indicates the per capita cumulative well-being losses of the groups. Finally, the curvature of the WLAS curve before point *h* embodies the inequality in well-being losses that exists among the groups who experience those losses.

2.3 Social Welfare Losses Associated with Segregation: A Dominance Criterion

Definition. We say that vector $(d;G)$ *dominates in social welfare loss associated with segregation* vector $(d';G')$ if the WLAS curve of the former lies at no point above the latter and at some point below. Namely, $(d;G)$ *dominates in social welfare losses* $(d';G')$ if $\tilde{d} \neq \tilde{d}'$ and $W^{\varepsilon}_{dG}(p) \le W^{\varepsilon}_{d'G'}(p)$ for all $p \in [0,1]$.

Let us denote by $D \subset R^m$ (m ≥ 2) the set of vectors $\tilde{d}$ and by $\Phi^* : D \to R$ the class of functions that are *symmetric, replication-invariant, strictly monotonic, and equally preferring*. We now discuss the properties that we are imposing on any function $\Phi \in \Phi^*$. *Symmetry* means that Φ does not favor any individual and, therefore, any demographic group. The requirement that Φ satisfies *replication invariance* implies that if we replicate the economy *r* times, the value of Φ does not change, which allows comparisons of economies that have different numbers of workers—using replications, we can convert two economies with different population' sizes into two economies of

[8] Similar curves have been proposed in the field of wage discrimination, where they are labeled as *inverse generalized Lorenz curves for distribution of wage gaps* (Jenkins, 1994) and *discrimination curves* (Del Río et al., 2011), and also in the field of unemployment, where they are labeled *duration profiles* (Shorrocks, 2009).

the same size. If Φ is *strictly monotonic*, the higher the magnitude of the well-being losses of a group, the higher the social welfare losses. In addition, if Φ is *equally preferring* and a disadvantaged group increases its well-being losses while the losses of an equal size but less disadvantaged group reduce in the same magnitude, the value of Φ necessarily increases. In other words, the higher the inequality among groups' losses, the higher the social welfare loss.

Given that Φ is defined based on individuals' deprivation (i.e., the well-being losses of individuals), it also satisfies the *focus* property, which is an axiom usually required in poverty measurement. In our case, this property implies that the social welfare loss that society derives from the occupational sorting of its groups is not affected by the well-being gains of privileged groups since these gains are transformed into zeros in vector *d* and, therefore, in vector $\tilde{d}$. In other words, the excess of privileged groups can never offset the shortfalls of deprived groups.

Result. *Let us denote by* $(d;G)$ *and* $(d';G')$ *two different economies. Vector* $(d;G)$ *dominates in social welfare loss associated with segregation* vector $(d';G')$ *if and only if* $\Phi(\tilde{d}) < \Phi(\tilde{d}')$ *for all* $\Phi \in \Phi^*$.

Proof: This result follows from Theorem 2 proposed by Shorrocks (1998) in the field of individual deprivation. Note that in his theorem, Φ is expressed in terms of the cumulative deprivation distribution function while in our case, for the sake of simplicity, it is directly expressed as a function of deprivation. For this reason, we need to make it explicit that Φ has to be symmetric and replication invariant (apart from strictly monotonic and equally preferring). □

It is well-known that *symmetry, replication invariance, strict monotonicity, equally preferring property* (equivalent to the *transfer axiom),* and *focus* are standard properties assumed to measure poverty since Sen (1976). Both poverty and the social welfare loss associated with segregation are "bads," which makes it possible to deal with them using a common theoretical framework. In other words, the above properties seem reasonable to measure the welfare losses that a society experiences due to the segregation of its groups. For the same reason, we can label functions $\Phi \in \Phi^*$ as social welfare losses indices (associated with segregation). Note that these properties are the minimum set of

value judgments behind the dominance criterion defined above, as our Result shows. Consequently, this criterion is a powerful device to use in empirical studies because when the WLAS curves do not cross, one can implement a unanimous ranking of social welfare losses for a broad set of indices. Thus, if a WLAS curve never goes above another and is below the other at least at one point, all indices $\Phi \in \Phi^*$ would conclude that the social welfare loss in the first case is lower than that in the second. This criterion has also the advantage of providing a clear picture of the situation based on simple graphical representations, showing the share of the population who belong to disadvantaged groups, the average well-being losses of society, and the inequality that exists among the groups who experience those losses.

