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Concentration of economic activity: Inequality-based measures[*]

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Abstract

This paper reflects about the invariance property that regional economics is implicitly assuming when “relative” inequality measures, such as the Gini index, are used to quantify the geographic concentration of economic activity. In addition, it proposes a new concentration measure that is based on an “absolute” inequality index. The properties of this variance-type index are analyzed. An “absolute” employment Lorenz curve is also proposed to measure concentration, the dominance criterion of which is consistent with this new index. Finally, the usefulness of the new measures is illustrated by using manufacturing employment data in Spain.

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1. Introduction

In recent years, researchers have shown increasing interest in the study of spatial concentration patterns of economic activity, both empirically and theoretically. This heightened interest is in part motivated by the general concern with the effects of economic integration processes on production location patterns, especially in Europe where the creation of the Single Market has stimulated the debate (Amiti, 1999; Haaland et al., 1999; Brülhart, 2001; and Aiginger and Pfaffermayr (2004), inter alia).[1] Among the spatial concentration measures existing in the literature, those borrowed from the literature on income inequality are some of the most widely used.[2] In this regard, the locational Gini coefficient has been traditionally used for analyzing the spatial location patterns of manufacturing industries (Krugman, 1991; Amiti, 1999; Brülhart, 2001; and Suedekum, 2006, among many others), and lately, some of the indexes included in the generalized entropy family have been used as well (Brülhart and Traeger, 2005; Mori et al., 2005; Brakman et al., 2005; Pérez-Ximénez and Sanz-Gracia, 2007; and Cutrini, 2009).

There is a wide consensus in the literature on income distribution about the properties an inequality measure has to satisfy when it is used to compare income distributions having the same mean. Basically, one must invoke the symmetry axiom, which guarantees anonymity among individuals, and the Pigou-Dalton principle of transfers, which requires a transfer of income from a poorer to a richer person to increase inequality. However, if one is interested in comparing two income distributions that have different means, an additional property has to be specified, the one regarding the type of mean-invariance.[3] This requires introducing another value judgment into the analysis, and scholars have reached no agreement with respect to this matter. Some opt to invoke the scale invariance axiom, which stipulates that the inequality of a distribution remains unaffected when all incomes increase (or decrease) by the same proportion. This property gives rise to "relative" inequality measures such as the Gini index and the generalized entropy family of indexes, which are consistent with the Lorenz criterion. Others prefer, instead, to call on the translation invariance axiom, under which

[1] From a theoretical perspective, the literature of the new economic geography has contributed extensively to this debate. A review of this literature can be seen in Fujita et al. (2000), Neary (2001), and Ottaviano and Thisse (2004), among others.

[2] Other concentration measures proposed in the literature are formally derived from location models (Ellison and Glaeser, 1997; Maurel and Sédillot, 1999; Guimarães et al., 2007). There are also distance-based measures related to the literature on spatial statistics (Marcon and Puech, 2003; Duranton and Overman, 2005).

[3] Properties such as normalization, continuity, differentiability, and population principle are also commonly invoked, but they are more technical.

inequality remains unaltered if all incomes are augmented (or diminished) by the same amount, thereby giving rise to “absolute” inequality measures (which are consistent with “absolute” Lorenz curves, see Moyes, 1987).

Certainly, in a context of income distribution, the properties of these inequality measures are well-known since this literature has tackled inequality measurement from an axiomatic perspective (Atkinson, 1970; Kolm, 1976; Shorrocks 1980; and Cowell, 2000, inter alia). This axiomatic approach has facilitated comparisons among inequality measures, and has permitted researchers to go further in their empirical analyses. The approach followed by the literature on geographic concentration has been rather different, since such an axiomatization does not exit (Combes and Overman, 2004, develop several criteria by taking into account considerations from the location theory but no axiomatic approach is actually proposed). In fact, some inequality-based measures have been extensively used to quantify the geographic concentration of the economic activity without exploring their invariance properties in the new context. For this reason, it seems timely to reflect about the consequences of using inequality indexes to measure the spatial concentration of production depending on whether they satisfy one mean-invariance condition or the other.

The aim of this paper is double. First, it shows the invariance property that regional economics is implicitly assuming when using “relative” inequality measures to quantify the geographic concentration of economic activity. Second, this paper suggests that, in measuring the concentration of economic activity, apart from the locational Gini index, the generalized entropy family of concentration indexes, and employment Lorenz curves, measures based on the “absolute” inequality notion can be used as well. In this regard, this paper defines “absolute” employment Lorenz curves in this context and proposes a variance-type concentration measure that is consistent with the dominance criterion established by these curves. In addition, the usefulness of these measures as a complement to traditional inequality-based concentration measures is illustrated by using manufacturing employment data in Spain.

The question we pose in this paper is not what inequality measure should be used to quantify concentration, but why one should be constrained to employ a single type of tools when other good measures, complementary to the former, can be used as well allowing to delve deeper in empirical research. The implicit invariance criterion of each index is only the result of particular value judgments and, for this reason, scholars can hardly reach a consensus regarding which one should be used. In fact, the translation invariance condition, which is the characteristic of “absolute” inequality measures, is neither worst nor better than the scale invariance since each notion represents a different perception of inequality. We find interesting to introduce this debate in the field of regional science, where so far only some types of inequality-based concentration indexes have been used. For this purpose, several properties borrowed from the literature on income distribution and others borrowed from the literature on occupational segregation are explored in our context (Hutchens, 1991; 2004; Alonso-Villar and Del Río, 2010). Several of these properties can be directly used in our context, while others are conveniently adapted (as in the case of the invariance properties).

It is important to keep in mind that the labels “relative” and “absolute” used in the literature on income distribution do not have the same meaning as the labels *relative* and *absolute* in the literature on spatial concentration. The latter refer to the distributions of reference against which that of the sector under consideration is contrasted: the distribution of the whole economic activity in the *relative* case and the uniform distribution in the *absolute* case (Brülhart and Traeger, 2005; Bickenbach and Bode, 2008).[4] In quantifying the spatial concentration of a given sector, we follow a *relative* approach, according to which the spatial distribution of the sector under study is compared with that of the whole set of sectors (Amiti, 1999; Brülhart, 2001; Brülhart and Traeger, 2005).

The paper is structured as follows. Section 2 reflects, from an analytical perspective, on the implications of using inequality-based concentration indexes. Section 3 introduces two new concentration measures, an “absolute” employment Lorenz curve and a variance-type index, which satisfy a translation invariance condition that differs from that assumed by the standard employment Lorenz curve, the locational Gini index, and the generalized entropy family. As with the latter, this new concentration index is additively decomposable, which is a helpful property for empirical analysis. Using employment data of manufacturing industries in Spain, Section 4 first illustrates the differences and complementarities between the aforementioned concentration measures, and, second, it analyzes the Spanish case in more detail by using the decompositions of the new index. Finally, Section 5 presents the main conclusions.

[4] An alternative notion is that of *topographic* concentration, according to which the distribution of reference is that of physical space (Brülhart and Traeger, 2005).

2. Geographic concentration: an analytical approach

2.1 Notation

Consider an economy with $L > 1$ location units (counties, regions, countries, etc.) across which aggregate employment, denoted by T, is distributed. Let $t \equiv (t_1, t_2, ..., t_L)$ denote this distribution, where $T = \sum_l t_l$. This distribution represents the benchmark against which the distribution of any sector is compared. This concentration notion is labeled *relative* and has been extensively used in empirical research. If a researcher is concerned, for example, with the geographic concentration of manufacturing industries, t could represent the distribution of manufacturing employment among regions (as in Amiti, 1999; and Brülhart, 2001). If a researcher is concerned with a broader perspective, t could instead represent the distribution of overall employment, services included (as in Brülhart and Traeger, 2005).

