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Measures of Economic Segregation
An application to French data

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by

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Abstract: As various studies have shown (eg, Maurin (2004)), most cities have a stratification of residential space, separating wealthy districts from poorest neighborhoods with a concentration of social and economic difficulties. Most of the previous studies analyzing segregation have focused on racial segregation, whereas economic segregation has received little attention in the literature. We study here the spatial dimension of economic and social inequalities, analyzing the allocation between neighborhoods of households themselves unequal in terms of income. We formalize the issues we should address while measuring segregation and analyze some indexes. We then provide an empirical study for several urban areas in France among five years.

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Table of contents

Introduction

With the raising urbanization appears also the phenomenon of segregation, i.e. the separation for special treatment or observation of individuals or items from a larger group. In the literature the segregation by ethnics, gender has been widely documented (e.g. Cutler and Gleaser) especially in the United States but few studies have been done concerning economic segregation, that is, the spatial segregation of households by income.

This work aims to provide a better understanding in the phenomenon of economic segregation, Through the presentation of few indexes and an empirical application to French data.

The main issue when we analyze the phenomenon of economic segregation is its measure.
Indeed, when we want to measure segregation, some issues have to be addressed:
What do we mean by segregation, in other terms, what do we want to measure?
What would be a "good" measure of segregation, what kind of properties can we expect from the index we use?

These questions have to be answered in order to justify the computation of an index.

We thus first introduce the meaning of segregation, highlighting the interest of the topic through the exposition of its causes and consequences (Section 1). We then formalize the issue concerning the measurement of segregation and expose some desirable properties that an index should respect, we also present some issues which can be faced while measuring segregation (Section 2), we then provide an empirical study for the French urban areas among 5 years. (Section 3)

1. Motivations

1.1. What is economic segregation?

The meaning of "segregation" has expanded over time; it means at once a behavior, a state and a process. Initially, the term comes from the Latin "segregare" which means "to separate the herd, isolate, remove, set aside, reject ". Etymologically, the segregation is therefore a rejection behavior against an individual or a group of individuals. In its original sense, segregation refers therefore to a deliberate act of exclusion social, institutionalized or not, to a group distinguished by the dominant group real characteristics (ethnocultural, color, religion, etc..) or assumed (noise, crime, etc..). The segregation of blacks in the United States (legal between 1870 and 1964),the establishment of Jewish ghettos, the caste of untouchables in India or apartheid in South Africa are stark examples of institutionalized segregation in the original sense of the word.

Since the mid-twentieth century, the concept of segregation has however been a semantic shift. In common use today, the residential segregation described also the urban configuration that results from this rejection behavior. It describes a "space organization in areas of high internal social homogeneity and social disparities between them"(Castells (1972)). In this sense, segregation has two dimensions, social and spatial, and is synonymous with social differentiation or segmentation of space.

1.2. Causes of segregation

We expose in this paragraph some explanations of the phenomenon of segregation.

Why are cities segregated? Economic theory brings several answers that we will try to summary in this section.

A result of the competition on the land market

First, the land market plays a separator and urban segregation may result simply from the competition between these families to live in a metropolitan area. If we assume that jobs are all located in one center, one can consider that in their residential choice families make a choice between finding reduction costs of transportation to work, or locate in the periphery, where the land is present in greater quantity. The land market is competitive; the homes are allocated to the highest bidder.

In the presence of families with different characteristics, such competition leads to a stratification of the urban space.

Other explanations can be found with the Tiebout model developed in the 50s (Tiebout, (1956)). Individuals who have different preferences for the provision of public goods have the opportunity to "vote with their feet” by locating in homogeneous municipalities where they optimize their consumption of public good financed by local taxes. Thus differences in preferences for local amenities (parks, green spaces, cultural activities and sports offered by municipalities ...) **can** cause a stratification resulting solely from the free choice of families to locate. It is important to point that the segregation by preference does lead to segregation by income under particular condition on the individuals’ preferences (see Gravel and Thoron, 2007).

The preferences of individuals and families can also take into account the ethnic or social composition in their neighborhood. Other model explaining spatial stratification is the one's developed by Shelling,

Known as "the tyranny of small decisions," Schelling (1978) shows in its micro-economic model of spatial proximity how an integrated city can become segregated according to the preferences of individuals in relation to the composition of their neighborhoods (*tipping -process*). Even if no individual wants to be in a homogeneous group, seeking proximity to a minimum of similar people can lead to a situation of segregation.