2.4 Indexes Consistent with this Dominance Criterion

The dominance criterion is a very useful tool when the WLAS curves do not cross. However, if the curves cross or if one is interested in quantifying the differences between two situations, the use of indices that measure the social welfare loss associated with segregation becomes necessary.[9]

A wide number of possible candidates could be used to measure our phenomenon satisfying the above properties (*symmetry, replication-invariance, strict monotonicity, transfer axiom,* and *focus*). In particular, those developed in the poverty literature (Zheng, 1997) can be easily adapted to our context.[10] Here we make use of the well-known family of poverty indices proposed by Foster et al. (1984), usually referred to as the FGT indices, which apart from satisfying the above five properties, are *additively decomposable*, which may be convenient in empirical analyses. This property means that the social welfare loss of society can be written as the weighted sum of the losses of the supergroups into which society can be additionally grouped.[11]

[9] Note that when two WLAS curves do not cross, it is possible to determine the range of $z \geq 0$ values associated with the dominated distribution (as explained in footnote 7) for which the dominance relationship is kept. By doing so, one could incorporate a certain degree of cardinality in the analysis without using indices.

[10] Examples of these indices are: the Sen-Shorrocks-Thon index, the Hagenaars index, the Watts index, and the Clark-Hemming-Ulph-Chakraverty family of indices (see Foster et al., 2013).

[11] This means, for example, that the value of a FGT index due to segregation by both gender and race/ethnicity can be expressed as the weighted sum of the values of that FGT index for those supergroups (i.e. for each race/ethnicity or for each gender), with weights being equal to the demographic shares of those supergroups. In this way, one can determine the extent to which each race/ethnicity or each gender contributes to the social welfare loss.

Based on the deprivation approach proposed by Shorrocks (1998), we adapt the FGT poverty indices to measure the social welfare loss that the whole society experiences due to the occupational segregation of its groups as follows:

$$FGT_{\alpha}(\tilde{d}) = \frac{1}{T}\sum_{s=1}^{T}(\tilde{d}_s)^{\alpha}, \qquad (4)$$

where $\alpha \geq 0$ is an inequality aversion parameter.

For $\alpha > 1$, $FGT_{\alpha}(\tilde{d})$ represents the welfare loss of society when the losses of groups are aggregated consistently with the value judgments behind the dominance criterion of the WLAS curves. This is in line with what happens with the corresponding FGT indices in the fields of poverty and discrimination, where they are consistent with the dominance criteria given by the TIP and discrimination curves, respectively (Jenkins and Lambert, 1997; Del Río et al., 2011).

If $\alpha = 0$, the index is actually the headcount ratio, which measures the incidence of the phenomenon, given that $FGT_0(\tilde{d}) = \frac{k^*}{T}$ was defined above as the share of the population that belongs to groups that have well-being losses associated with their occupational sorting. This index is not, however, consistent with our dominance criterion because it does not satisfy either the transfer principle or strict monotonicity. If $\alpha = 1$, $FGT_1(\tilde{d}) = \frac{1}{T}\sum_{s=1}^{T}\tilde{d}_s$ represents the mean well-being losses of society. This index is not consistent with the dominance criterion either, because the transfer principle does not hold. Despite this, in our empirical illustration we will use these indices to show the incidence and intensity of the phenomenon separately.