Let us denote by $x \equiv (x_1, x_2, ..., x_L)$ the employment distribution of the sector in which we are interested and by X its employment level ($X = \sum_l x_l$). In this paper, an index of *relative* geographic concentration is a function $I_c : D \rightarrow \mathbb{R}$ such that $I_c(x;t)$ represents the concentration level of the sector having distribution x when comparing it with the distribution of reference t, where $D = \bigcup_{L>1} \left\{ (x;t) \in \mathbb{R}^L_+ \times \mathbb{R}^L_{++} : x_l \le t_l \forall l \right\}$.

In order to better understand the properties showed below, first of all, we formally establish the relationship between the measurement of spatial concentration of economic activity and the measurement of income inequality. For that purpose, a hypothetical "income" distribution, y, derived from vector $(x;t)$ is obtained. In doing so, in each location l, x_l is allocated in equal amounts among t_l workers. In other words, in each location, the variable of study (employment in the sector of study) is equally split among all individuals (both those working in the sector of study and those in the remaining sectors). This per capita employment level, $\frac{x_l}{t_l}$, represents the employment in the sector of study that corresponds to each individual in location l, and it plays the role of individual "income". Namely, the fictitious "income" distribution is constructed as follows: there are t_1 persons with an individual "income" of $\frac{x_1}{t_1}$,

t_2 persons with an individual "income" of $\frac{x_2}{t_2}$, and so on. Therefore, we have built fictitious distribution $y \equiv (\underbrace{\frac{x_1}{t_1},...,\frac{x_1}{t_1}}_{t_1 \text{ individuals}},...,\underbrace{\frac{x_L}{t_L},...,\frac{x_L}{t_L}}_{t_L \text{ individuals}})$ in a world of $T = \sum_l t_l$ individuals where total income is $X = \sum_l t_l \frac{x_l}{t_l}$.

Suppose, for example, that we want to measure the geographic concentration of the chemical sector by comparing its employment distribution across regions with that of manufacturing employment. Consider that the economy has three locations and that the employment distribution of the chemical industry among them is $(3,2,5)$, while the distribution of manufacturing workers is $(30,10,30)$. In other words, $(x;t) = (3,2,5;30,10,30)$. Therefore, our fictitious distribution would be one with 70 people having a total income of 10 units: there are 30 people with an individual "income" of 0.1, 10 people with an individual "income" of 0.2, and 30 people with an individual "income" of 0.16, i.e., the "income" distribution is equal to $y \equiv \left(\underbrace{\frac{3}{30},...,\frac{3}{30}}_{30},\underbrace{\frac{2}{10},...,\frac{2}{10}}_{10},\underbrace{\frac{5}{30},...,\frac{5}{30}}_{30}\right)$.

The parallelism between employment distribution $(x;t)$ and fictitious distribution y will be helpful for understanding the analytical framework presented in what follows, where some basic properties, borrowed from the literature on income distribution and occupational segregation, are adapted to analyze spatial concentration measures.[5]

2.2 Inequality-based concentration measures: Basic properties

We can start our list with the *symmetry in locations* property, which means that if locations are enumerated in a different order, the concentration index should remain unchanged.[6]

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[5] Some of these properties have been used in Alonso-Villar (2010) to characterize employment Lorenz curves and in Alonso-Villar and Del Río (2009) to characterize the generalized entropy family of concentration indexes.
[6] In the income distribution literature this axiom requires that the inequality index does not change when individuals' incomes swap. In the occupational segregation literature, this axiom is called "symmetry in groups" and requires anonymity among occupations (see Hutchens, 1991).

Property 1: *Symmetry in locations*. If $\left(\Pi(1),...,\Pi(L)\right)$ represents a permutation of locations, then $I_c\left(x\Pi;t\Pi\right)=I_c\left(x;t\right)$, where $x\Pi=\left(x_{\Pi(1)},...,x_{\Pi(L)}\right)$ and $t\Pi=\left(t_{\Pi(1)},...,t_{\Pi(L)}\right)$.

As mentioned earlier, another basic property of any inequality measure is the Pigou-Dalton principle, which requires a transfer of income from a poorer to a richer person to increase inequality. This property gives rise to the next property: *movement between locations.* If we focus again on the chemical sector, this property requires that when a region with a lower employment level in chemicals than another (but with the same manufacturing employment) loses employment in chemicals in favor of the other location, concentration in the chemicals sector must increase.[7]

Property 2: *Movement between locations*. If $\left(x';t\right)\in D$ is obtained from $\left(x;t\right)\in D$ in such a way that:

(i) location *i* loses employment in the sector of study, while the opposite happens to location *h*, i.e., $x'_i=x_i-d$, $x'_h=x_h+d$ $(0<d\le x_i)$, where *i* and *h* are two locations with the same aggregate employment level, $t_i=t_h$, but with different shares in the sector of study since $x_i<x_h$;

(ii) the employment level of the sector of study does not change in the remaining locations, i.e., $x'_l=x_l \quad \forall l\neq i,h$;

then $I_c\left(x';t\right)>I_c\left(x;t\right)$.

The next property we present, *insensitivity to proportional subdivisions of locations,* is not borrowed from the literature on income distribution but from that on occupational segregation (see Hutchens, 2004). This property requires that subdividing a location into several units of equal size, both in terms of aggregate employment and in terms of employment in the sector of study, does not affect the concentration level of the sector. Without loss of generality, the subdivision in the next property is written for the last location in order to make notation easier.

Property 3: *Insensitivity to proportional subdivisions of locations.* If $\left(x';t'\right)\in D$ is obtained from $\left(x;t\right)\in D$ in such a way that:

[7] This property has also been adapted to measure occupational segregation, where it is called "movement between groups" (see Hutchens, 2004; and Alonso-Villar and Del Río, 2010).

(i) all locations except the last one remain unaltered both in terms of aggregate employment and employment in the sector of study, i.e., $t'_l = t_l$ and $x'_l = x_l$ for any $l = 1,...,L-1$;

(ii) the last location is subdivided in M location units without introducing any differences among them in terms of employment shares, i.e., $x'_l = x_L/M$, $t'_l = t_L/M$ for any $l = L,...,L+M-1$,

then, $I_c(x';t') = I_c(x;t)$.

In order to understand the relevance of the above property, we go back to the example given at the beginning of Section 2. Note that fictitious distribution $y \equiv \left(\frac{3}{30},...,\frac{3}{30},\frac{2}{10},...,\frac{2}{10},\frac{5}{30},...,\frac{5}{30}\right)$ can be obtained from different $(x;t)$ vectors, depending on how the "income" data are grouped. We could, for example, group the "income" data into three groups, $\left(\underbrace{\frac{3}{30},...,\frac{3}{30}}_{group1(30)},\underbrace{\frac{2}{10},...,\frac{2}{10}}_{group2(10)},\underbrace{\frac{5}{30},...,\frac{5}{30}}_{group3(30)}\right)$, so that the 30 individuals having an "income" level equal to 0.1 are in group 1, the 10 individuals having an "income" of 0.2 are in group 2, and the 30 individuals having an "income" of 0.16 are in group 3. In this case, we would obtain former vector $(x;t) = (3,2,5;30,10,30)$. But we could also group individuals into five groups, $\left(\underbrace{\frac{3}{30},...,\frac{3}{30}}_{group1(10)},\underbrace{\frac{3}{30},...,\frac{3}{30}}_{group2(10)},\underbrace{\frac{3}{30},...,\frac{3}{30}}_{group3(10)},\underbrace{\frac{2}{10},...,\frac{2}{10}}_{group4(10)},\underbrace{\frac{5}{30},...,\frac{5}{30}}_{group5(30)}\right)$, so that 10 of the individuals having an "income" of 0.1 are included in the first group, 10 are in group 2, and the remaining 10 are in the third group, while those having an "income" of 0.2 are included in the fourth group, and those with an "income" of 0.6 are in the fifth group. In this case, $(x';t') = (1,1,1,2,5;10,10,10,10,30)$. Note that, according to property 3, both $(x;t)$ and $(x';t')$ have the same concentration level since the latter can be obtained from the former by a proportional subdivision of locations. As a consequence of property 3, the value of the concentration index evaluated at any employment distribution $(x;t)$ does not change so long as the corresponding fictitious distribution y remains unaltered. Note that property 2 together with property 3 allows one to conclude that if $\frac{x_i}{t_i} < \frac{x_h}{t_h}$, $x'_i = x_i - d$, $x'_h = x_h + d$ $(0 < d \leq x_i)$, and $x'_l = x_l \ \ \forall l \neq i,h$, then $I_c(x';t) > I_c(x;t)$, even when $t_i \neq t_h$. The explanation is that, as a consequence of property 3, locations can be subdivided, without affecting concentration, in such a way that the distribution of reference becomes eventually equal to $\left(\underbrace{1,...,1}_{T}\right)$.