Looking for positive externalities

Some also refer to a phenomenon of communitarianism, or a willingness to "the inter-se" (Donzelot, 2004), the phenomenon of segregation could correspond to the fact that agents are looking for positive externalities; "Cities are not just about production (…) just as the elimination of transport costs between firms improves productivity, eliminating transport costs between people can radically alter social life", (Gleaser and Gottlieb, 2006).

Some individuals of the same group choose to live near each other to take advantage of different forms of solidarity and mutual assistance.

To test these hypotheses, Cutler and Gleaser based their analysis on the relationship between the level of segregation and the housing price differential between blacks and whites. The segregation in housing is the result of preferences of white if the increase is associated with a decrease in the relative housing costs for blacks and whites. However it would be the consequence of discrimination and / or preference of blacks for black neighborhoods if the increase is accompanied by an increase of the price difference between blacks and whites.

After computing a regression with 237 metropolitan areas, they show that segregation is the result of preferences of white people who are willing to pay more to live in white neighborhoods.

Roland Benabou has proposed an interesting illustration of this process of externalities for the case of education externalities. This author believes that individuals mobile within a city choose their location from between two neighborhoods and their level of training, low or high. In each neighborhood, the cost of training decreases with the proportion of locally qualified individuals who reside there. However, this cost decreases more for high training than for low training. Individuals wishing to acquire a High training are therefore willing to pay a higher price to avoid negative externalities of low-skilled people (The coexistence with the latter being raising their training cost).

In this context, there is a mechanism of cumulative drain Individuals wishing to acquire a high qualification. And the more a neighborhood becomes qualified, the more it becomes attractive. The "snowball" effect continues until lead to a total segregation of populations. This model seems quite appropriate to explain the stratification of a French town where the production of education is actually locally segmented since the principle of the “carte scolaire” makes it compulsory to go in the school located in the area of residence.

1.3. Why does it matter?

Often, socio-spatial segregation refers more specifically to the stratification of residential space, pitting wealthy districts to less affluent neighborhoods with concentrations of social and economic difficulties, as several studies have shown (e.g Maurin, (2004))

According to the 1990 census, the population in the metropolis areas was of 4.7 million (or one in every 12), in ZUS. A significant fraction of the population of ZUS lived in the Paris area (27%), mainly in the suburbs, or in another large metropolitan area (18%). Compared to the settlement which they belong, the ZUS had a higher proportion:

- Unemployed (18.9% against 11.6%)
- People whose income is at least composed of one quarter of social benefits (26% against 14%)
- People living in public housing (62% against 22%)
- Workers or employees (50.6% against 33.2%)
- In households where the reference person is a foreigner (15.8% against 8.1%)
- Youth under 25 year old (43% against 34.7%)
- Young people aged 15-24 who do not pursue their studies (47.2% against 39.1%)
- In non-graduates among young people over 15 who have completed their studies (39.3% against 26.8%)

Source: Ségrégation urbaine et intégration sociale, rapport de CAE (2004)

The study of segregation has often concerned both economists and sociologists. The literature emphasizes in particular the negative consequences of urban segregation, in access to employment or further training of human capital have often been addressed, thus highlighting its adverse effects on the stability and functioning of society .

The consequences of segregation

What are the effects of residential segregation? There is an abundant literature showing that the lack of urban diversity can have very negative effects (e.g Maurin (2004)).
Segregation is strongly present in political discourse on the city. Examples include the debates on the *sensitive* suburbs, especially after the suburban riots of 2005. Studies on the economic impact of segregation are based generally on the issue of accessibility to employment and positive and negative externalities that can explain the problems of unemployment, school failure or criminality.
Cutler and Gleaser (1997) for example examined the effects of segregation on the education, employment and single parenthood of black Americans. They show a net negative impact on the population in segregated areas.

Most studies address the issue of spatial segregation and its negative consequences in terms of inequality and social justice. The long-term segregation can indeed be very important; « spatial disparities increase poverty in the short run and also reduce equality of opportunity and therefore contribute to inequality in the long run » (Jargowsky, 2002)

Implications in terms of public policy

Willingness to fight against economic and social manifestations of segregation has led to the emergence of the objective of social mix, which means the mixture and diversity of social groups and urban functions.