Finally, note that the $\tilde{d}_s$ values used in expression (4) could be grouped according to any criterion. If there were L supergroups $(1 < L < n)$, for each supergroup l $(l = 1,...,L)$, we could define $\tilde{d}^l = (\tilde{d}_1^l,...,\tilde{d}_{T^l}^l)$ and obtain its social welfare loss: $FGT_{\alpha}(\tilde{d}^l) = \frac{1}{T^l}\sum_{s=1}^{T^l}(\tilde{d}_s^l)^{\alpha}$, where T^l is the size of supergroup l and $T = \sum_{l=1}^{L}T^l$.

Using the *additively decomposition* property of the FGT indices we have: $FGT_\alpha(\tilde{d}) = \sum_{l=1}^{L} \frac{T^l}{T} FGT_\alpha(\tilde{d}^l)$. Therefore, the contribution of each supergroup to the social welfare loss would be: $C_\alpha^l = \frac{\left(\frac{T^l}{T}\right) FGT_\alpha\left(\tilde{d}^l\right)}{FGT_\alpha(\tilde{d})}$.

3. Measuring the Social Welfare Loss due to Segregation in the U.S.

Occupational segregation, especially segregation by gender, is still a quite pervasive phenomenon in the U.S. (Blau et al, 2013; Del Río and Alonso-Villar, 2015). Women and men tend to work in different occupations, the former being more intensively concentrated in jobs with lower wages, authority, and chances of promotion (Reskin and Bielby, 2005). Differences by race/ethnicity in the distribution of workers across occupations are also well documented (King, 1992; Huffman, 2004; Kaufman, 2010; Gradín, 2013). The literature also shows that segregation by gender does not affect all racial/ethnic groups in the same way (Hegewisch et al., 2010; Mintz and Krymkowski, 2011). On the other hand, segregation by race/ethnicity does not affect women and men equally (Spriggs and Williams, 1996; Reskin et al., 2004; Alonso-Villar et al., 2012). Therefore, when exploring occupational segregation, the crossing of gender and race/ethnicity seems to be particularly relevant, although this is a topic that so far has received little attention in the literature. Moreover, while overall or aggregate segregation in this multiracial society is an issue that has recently started to be dealt with by scholars to analyze residential segregation (Iceland, 2004; Hao and Fong, 2011), we know little about the overall segregation that arises from the occupational sorting of gender-race/ethnicity groups in the U.S. (Watts, 1995; Del Río and Alonso-Villar, 2015; Gradín et al., 2015), given that most studies have been based on pair-wise comparisons among groups (King, 1992; Hegewisch et al., 2010; Mintz and Krymkowski, 2011).

In this section, we explore the occupational segregation in the U.S. from 1980 to 2012 in a multigroup context resulting from the crossing of gender (2 groups) and race/ethnicity (6 groups) to assess the consequences that the occupational sorting of the subsequent 12 groups has in terms of social welfare.

3.1 Data

Our dataset comes from the Integrated Public Use Microdata Series (IPUMS) samples covering the period 1980-2012 (Ruggles et al., 2010). These data are drawn from the decennial censuses for the period 1980-2000 and the 5-year 2008-12 American Community Survey (ACS).[12] This dataset offers harmonized information assigning uniform codes to variables, which makes long-term comparisons possible. Regarding occupational breakdown, the Census Bureau has reorganized its occupational classification system several times, but the IPUMS provides a consistent long-term classification based on the 1990 classification, which accounts for 389 occupations.[13]

Regarding race and ethnicity, this paper considers 6 mutually exclusive groups of workers composed of the 4 major single-race groups that do not have a Hispanic origin, plus Hispanics of any race and others: Whites, African Americans or Blacks, Asians (Chinese, Japanese, and other Asians or Pacific Islanders), Native Americans (American Indians and Alaskan natives), Hispanics, and "other race" (those non-Hispanics reporting some other race or more than one race).[14] This paper crosses the above groups with sex to finally obtain 12 mutually exclusive gender-race/ethnic groups of workers. The wage of each occupation is proxied by the average hourly wage, which is estimated based on reported wages and number of hours worked.[15]