Another standard assumption of inequality indexes is the replication invariance or population principle, which allows comparisons among income distributions having different population sizes. This property requires that when replicating the economy k-times, so that for every individual in the previous economy there are now *k* identical individuals, income inequality is not altered. This principle is adapted to our context in order to make it possible to compare economies with different numbers of location units.

Property 4: *Population Principle*. If $(x';t')$ is a k-replication of distribution $(x;t)$ so that for any initial location unit l there are now k identical locations where the employment level of the sector of study and the aggregate employment in each of them is equal to x_l and t_l, respectively, then $I_c(x';t') = I_c(x;t)$.

Note that properties 3 and 4 imply that $I_c(ax;at) = I_c(x;t)$ for any $a > 0$. Therefore, any concentration index satisfying these two properties is cardinally unaffected by the unit of measurement (if employment is measured either in hundreds or thousands of individuals, the index does not change).

The next property, scale invariance, is not satisfied by all inequality indexes, since there is no consensus in the literature with respect to this matter. Only “relative” inequality measures (such as the Gini index and the generalized entropy family of indexes) satisfy it. As mentioned above, it requires that inequality remains constant when multiplying all incomes by the same positive scalar. We propose to adapt this property to our context as follows.

Property 5: *Scale Invariance*. If employment in the sector of study increases (or decreases) in such a way that the change, a, is distributed across locations according to their employment weights in the initial distribution of the sector, i.e., $(x';t) = \left(x_1 + a\frac{x_1}{X},...,x_L + a\frac{x_L}{X};t\right)$, and

$0 \le x_l + a\frac{x_l}{X} \le t_l \;\; \forall l$, then the concentration level of the sector should not change, i.e., $I_c\left(x';t\right) = I_c\left(x;t\right)$.[8]

Therefore, if the employment level of the chemical sector doubles, for example, its concentration level does not change, so long as the chemical employment in each location doubles as well. In other words, in measuring spatial concentration, it is only employment shares that matter, not employment levels.

However, as mentioned above, some scholars opt to invoke the translation invariance property rather than the scale invariance property so that inequality remains, instead, unaltered if all incomes are augmented (or diminished) by the same amount. This property gives rise to "absolute" inequality measures. We propose to define this property in our context as follows.

Property 5': *Translation Invariance*. If employment in the sector of study increases (or decreases) in such a way that the change, a, is distributed across locations according to their employment weights in the distribution of reference, i.e., $(x';t) = \left(x_1 + a\frac{t_1}{T}, \ldots, x_L + a\frac{t_L}{T}; t\right)$, and $0 \le x_l + a\frac{t_l}{T} \le t_l \;\; \forall l$, then the concentration level of the sector should not change, i.e., $I_c\left(x';t\right) = I_c\left(x;t\right)$.

As a consequence of this property, if the employment in the chemical industry increases, and this surplus is distributed among locations in such a way that if in a location aggregate manufacturing employment doubles that of another location, the former location receives twice as much of the extra employment in chemicals as the latter, then, the spatial concentration of the chemical industry should not change.

From all of the above, it follows that the translation and scale invariance properties differ regarding the type of increments in the sector of study that are considered to be concentration

[8] In addition, the concentration index should not vary if distribution t, rather than x, varies in such a way that $(x;t') = \left(x; t_1 + a\frac{t_1}{T}, \ldots, t_L + a\frac{t_L}{T}\right)$. Therefore, if T doubles, for example, the concentration of the sector does not change, so long as the employment growth is allocated along locations according to the initial weights. Note that properties 3 and 5 imply property 4.

invariant. To illustrate these differences, consider an economy with two locations (see Figure 1 and Figure 5 in the Appendix).

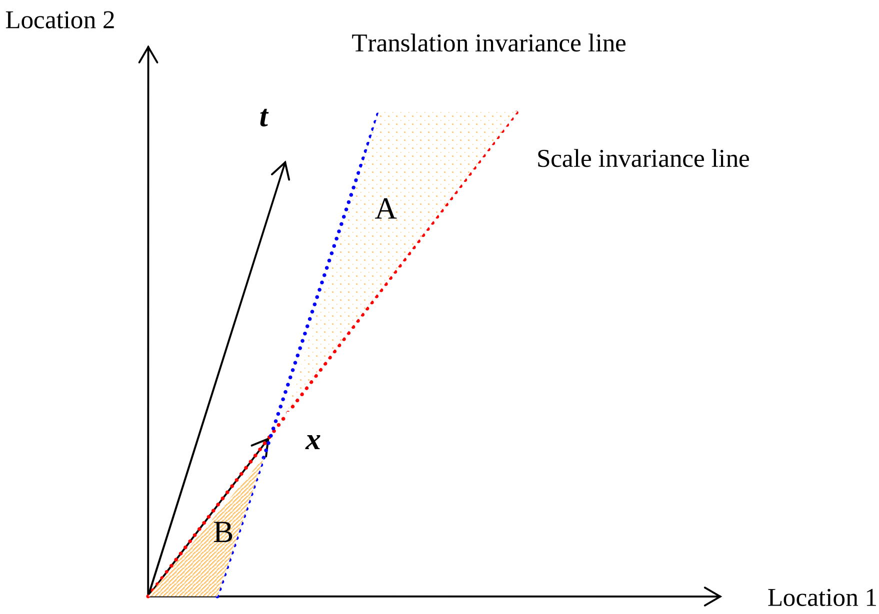

Figure 1. Translation and scale invariance lines in the case of two locations.

Those distributions having the same concentration level as x according to the translation invariance notion are included in the line given by point x and vector t, while those having the same concentration as x according to the scale invariance notion are included in the ray given by x. In Figure 1, where vector t is at the LHS of vector x, those distributions at the RHS of the translation (scale) invariance line have higher concentration than x according to the translation (scale) invariance condition (the analysis at the LHS of the ray given by t becomes more complex since rerankings appear, see Figure 5 in the Appendix). This is so, on the one hand, because the translation invariance lines corresponding to distributions at the RHS of the translation invariance line of x are more distant from the ray given by the distribution of reference, t, than the translation invariance line of x. On the other hand, the rays corresponding to distributions at the RHS of the scale invariance line of x represent distributions whose employment shares are more distant from those of t than those of x. Consequently, the distributions included in region A, which have a higher employment level than x, have higher concentration than x according to the translation condition but lower concentration according to the scale condition (the opposite happens to distributions included in region B, which have a lower employment level than x). Therefore, when there is employment growth in a sector, the translation invariance condition is more demanding. In this regard, note that property 5' requires that the proportion of the sector in each location become closer to the employment shares of the distribution of reference than property 5 does since $\lim_{a\to\infty} \frac{x_l + a\frac{t_l}{T}}{X+a} = \frac{t_l}{T}$ and $\lim_{a\to\infty} \frac{x_l + a\frac{x_l}{X}}{X+a} = \frac{x_l}{X}$.