3.2 The Evolution of the Social Welfare Losses

Figure 2 illustrates the evolution of the WLAS curves (with parameter $\varepsilon = 1$) throughout the last three decades. The first finding that emerges is that the curve of 1980 crosses that of 2008-12 and, therefore, there is no dominance between them. This implies that the social welfare loss associated with occupational segregation may increase or

[12] There is no information about occupations in the decennial censuses from 2000 onward; the ACS is the nationwide survey, also provided by the Census Bureau, which replaced the decennial census long form and that includes occupation. The 5-year sample that we use, which considers the two years before and after 2010, accounts for 6.9 million workers. The number of workers in the sample for 1980 is about 5 million, roughly 5.8 million for 1990, and 6.4 million for 2000.

[13] In any case, the harmonization process involved several adjustments which imply that the classification has some empty employment occupations in several years. The real number of occupations in 1980, 1990, 2000, and 2008-12 are, respectively, 382, 384, 337, and 333. Fortunately, the majority of the empty occupations have a low employment in the years in which they appear.

[14] The residual category "other race" is different each year. In particular, multiple-race responses were allowed since 2000.

[15] 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.

decrease throughout the period depending on the index used. However, the curve of 1980 is above those of 1990 and 2000. Consequently, the social welfare loss associated with occupational segregation decreased between 1980 and 2000. In other words, there was an improvement in the integration of the gender-race/ethnicity groups in this period not only according to these curves but also according to a wide range of indices (all those consistent with the dominance criterion given by the curves, in particular, the FGT_{α} indices with $\alpha > 1$).

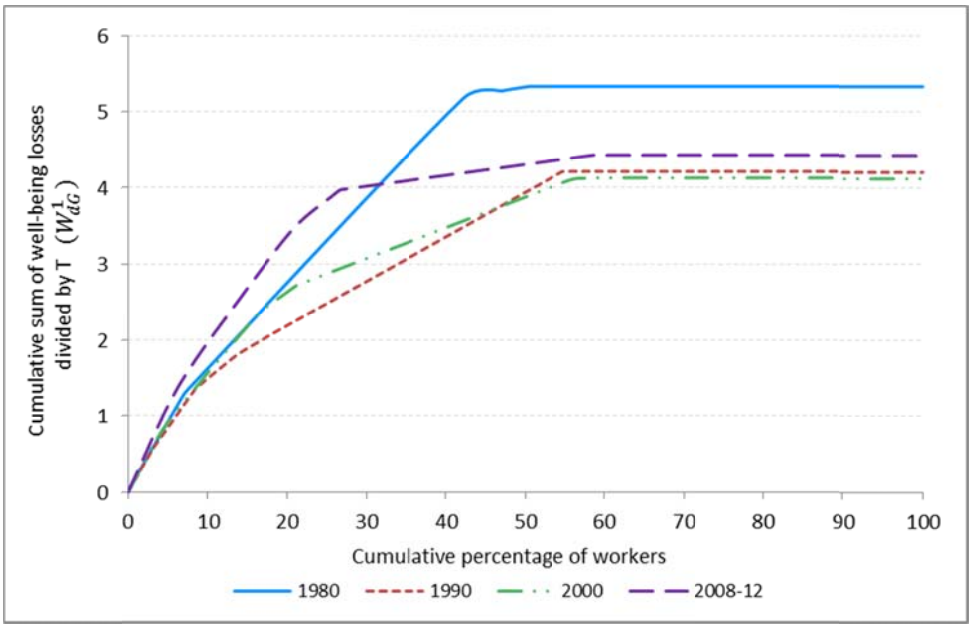

Figure 2. The WLAS curves (W_{dG}^{1})

When analyzing each decade separately, we find that between 1980 and 1990, there was a dramatic decrease in the intensity of the problem (i.e., the average well-being losses of the country diminished), as shown by the maximum height of the corresponding WLAS curves. However, the incidence of the problem increased. The point at which the WLAS curve becomes horizontal in 1980 indicates that 50% of workers in the country belonged to groups who had well-being losses due to their segregation, while this percentage rose to 55% in 1990. In any case, the WLAS curve of 1990 clearly dominates that of 1980. This improvement may be the result of the occupational advancement of white, black, and Asian women throughout this period, since some minority men actually worsened (Kurtulus, 2012; Del Río and Alonso-Villar, 2015; Alonso-Villar and Del Río, 2016b).