Given that different invariance notions reflect different value judgments, it does not seem easy to reach an agreement in the literature with respect to the type of measure one should use, and, therefore, it appears reasonable to use both types of measures. Moreover, concentration measures consistent with the translation notion are not a merely theoretical refinement of concentration measurement but a helpful tool for empirical research. In this vein, if a sector having employment growth evolves towards a lower concentration level according to the scale invariance condition, it may be helpful to explore whether concentration also decreases according to the translation invariance condition since this would indicate that the concentration reduction in the sector has been rather intense.

3. Inequality-based concentration measures

3.1 Scale-invariant measures

In the literature on geographic concentration, the locational Gini index of a given sector can be written as the sum of the differences between the employment shares of the sector in each pair of locations weighted by their demographic weights, divided by twice the employment share of the sector in the whole economy:

$$G = \frac{\sum_{l,l'} \frac{t_l}{T}\frac{t_{l'}}{T}\left|\frac{x_l}{t_l} - \frac{x_{l'}}{t_{l'}}\right|}{2\frac{X}{T}}.$$

It is easy to see that this index satisfies properties 1, 3, 4 and 5. In order to see that it also satisfies property 2, note that if $x_i < x_h$ and $t_i = t_h$, any disequalizing movement of employment in the sector of study from location *i* to location *h* would make the index increase since:

a) $\left|\frac{x_i - d}{t_i} - \frac{x_h + d}{t_h}\right| = \frac{x_h + d}{t_h} - \frac{x_i - d}{t_i} > \frac{x_h}{t_h} - \frac{x_i}{t_i} = \left|\frac{x_i}{t_i} - \frac{x_h}{t_h}\right|$;

b) If l $(l \neq i,h)$ is such that $\frac{x_l}{t_l} < \frac{x_i}{t_i}$ or $\frac{x_l}{t_l} > \frac{x_h}{t_h}$, then any change in component $\left| \frac{x_l}{t_l} - \frac{x_h + d}{t_h} \right|$ is exactly offset by a change of the same magnitude and opposite direction in component $\left| \frac{x_i - d}{t_i} - \frac{x_l}{t_l} \right|$;

c) If l $(l \neq i,h)$ is such that $\frac{x_i}{t_i} \leq \frac{x_l}{t_l} \leq \frac{x_h}{t_h}$, then no component decreases.

Consequently, when using the locational Gini index, scholars are implicitly assuming the above properties.

Analogously, the generalized entropy (GE) family

$$\Psi_\alpha(x;t) = \begin{cases} \frac{1}{\alpha(\alpha-1)} \sum_l \frac{t_l}{T} \left[\left(\frac{x_l/X}{t_l/T} \right)^\alpha - 1 \right] & \text{if } \alpha \neq 0,1 \\ \sum_l \frac{x_l}{X} \ln \left(\frac{x_l/X}{t_l/T} \right) & \text{if } \alpha = 1 \end{cases},$$

where α is a sensitivity parameter, satisfies properties 1-5 (see Alonso-Villar and Del Río, 2009).[9]

As a consequence of the above, both measures (the locational Gini index and the GE family) are consistent with non-crossing employment Lorenz curves since any concentration measure satisfying properties 1-3 and 5 is consistent with these curves (Alonso-Villar, 2010), which are built by plotting the cumulative proportion of employment in the sector of study against the cumulative proportion of aggregate employment, once locations are lined up in ascending order of the Hoover-Balassa index.

3.2 Translation-invariant measures

In recent years, the GE family of concentration indexes has been widely used because of its advantages in terms of decomposability (Brülhart and Traeger, 2005; Brakman et al., 2005;

[9] Note that if there exists a location l where $x_l = 0$, Ψ_α can only be calculated for parameter values such that $\alpha > 0$ and $\alpha \neq 1$. If we had considered concentration indexes defined on the space of employment distributions $(x;t)$ where all components of vector x were strictly positive, rather than positive, then another index could be defined: $\Psi_\alpha(x;t) = \sum_l \frac{t_l}{T} \ln \left(\frac{t_l / T}{x_l / X} \right)$ if $\alpha = 0$.

Pérez-Ximénez and Sanz-Gracia, 2007; Cutrini, 2010).[10] However, we should notice that these indexes are not the only decomposable indexes that can be defined by extending inequality measures. In fact, the variance is another inequality measure that can be additively decomposed (Chakravarty, 2001), while satisfying a property, the translation invariance notion, which differs from that of the above inequality measures.

Accordingly, we define the following variance-type concentration index:

$$\Phi\left(x;t\right)=\sum_{l}\frac{t_l}{T}\left[\frac{x_l}{t_l}-\frac{X}{T}\right]^2 .$$

If location units (regions, for example) are grouped into K classes (countries, for example), this variance-type concentration index can be decomposed as

$$\Phi(x;t)=\sum_{k}\frac{T_k}{T}\Phi(x^k;t^k)+\Phi(X_1,...,X_K;T_1,...,T_k)\,, \tag{1}$$

where X_k and T_k are the employment of the sector and the aggregate employment in class *k*, respectively. This decomposition of total concentration in the *within* (first addend) and *between* (second addend) components is analogous to the one corresponding to the GE family. Therefore, the concentration of the sector by regions can be written as the weighted sum of regional concentration inside each country (according to its demographic weight) plus the concentration that would exist if there were no regional disparities within countries but only among countries.

If the sector of study is partitioned into several mutually exclusive subsectors, $s=1,...,S$, then $\Phi\left(x;t\right)$ can also be decomposed by subsectors:

$$\Phi\left(x;t\right)=\sum_{s}\Phi\left(x^s;t\right)+2\sum_{s=1}^{S}\sum_{s'>s}\tilde{\Phi}\left(x^s;x^{s'};t\right), \tag{2}$$

[10] $\Psi_{\alpha}(x;t)$ can be decomposed in the well-known *within-between* components, so that concentration at regional level, for example, can be written as the weighted sum of regional concentration inside each country (*within* component) plus the concentration that would exist if there were no regional disparities within countries but only among countries (*between* component). Index Ψ_2 can also be decomposed by subsectors, so that the contribution of each subsector to the concentration of the sector can be determined (see Brülhart and Traeger, 2005).

where $\tilde{\Phi}\left(x^{s};x^{s'};t\right)=\sum_{l}\frac{t_l}{T}\left(\frac{x_l^{s}}{t_l}-\frac{X^{s}}{T}\right)\left(\frac{x_l^{s'}}{t_l}-\frac{X^{s}}{T}\right)$ represents the covariance between the distributions of subsectors s and s' across locations. The first addend of the former decomposition is a summary of the internal contribution of each subsector to the overall concentration of the sector, while the second addend involves the concentration due to locational interdependencies among subsectors.

It is important to note that even though index $\Phi\left(x;t\right)$ has been obtained by extending an "absolute" inequality measure, it is actually a *relative* concentration measure since it quantifies how much the distribution of the sector across locations, x, departs from the distribution of reference, t. Observe also that, since index $\Phi\left(x;t\right)$ can be rewritten as

$$\Phi\left(x;t\right)=\left(\frac{X}{T}\right)^{2}\sum_{l}\frac{t_l}{T}\left(\frac{\frac{x_l}{X}-\frac{t_l}{T}}{\frac{t_l}{T}}\right)^{2}=2\left(\frac{X}{T}\right)^{2}\Psi_2\left(x;t\right),$$

this concentration measure not only depends on how much $\frac{x_l}{X}$ departs from $\frac{t_l}{T}$ (as Ψ_2 does) but also on the weight that the sector of study represents in the economy, $\frac{X}{T}$. In other words, this measure takes into account not only the employment shares of the sector in each location but also its total employment share.

By using simple calculations, it can be shown that index $\Phi\left(x;t\right)$ satisfies properties 1-4. In order to show that it also satisfies property 5' note that

$$\Phi\left(x_1+a\frac{t_1}{T},\ldots,x_L+a\frac{t_L}{T};t\right)=\sum_{l}\frac{t_l}{T}\left[\frac{x_l+a\frac{t_l}{T}}{t_l}-\frac{X+a}{T}\right]^{2}=\sum_{l}\frac{t_l}{T}\left[\frac{x_l}{t_l}-\frac{X}{T}\right]^{2}=\Phi\left(x;t\right).$$

Taking into account the parallelism between measuring the concentration of employment distribution x (as compared to t) and the inequality of fictitious distribution $y\equiv(\underbrace{\frac{x_1}{t_1},\ldots,\frac{x_1}{t_1}}_{t_1\text{ individuals}},\ldots,\underbrace{\frac{x_L}{t_L},\ldots,\frac{x_L}{t_L}}_{t_L\text{ individuals}})$, we propose to adapt the absolute Lorenz curve used in the literature on income distribution to our case. This new curve, labeled here "absolute" employment Lorenz curve, can be defined analogously to the aforementioned employment Lorenz curve except that on the vertical axis one has to accumulate $\left(\frac{x_l}{t_l}-\frac{X}{T}\right)\frac{t_l}{T}$, rather than $\frac{x_l}{X}$, once locations are lined up in ascending order of the Hoover-Balassa index ($\frac{x_l}{t_l}$). The further away is the curve from the horizontal axis, the higher the concentration of the sector (see Figure 2 where sector B shows a higher concentration than A according to the dominance criterion defined by these curves).

It can be shown that any concentration measure satisfying properties 1-4 and 5' is consistent with these new curves. In other words, when an employment distribution is more concentrated than another according to these curves, any concentration index satisfying the above properties (in particular, the variance-type concentration index we propose) would lead to the same conclusion.

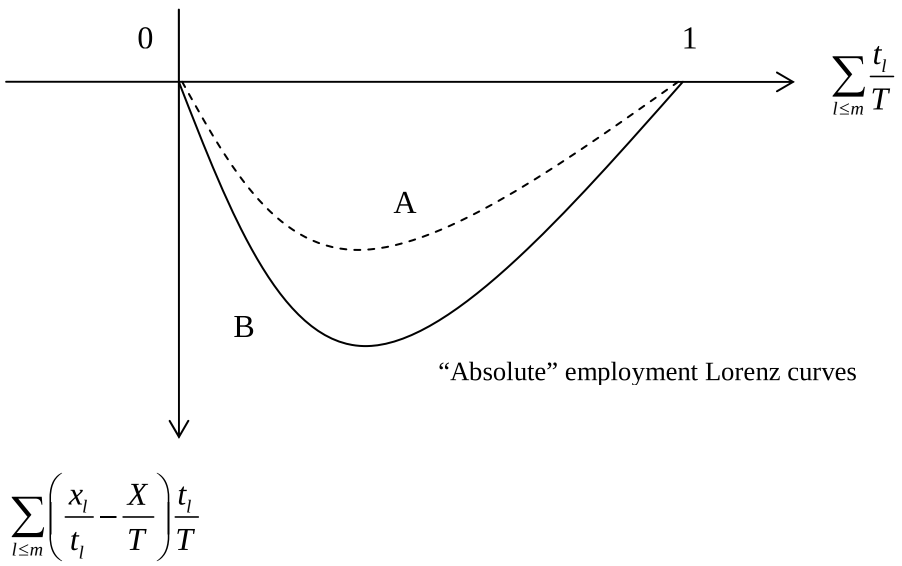

Figure 2. "Absolute" employment Lorenz curves.

From all of the above, it follows that apart from the concentration measures derived from the generalized entropy family, other decomposable measures satisfying alternative invariance properties can be used to determine the spatial concentration of economic activity. The use of this kind of measures allows one to delve deeper in the empirical analysis since it permits to assess the extent of concentration changes that occur along time with insights which complements those of traditional inequality-based measures.

4. The geographic concentration of manufacturing in Spain

The data used in this paper come from the Labor Force Survey (*EPA*) conducted by the Spanish Institute of Statistics (*INE*) by following EUROSTAT's guidelines. They correspond to the second quarter of the years 1996 and 2008. The employment in each sector is obtained taking into account whether workers are in full- or part-time jobs. Manufacturing industries are considered at a two- and three- digit level of the National Classification of Economic Activities (*CNAE-1993 Rev1*).

4.1 Evolution between 1996 and 2008

Table 1 shows the evolution of concentration (and the employment share) between 1996 and 2008 for the Spanish manufacturing industries at a two-digit level (23 industries). In order to quantify geographic concentration a *relative* approach has been followed: the employment distribution of each sector across provinces is compared with the distribution of total manufacturing employment. For this purpose several concentration measures are used: Φ, Ψ_α with $\alpha = 1, 2$, and G.[11] This analysis allows us to determine the complementarity that exists between indexes satisfying the translation invariance property and those satisfying the scale invariance, when analyzing the evolution of manufacturing industries.

If we look at those industries which have increased their employment levels, we find that in several of them concentration has notably declined, since not only "relative" inequality-based measures but also "absolute" measures yield to the same conclusion. We only highlight those results in which there are dominance according to both Lorenz criteria, the absolute and the standard Lorenz criteria. This is the case of two medium-low technology sectors (**27** and **28**),[12] two low-technology sectors (**20** and **36**), and one high-technology sector (**32**) (as an example, Figure 3 shows the corresponding Lorenz curves for sector **28**).[13] Intuitively, these dominances mean that in these sectors not only the proportion of workers but also the number of workers who would be necessary to switch across locations to reach the employments shares of the distribution of reference is lower in 2008 than in 1996.

[11] For other studies of the concentration of manufacturing industries in Spain, see Callejón (1997), Paluzie et al. (2004), and Jofre Monseny and Viladecans Marsal (2007), which use alternative indices for earlier periods.
[12] For a classification of manufacturing industries based on technology, see OECD (2007), annex 1.1.
[13] Sectors **23**, **25**, **29** and **31** also show a concentration reduction according to the four indexes given in Table 1, but the employment Lorenz curves does not show dominance among 1996 and 2008 (in some sectors the absolute Lorenz curves of both years cross, in others sectors the cross occur between the standard Lorenz curves, and in others there are crosses in both cases). Therefore, in these sectors other inequality-based concentration indexes also consistent with Lorenz could lead to a different conclusion.