The situation between 1990 and 2000 is not so clear, however, since the curves cross. This means that some indices would suggest an improvement while others would conclude that there was a worsening. When focusing just on the incidence of the problem, we see almost no change between 1990 and 2000. The point at which the WLAS curves of these years become horizontal is nearly the same. The intensity of the problem was also similar between these two years given that the maximum height of the corresponding WLAS curves barely changed. The differences between these two years mainly arise from the differences among deprived groups. The curvature of the WLAS curve of 2000 is larger than that of 1990, which suggests that differences in the losses of disadvantaged groups were stronger in 2000 than in the previous decade.

Another important finding is that the social welfare loss rose between 2000 and 2008-12, not only in terms of intensity but also in terms of disparities among the most deprived groups (the incidence also increased, although only slightly). Consequently, the WLAS curve of 2000 dominates that of 2008-12. And this happens not only when $\varepsilon = 1$ (as shown in Figure 2) but also when $\varepsilon = 0$ and 2.[16] This suggests that integration in the labor market by gender-race/ethnicity has deteriorated in the last decade. The reason for this may be the large increase in the share of Hispanic women and men,[17] two disadvantaged groups whose losses have been increasing steadily since the 1980s (Alonso-Villar and Del Río, 2016a). On the other hand, there has been a slight increase in the share of both Asian men—whose well-being gains have been increasing since the 1990s—and Asian women, who apart from being the female group with the highest position in the ranking, started to have gains associated with their occupational sorting in the 2000s, at least for some values of ε (Del Río and Alonso-Villar, 2015; Alonso-Villar and Del Río, 2016a). It seems, however, that the occupational advancement of Asian men and women, who are the groups with the highest educational achievements

[16] When using $\varepsilon = 2$, we also find that the WLAS curve of 1980 is dominated by those of 1990 and 2000, and crosses that of 2008-12 (the latter is dominated by that of 2000). The results for $\varepsilon = 0$ are similar, except that the WLAS curve of 1980 crosses that of 2000 (apart from crossing that of 2008-12). In addition, we see that since 1990, each WLAS curve is dominated by that of the previous decade, which means that there is an undisputed deterioration between 1990 and 2008-12, decade by decade. These charts are not included in the document.

[17] See Table A1 in the Appendix.

of the country,[18] has not compensated the dramatic rise in the well-being losses of the other groups with a clear immigration profile, Hispanic women and men.

Figure 3 shows the FGT_{α} indices given in expression (4). In line with the WLAS curves shown above, the FGT_0 index (i.e., the headcount ratio) increased throughout the whole period. The rise in this incidence is more evident in 2000 when measuring the losses of the groups in terms of well-being ($\Psi_{\varepsilon}(g^i;t;w)$, $\varepsilon = 1$ and 2) than when doing it in monetary terms ($\Gamma \equiv \Psi_0$). On the contrary, the evolution of the average losses of the economy associated with the segregation of its groups has a U-shape (see FGT_1). This shape is even more intense when taking into account intensity and differences among the most deprived groups (see FGT_2). We may, therefore, conclude that when taking the three dimensions all together, the U.S. experienced an improvement in the integration of its gender-race/ethnicity groups in the labor market up until sometime in the 1990s but has drawn back since then. The FGT_2 index in 2008-12 is similar to that in 1980: the values slightly increase throughout the period with $\varepsilon = 2$ (0.84 and 0.86 in 1980 and 2008-12, respectively) and decrease a little with $\varepsilon = 1$ (0.67 and 0.65).