	Differences between 2008 and 1996				
Manufacturing industries	Ψ_1	Ψ_2	G	Φ	**Employment**
15 *Manufacture of food products and beverages*	0.001	-0.004	0.003	-0.000177	104,430
16 *Tobacco industry*	0.866	9.946	0.065	-0.000018	-2,417
17 *Textile industry*	-0.061	-0.051	-0.037	-0.000973	-9,866
18 *Clothing and fur industry*	0.098	0.199	0.048	-0.001127	-49,863
19 *Preparation, tanning and dressing of leather; manufacture of leather goods and luggage articles*	0.184	0.672	0.026	-0.006091	-35,718
20 *Wood and cork industry, except furniture; basket making and wickerwork*	-0.047	-0.053	-0.040	-0.000042	29,803
21 *Paper industry*	0.036	0.059	0.000	0.000014	7,753
22 *Publishing, graphic arts, and reproduction of recorded supports*	0.013	0.028	0.017	0.000256	41,761
23 *Manufacture of coke, refinement of petroleum and treatment of nuclear fuels*	-0.242	-1.091	-0.048	-0.000018	5,578
24 *Chemical industry*	-0.017	-0.019	0.001	0.000380	64,823
25 *Manufacture of rubber and plastic products*	-0.022	-0.047	-0.004	-0.000164	19,192
26 *Manufacture of other non-metallic ore products (Glass, ceramic products, bricks, tiles, cement, etc.)*	-0.049	-0.023	-0.068	0.000249	53,913
27 *Metallurgy*	-0.223	-0.554	-0.087	-0.001383	27,706
28 *Manufacture of metal products, except machinery and equipment*	-0.049	-0.055	-0.074	-0.000459	162,922
29 *Machinery and mechanical equipment construction industry*	-0.061	-0.063	-0.065	-0.000112	85,798
30 *Manufacture of office machines and IT equipment*	0.211	0.548	0.056	-0.000064	-6,761
31 *Manufacture of electrical machinery and material*	-0.066	-0.097	-0.035	-0.000127	22,561
32 *Manufacture of electronic material; manufacture of radio, television and communications apparatus*	-0.081	-0.071	-0.028	-0.000019	6,695
33 *Manufacture of medical-surgical, precision and optical equipment and instruments, and clocks and watches*	0.100	0.123	0.071	0.000043	9,407
34 *Manufacture of motor vehicles, trailers and semi-trailers*	-0.006	-0.042	0.015	-0.000338	51,470
35 *Manufacture of other transport material (Ships, railway material, aircraft, bicycles, motorcycles, etc.)*	-0.059	0.177	-0.040	0.000493	22,988
36 *Manufacture of furniture; other manufacturing industries (Jewelry, musical instruments, sport articles, toys, etc.)*	-0.035	-0.046	-0.028	-0.000699	39,380
37 *Recycling*	0.045	-0.244	0.035	0.000008	5,317

Table 1: Concentration and employment differences between 2008 and 1996.

Note that in this set of sectors, we find both a small industry with a moderate employment growth (**32**) and large industry with a remarkable employment growth (**28**). Consequently, the size of the sector does not determine the sign of the concentration change when using concentration measures based on “absolute” inequality, i.e., a big employment increase does not necessarily leads to higher concentration. However, one should note that the larger the employment increase in a sector, the more difficult it is to reduce its concentration according to this kind of measures since it requires departing more and more from its initial distribution.

On the contrary, sector **33,** which is a high-tech sector having an employment level in 1996 similar to that of sector **32** and experiencing a similar employment growth, has increased its concentration level not only according to “absolute” but also “relative” inequality-based measures. This suggests, that the concentration augment has been particular intense for this industry.

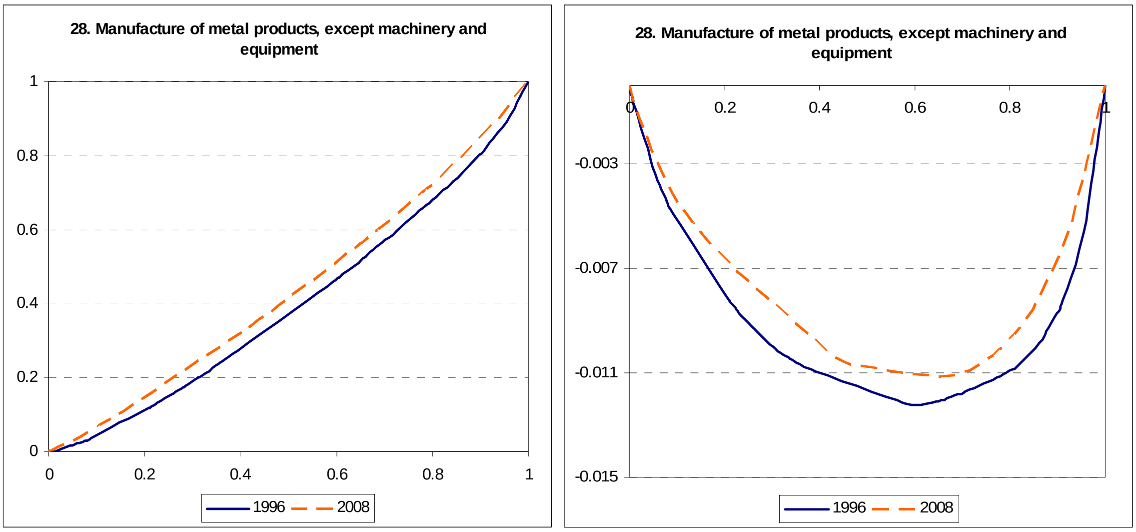

Figure 3. “Relative” Lorenz curves (left) and “absolute” Lorenz curves (right) for sector **28** in 1996 and 2008.

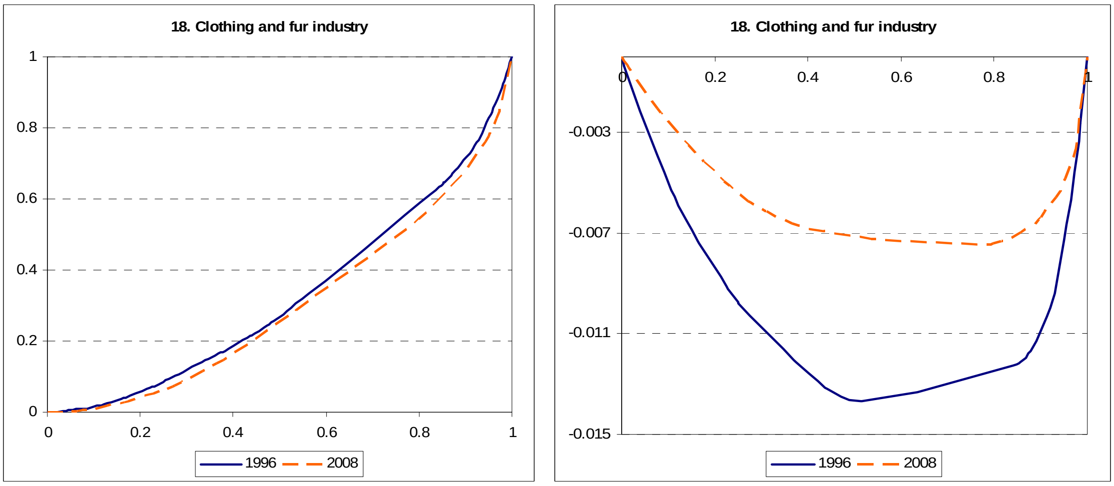

Figure 4. “Relative” Lorenz curves (left) and “absolute” Lorenz curves (right) for sector **18** in 1996 and 2008.

Among the five industries which lost employment along the period, most of which are low-tech, we find that four of them (**16**, **18**, **19**, and **30**) experienced a reduction according to “absolute” inequality-based measures but not according to “relative” measures (which are more demanding when employment declines). The case of sector **18** is shown in Figure 4. This suggests than the concentration reduction in these sectors has not been too intense since even though the number of workers in each location has became closer to what would be expected according to the distribution of reference, the proportion of workers in each location are further away.

4.2 Decompositions of index Φ in 2008

When analyzing concentration in 2008, we find important discrepancies between Φ and the remaining indexes (see Table 4 in the Appendix, where industries are ranked in descending order according to Φ). In fact, the Spearman correlation coefficient between them ranks between -0.41 and -0.31. It is important to note, however, that all of them coincide in classifying sector **19** (leather industry) in the group of the most concentrated sectors, which suggests that the agglomeration of this industry is rather intense. Therefore, the use of the variance-type concentration measure does not prevent a small industry from being classified as highly concentrated (nor a large sector from being low concentrated, as is the case of sector **28**, manufacture of metal products). In what follows, we explore concentration in more detail by using the decompositions of index Φ.

Decomposition by subindustries

We now analyze whether the concentration level of each manufacturing industry in Spain is mainly due to the concentration of each subindustry at the three-digit level taken separately or whether, on the contrary, there are strong spatial interdependencies among them.

Table 2 illustrates the decomposition of index Φ by subsectors (see Section 3, expression (2)) so that for each manufacturing industry at a two-digit level two components are given: one showing the summary contribution of its subindustries at a three-digit level to the concentration of the industry and the other showing the concentration due to the locational interdependencies among subindustries. Focusing on the most concentrated industries, we observe that the contributions of both factors are rather similar in the case of sectors **24** and **27** (55.5%-44.5% in the former case and 57.9%-42.1% in the latter; see Table 2, columns 3 and 4). Consequently, the spatial interdependencies among subsectors in the *Chemical industry* and in *Metallurgy* are remarkably high (perhaps due to knowledge spillovers in the former case and to input-output linkages in the latter). Something similar happens in the case of *Manufacture of food products and beverages* (**15)** and *Manufacture of motor vehicles, trailers and semi-trailers* (**34)**, even though at a lower degree**.** However, in sectors **19** and **26**, the spatial interdependencies among subsectors are much lower.

Manufacturing industries **2008**	**Number of subindustries** (S)	$\Phi\left(x;t\right)$	$\frac{\sum_{s}\Phi\left(x^{s};t\right)}{\Phi\left(x;t\right)}$ **(%)**	$\frac{2\sum_{s=1}^{S}\sum_{s'>s}\tilde{\Phi}\left(x^{s};x^{s'};t\right)}{\Phi(x;t)}$ **(%)**
15	9	0.00626	63.29	36.71
16	1	0.00008	100.00	0.00
17	7	0.00076	40.95	59.05
18	3	0.00080	107.06	-7.06
19	3	0.00195	87.67	12.33
20	5	0.00071	84.39	15.61
21	2	0.00013	93.02	6.98
22	3	0.00153	62.79	37.21
23	3	0.00013	100.69	-0.69
24	7	0.00197	55.47	44.53
25	2	0.00050	115.14	-15.14
26	8	0.00412	94.79	5.21
27	5	0.00196	57.92	42.08
28	7	0.00090	136.81	-36.81
29	7	0.00155	50.76	49.24
30	1	0.00002	100.00	0.00
31	6	0.00036	85.51	14.49
32	3	0.00011	63.00	37.00
33	5	0.00011	75.40	24.60
34	3	0.00393	67.72	32.28
35	5	0.00164	93.60	6.40
36	6	0.00110	88.20	11.80
37	2	0.00002	105.10	-5.10

Table 2: Concentration index Φ of each manufacturing industry at a two-digit level in 2008 and decomposition by subsectors at a three-digit level.

With respect to the industries with low concentrations, we see that in most of them, the spatial interdependencies among subsectors are low or even negative. Exceptions to this pattern are two high-tech industries: *Manufacture of electronic material; manufacture of radio, television and communications apparatus* (**32**), and *Manufacture of medical-surgical, precision and optical equipment and instruments, and clocks and watches* (**33**), which present important internal interdependencies. In fact, this pattern is generally shared with the remaining high-technology industries, which suggests that externalities among firms may play a role that exceeds the three-digit industrial classification.

Decomposition by location groups

We now raise another question. Is it relevant to classify Spanish provinces according to their per capita GDP levels in order to explain the spatial concentration of manufacturing industries? In order to find an answer, provinces were classified into three groups of similar sizes: one including the poorer provinces (those having a per capita GDP lower than 85% of the national average), another including those with an intermediate level (between 85% and 105%), and another including the richest provinces.[14]

Manufacturing industries (two-digit) 2008	Φ	$\frac{X}{T}$ %	**Within component** %	**Between component** %	$\frac{X_k}{T_k}$		
					Poor %	**Intermediate %**	**Rich %**
15	0.00626	15.9	64.62	35.38	24.15	17.75	12.02
16	0.00008	0.17	97.24	2.76	0.1	0.42	0.07
17	0.00076	2.9	97.97	2.03	2.69	3.55	2.66
18	0.00080	2.9	90.33	9.67	3.8	3.9	2.09
19	0.00195	1.62	93.20	6.80	1.92	3.35	0.65
20	0.00071	3.71	75.44	24.56	4.58	5.48	2.53
21	0.00013	1.47	95.41	4.59	1.16	1.25	1.69
22	0.00153	5.85	86.06	13.94	4.66	4.03	7.19
23	0.00013	0.57	97.10	2.90	0.97	0.44	0.49
24	0.00197	6.66	70.86	29.14	3.68	4.37	8.87
25	0.00050	3.43	90.28	9.72	2.12	4.16	3.54
26	0.00412	6.88	98.38	1.62	7.68	7.82	6.13
27	0.00196	3.8	99.10	0.90	2.95	4.06	3.98
28	0.00090	12.53	98.91	1.09	12.46	13.04	12.3
29	0.00155	8.23	57.83	42.17	4.49	6.29	10.52
30	0.00002	0.26	81.87	18.13	0.08	0.02	0.45
31	0.00036	2.98	98.31	1.69	2.69	2.73	3.21
32	0.00011	1.06	88.82	11.18	0.5	0.84	1.37
33	0.00011	1.16	97.18	2.82	0.8	1.23	1.25
34	0.00393	7.45	83.16	16.84	4.25	4.99	9.82
35	0.00164	2.65	91.14	8.86	5.01	2.63	1.81
36	0.00110	7.45	94.93	5.07	8.93	7.4	6.95
37	0.00002	0.36	97.49	2.51	0.32	0.27	0.42

Table 3: Concentration index and weight of each manufacturing industry at a two-digit level in 2008 and decomposition by groups of provinces according to their GDP in 2005.

Table 3 shows the decomposition of index Φ in the within and between components, as explained in Section 3, expression (1). We can see that this categorization of provinces is especially relevant to explaining the concentration of two highly concentrated sectors: **15** and **24**, since the between components explain about 30-35% of the concentration of the

[14] The latest available data at provincial level corresponds to 2005, and they are also offered by the *INE*. The first group includes the poorest provinces: Cádiz, Córdoba, Granada, Huelva, Jaén, Málaga, Sevilla, Ávila, Salamanca, Zamora, Albacete, Ciudad Real, Cuenca, Toledo, Badajoz, Cáceres, Lugo, Ourense, and Pontevedra. Almería, Huesca, Teruel, Asturias, Las Palmas, Santa Cruz de Tenerife, Cantabria, León, Palencia, Segovia, Soria, Valladolid, Guadalajara, Alicante, Valencia, A Coruña, Murcia, Ceuta, and Melilla are included in the second group while Zaragoza, Illes Balears, Burgos, Barcelona, Girona, Lleida, Tarragona, Castellón, Madrid, Navarra, Álava, Guipúzcoa, Vizcaya, and La Rioja are in the third group.

corresponding sector (see column four). Note, however, that while the former, *Manufacture of food products and beverages,* is overrepresented in the poorest provinces, the latter, *Chemical industry,* is mostly found in the richest ones (see columns five and seven). In the remaining concentrated sectors, this classification is less important. In fact, in the case of sectors **26** and **27**, the between component is irrelevant. Finally, note that sector **29** (which has an intermediate concentration level) is the one having the highest between component (over 42%), mainly due to the overrepresentation of the sector in the richest provinces. Even though in the remaining high- and medium-technology sectors (**24**, **30**, **31**, **32, 33** and **34**) the between component is much lower than in sector **29**, in all of them we find overrepresentation of the sector in the richest provinces.

5. Conclusions

This paper has reflected about the invariance property that the literature on regional economics is implicitly assuming when using the locational Gini coefficient and the GE family of concentration indexes, which are derived from "relative" inequality measures. In addition, a new concentration measure has been proposed. It has been analytically argued that this variance-type measure, based on an "absolute" inequality index, is also suitable to quantify the concentration of economic activity. Thus, as in the case of the locational Gini coefficient and the GE family, this variance-type measure satisfies several basic properties borrowed from the literature on income distribution and occupational segregation. In line with the GE family, it is also decomposable, which is very helpful for empirical research on industrial location. In addition, the new measure is consistent with the absolute Lorenz criterion, which, as far as we know, had not been used yet in a location context.