If we use the decomposition of the FGT indices to quantify the contribution of each race/ethnicity group to the social welfare losses of the country, we can determine the extent to which the occupational sorting of Hispanic workers contributed to these total losses. Using FGT_2 (with $\varepsilon = 1$), in 1980, Hispanic workers (women and men) accounted for almost 12% of the total welfare losses of the economy. Taking into account that they represented 5.6% of employees, their contribution to the losses more than doubled their demographic size. Some years later, in 2000 and 2008-12, their contribution to the welfare losses reached 56% and 76%, which represented 5 times their demographic weight (these weights were 10% and 15%, respectively).

[18] Although there are important differences in levels of education among Asian subgroups (Wang, 2004), the proportion of Asians, as a whole, holding a bachelor's degree is significantly higher than that of non-Asians (Allard, 2011), surpassing even that of Whites.

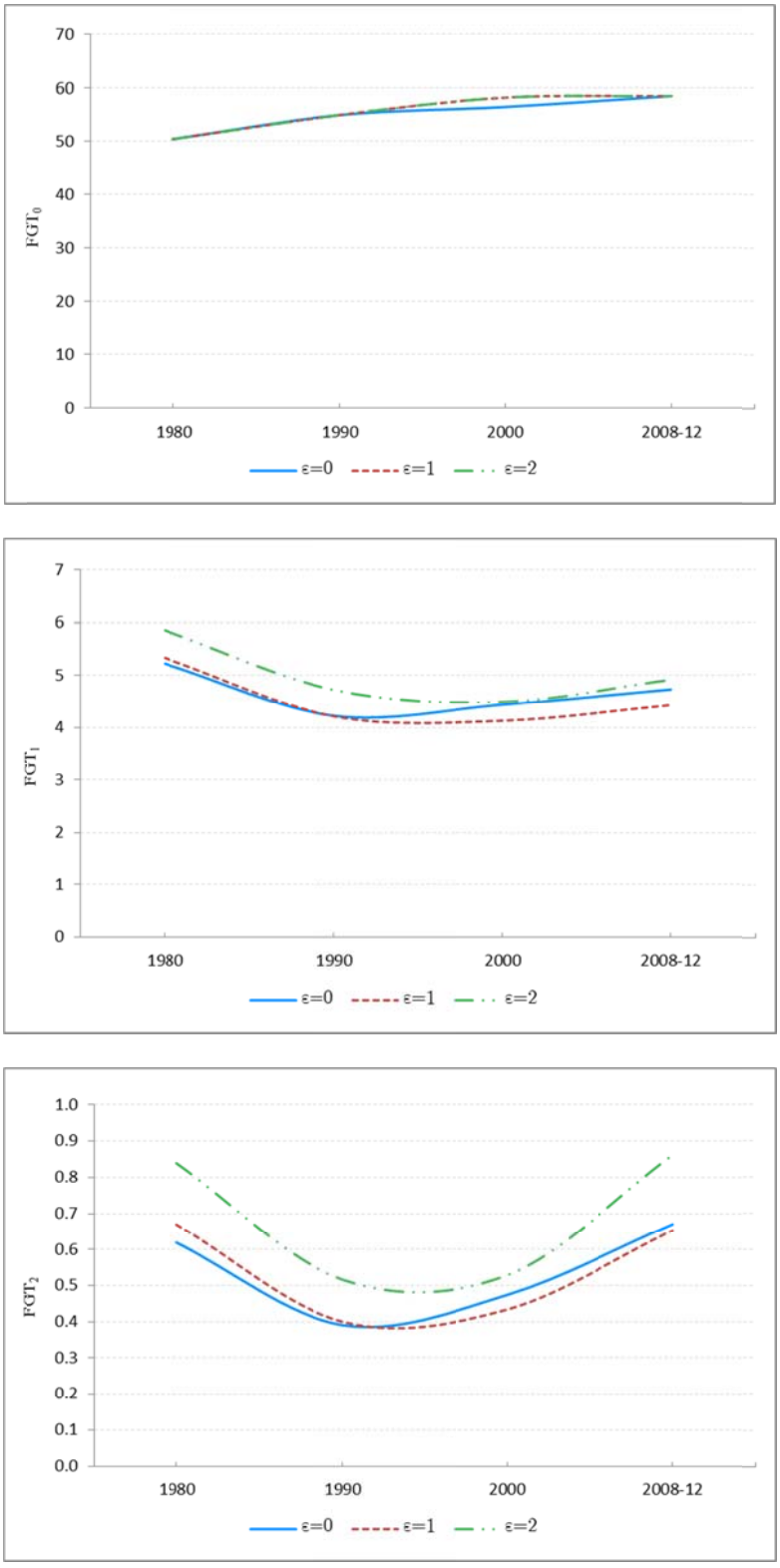

Figure 3. The social welfare losses due to segregation, FGT_α ($\alpha = 0,\ 1,$ and 2)

Let us compare now the evolution of these FGT_α indices with the evolution of overall segregation using several multigroup segregation measures that have been proposed in

the literature.[19] Figure 4 shows the values of three overall segregation indices: the I_p index proposed by Silber (1992), the mutual information index, M, developed by Frankel and Volij (2011), and the Gini index defined in Alonso-Villar and Del Río (2010), which is an unbounded version of that proposed by Reardon and Firebaugh (2002). An important finding of our analysis is that while nothing seems to have changed in terms of levels of segregation by gender-race/ethnicity in the U.S. since 1990 (the I_p, M, and *Gini* indices barely change, as shown in Figure 4 and Table A2 in the Appendix), our approach suggests an increasing lack of integration of some of these groups in the labor market (see, for example, the FGT_2 indices in Figure 3 and Table A2 in the Appendix).

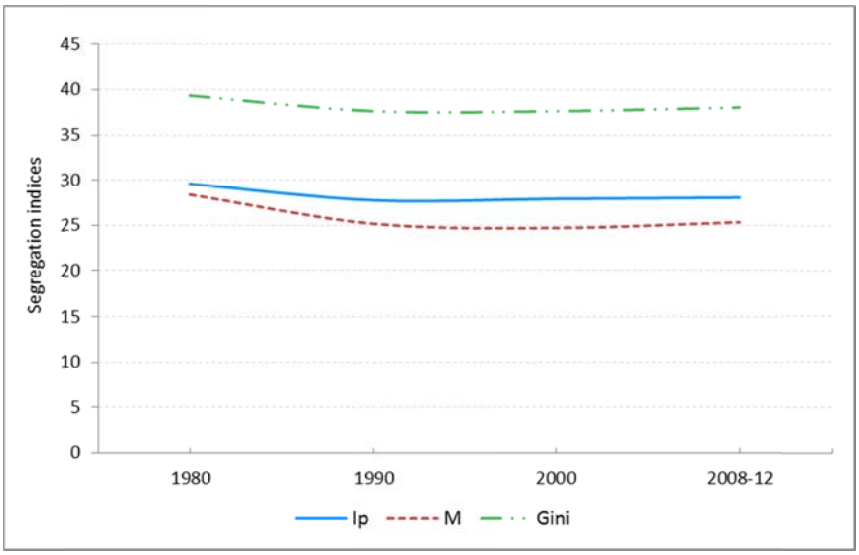

Figure 4. Overall segregation indices (I_p, M, and Gini)

In other words, the measurement of overall segregation may not capture the real problem behind the occupational sorting of groups. It is important to keep in mind that even in the extreme case where there were no changes in the occupational sorting of groups,[20] that would not necessarily imply stagnation in the situation of those groups. If there are alterations in occupational wages—some occupations increasing/decreasing their relative position as compared to others—there may be variations in the social welfare losses associated with occupational segregation.

[19] We use multigroup segregation measures because we have 12 gender-race/ethnicity groups.
[20] Note that this is not the case here since the segregation of some groups has actually changed (Del Río and Alonso-Villar, 2015).