These inequality-based concentration measures have been subsequently used to quantify the geographic concentration of manufacturing industries in Spain by following a *relative* approach, so that the distribution of each sector was compared with that of the whole manufacturing industry. All the indexes coincide in classifying the leather industry among the most concentrated sectors, which suggests that the concentration of this sector is a robust result against changes in the concentration-invariance condition. This study reveals that the use of the variance-type index does not prevent a small industry from being classified as highly concentrated (as is the case of the above industry) or a large sector from belonging to the group of medium-low concentrated industries (as it is the case of manufacturing of metal products). In the latter sector, we have also shown that the remarkable increase experienced by this sector between 1996 and 2008 was accompanied by a reduction of both the locational Gini index (together with the GE family) and our variance-type index, which suggests that this concentration reduction has been intense.

The decomposition of the variance-type index by subindustries showed that in all high-tech industries, the spatial interdependencies among their corresponding subindustries are remarkably high (which is in line with the result obtained by García Muñiz et al., 2009, since they find that knowledge spillovers may be working as an important source of agglomeration in this kind of sector).

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Appendix

Inequality-based concentration measures: An illustration in a two-location economy

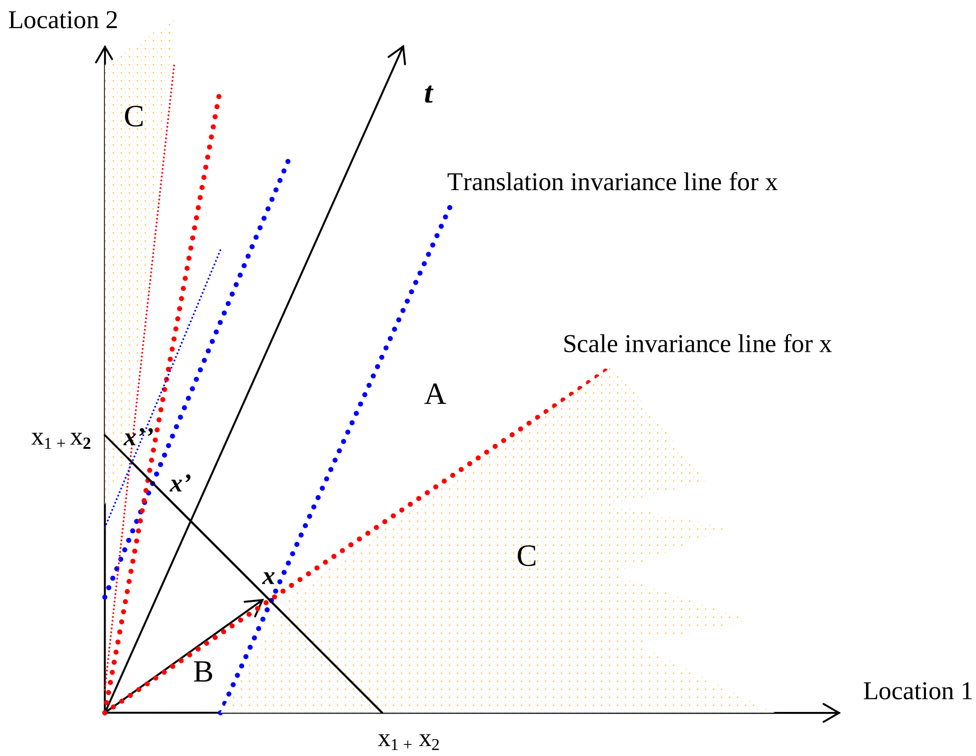

Figure 5. Regions of convergence and diverge between the translation and scale criteria in a two-location case.

Given two-dimensional vectors x and t, there is a limit vector, x', with the same employment level as x (i.e., $x_1 + x_2 = x'_1 + x'_2$), such that those distributions in the segment given by x and x' have lower concentration than x for any index consistent with the Lorenz criterion (either absolute or relative, since both criteria coincide when the level of employment in the sector is the same). Note than, as shown in Figure 5, x' does not have to be at the same "distance" from t than x. Concentration in those distributions located between the translation (scale) invariance lines of x and x' is lower than in x according to the translation (scale) invariance notion. Therefore, the "translation-concentration-reducing" region is included in the "scale-concentration-reducing" region when the employment of the sector rises while the opposite happens when it diminishes. In other words, concentration according to the translation criterion is more demanding when employment increases and less demanding when it decreases. The C regions include those distributions having more concentration than x according to both criteria. These distributions can be found either at the RHS of the two invariance lines corresponding to x or at the LHS of the corresponding invariance lines of a limit distribution x'', which is the first distribution having the same employment than x and but a higher concentration level according to the Lorenz criterion. The region defined by x' and x'' consists of those distributions where their absolute and/or standard employment Lorenz curves cross with those of x.

Concentration in 2008

MANUFACTURING INDUSTRIES (two-digit) 2008	Φ	Ψ_1	Ψ_2	G	$\frac{X}{T}$ **(%)**
15 *Manufacture of food products and beverages*	0.00626	0.11	0.12	0.26	15.90
26 *Manufacture of other non-metallic ore products (Glass, ceramic products, bricks, tiles, cement, etc.)*	0.00412	0.25	0.43	0.33	6.88
34 *Manufacture of motor vehicles, trailers and semi-trailers*	0.00393	0.39	0.35	0.47	7.45
24 *Chemical industry*	0.00197	0.22	0.22	0.37	6.66
27 *Metallurgy*	0.00196	0.46	0.68	0.49	3.80
19 *Preparation, tanning and dressing of leather; manufacture of leather goods and luggage articles*	0.00195	1.63	3.72	0.83	1.62
35 *Manufacture of other transport material (Ships, railway material, aircraft, bicycles, motorcycles, etc.)*	0.00164	0.68	1.17	0.59	2.65
29 *Machinery and mechanical equipment construction industry*	0.00155	0.11	0.11	0.24	8.23
22 *Publishing, graphic arts, and reproduction of recorded supports*	0.00153	0.21	0.22	0.36	5.85
36 *Manufacture of furniture; other manufacturing industries (Jewelry, musical instruments, sport articles, toys, etc.)*	0.00110	0.09	0.10	0.23	7.45
28 *Manufacture of metal products, except machinery and equipment*	0.00090	0.03	0.03	0.13	12.53
18 *Clothing and fur industry*	0.00080	0.32	0.48	0.39	2.90
17 *Textile industry*	0.00076	0.42	0.45	0.48	2.90
20 *Wood and cork industry, except furniture; basket making and wickerwork*	0.00071	0.21	0.26	0.35	3.71
25 *Manufacture of rubber and plastic products*	0.00050	0.23	0.21	0.35	3.43
31 *Manufacture of electrical machinery and material*	0.00036	0.20	0.20	0.34	2.98
23 *Manufacture of coke, refinement of petroleum and treatment of nuclear fuels*	0.00013	1.20	2.02	0.76	0.57
21 *Paper industry*	0.00013	0.28	0.30	0.37	1.47
32 *Manufacture of electronic material; manufacture of radio, television and communications apparatus*	0.00011	0.51	0.50	0.52	1.06
33 *Manufacture of medical-surgical, precision and optical equipment and instruments, and clocks and watches*	0.00011	0.44	0.39	0.49	1.16
16 *Tobacco industry*	0.00008	2.67	14.95	0.93	0.17
30 *Manufacture of office machines and IT equipment*	0.00002	1.22	1.64	0.76	0.26
37 *Recycling*	0.00002	0.70	0.67	0.59	0.36

Table 4: *Relative* concentration indexes and weights of two-digit sectors in 2008.

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