4. Conclusions

This paper has developed measures with which to quantify a phenomenon that up to now has not been quantified: What is the welfare loss that a society experiences as a consequence of the segregation of the various demographic groups that encompass it?

With the tools existing so far, one could certainly measure the aggregate or overall segregation that arises from the occupational sorting of the mutually exclusive groups into which society has been partitioned. However, an important question would still remain answered: What about the implications of that segregation in terms of well-being? The segregation of groups into different occupations would not be too problematic, at least in economic terms, if those occupations were equally "good," but the evidence shows that this is not the case. Some occupations have higher average wages, better working conditions, and more social prestige than others do. This paper has built a framework in which this social welfare loss associated with segregation can be determined. In doing so, we have linked our problem with the literature on deprivation (Shorrocks, 1998) and have offered measures with good normative properties. This approach is analogous to that followed in the measurement of poverty, and also in some kinds of unemployment and discrimination measurement (Jenkins and Lambert, 1997; Shorrocks, 2009; Jenkins, 1994).

In particular, we have developed *social welfare loss curves associated with segregation* (WLAS curves) and a dominance criterion associated with these curves. This has the advantage of showing the problem under analysis by means of an easy graphical representation. We have also offered indices (consistent with this dominance criterion) resulting from adapting the well-known FGT family of indices to our context. The original FGT poverty indices (Foster et al., 1984) have given rise to a broad literature and have been adapted to different fields. As discussed by the same authors a quarter of century after their seminar paper (Foster et al., 2010), there exist applications in domains as diverse as education, child malnutrition, affordability of public housing, productivity in academia, overweight population, aggregate corruption, etc. Our paper joins this literature by adjusting these indices to measure the social welfare loss of society due to segregation.

To show the usefulness of our measures, we have explored occupational segregation in the U.S. by gender-race/ethnicity. Our analysis shows that our measures reveal certain

aspects of the phenomenon that do not emerge when using overall segregation measures. Thus, for example, while nothing seems to have changed in U.S. labor market in the last decade according to some well-known overall segregation measures, the social welfare loss due to segregation has actually increased.

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Appendix

Table A1. Demographic weights of gender-race/ethnicity groups

Gender-race/ethnicity groups	1980	1990	2000	2008-12
White men	48.3	43.5	39.8	35.5
African American men	4.9	4.7	4.6	4.8
Asian Men	0.9	1.5	2.0	2.7
Native American men	0.3	0.3	0.3	0.3
Hispanic men	3.4	4.6	6.0	8.5
Men from other races	0.1	0.0	0.9	0.8
White women	34.3	35.4	34.0	31.7
African American women	4.7	5.1	5.3	5.8
Asian women	0.8	1.3	1.8	2.5
Native American women	0.2	0.3	0.3	0.3
Hispanic women	2.2	3.1	4.2	6.4
Women from other races	0.0	0.0	0.7	0.8

Table A2. Overall segregation indices (x 100) and social welfare losses indices (x 100)

	Overall Segregation Indices			**Social Welfare Losses Indices**								
				FGT_0			**FGT_1**			**FGT_2**		
	I_p	**M**	**Gini**	$\Psi_{\varepsilon=0}$	$\Psi_{\varepsilon=1}$	$\Psi_{\varepsilon=2}$	$\Psi_{\varepsilon=0}$	$\Psi_{\varepsilon=1}$	$\Psi_{\varepsilon=2}$	$\Psi_{\varepsilon=0}$	$\Psi_{\varepsilon=1}$	$\Psi_{\varepsilon=2}$
1980	29.60	28.40	39.36	50.45	50.45	50.45	5.22	5.33	5.86	0.62	0.67	0.84
1990	27.76	25.17	37.63	54.96	54.96	54.96	4.22	4.21	4.72	0.39	0.40	0.52
2000	27.92	24.70	37.62	56.48	58.24	58.24	4.44	4.13	4.49	0.47	0.43	0.53
2008-12	28.06	25.34	38.04	58.52	58.52	58.52	4.73	4.43	4.92	0.67	0.65	0.86