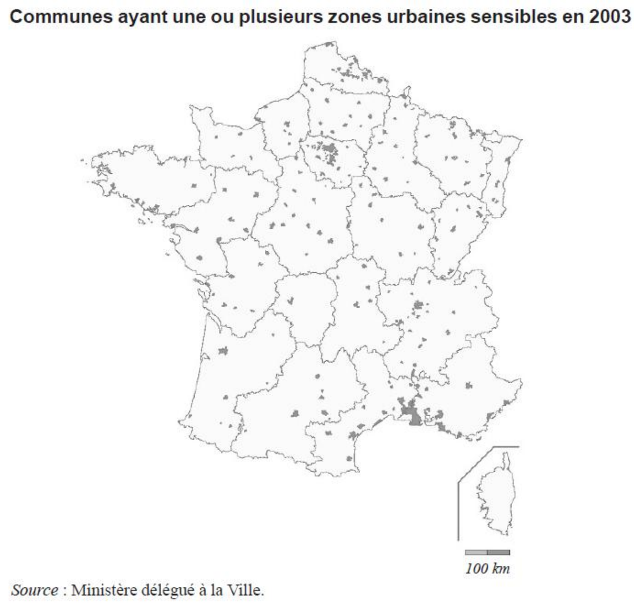
One of the public policy goals has been to improve the attractiveness of segregated neighborhoods; in the early 80s the fight against social segregation resulted in a policy known as "politique des grands ensembles," whose objective was to reduce the level of social homogeneity of these areas and improve access to employment and various services for their inhabitants.

From the years 90 and facing the failure to rehabilitate these areas other operations have been launched across urban renewal programs. With operations of demolition / reconstruction of housing (with the Borloo law in particular).

In 1997, new tools are developed with the creation of Urban Zones to enable enterprises locating in these areas to be exempt from taxes.

Creating Sensitive Urban Zones (ZUS) should also allow an exemption of rents for the most privileged households to prevent their departure and attract more affluent households. There are 751 ZUS in France; the following map shows their distribution in the territory.

Map 1: Municipalities with one or several sensitive areas in 2003



Source : ministère délégué à la ville.

Priority Education Zones (ZEP) are also affirmative action designed to fight against social reproduction.
Finally, the implementation of the Framework Act on the City (Loi d'Orientation sur la Ville, LOV) and the Act of Solidarity and Urban Renewal (SRU) has shifted the political struggle against the segregation from the single district toward agglomeration. The objective of the SRU law is to encourage municipalities with fewer than 20% of social housing to build more, which would allow a greater territorial equity in the distribution of social housing. The municipalities that do not meet these quotas are subject to penalties.
This law clearly raises questions about its effects, firstly, the HLM in wealthy municipalities would may be occupied by people already living in these communities, and in this case the law might not lead to a better spatial distribution of populations.
How otherwise ensure that the location of the "new" public housing in the richer municipalities will be uniform throughout the territory of these municipalities: Is there a risk to create groups of isolated individuals with no social interaction with the rest of the town? (Selod, 2004)

These questions remain open and need to respond to operate and develop tools to measure the phenomenon of segregation in order to provide more specific information about its scale and its evolution.

2. Measuring economic segregation

2.1. Dimensions of segregation

Segregation is a phenomenon which presents several dimensions, most of the studies concerning urban segregation concern racial segregation or segregation by social classes (eg Cutler and Gleaser (1997)), indeed the literature concerning segregation has especially focused on discrimination more than on the distribution of individuals with different income in different neighborhoods. Many indicators have been developed for the purpose of analyzing discrimination (Duncan and Duncan, (1955))). Massey and Denton (1988) compiled, augmented, and compared these measures and used cluster analysis with 1980 census data from 60 metropolitan areas to identify five dimensions of residential segregation: evenness, exposure, concentration, centralization, and clustering. We present here the definitions of these dimensions (Massey and Denton, (1988))

• *Evenness* involves the differential distribution of the subject population.

The most widely used measure of evenness is the dissimilarity Index, which measures the percentage of a group's population that would have to change residence for each neighborhood to have the same percent of that group as the metropolitan area overall.

For example, if a city is divided into three districts of equal size. Suppose there are one third of blacks in the total population. If we find one third of blacks in each district, then the index of dissimilarity is zero. If instead the entire black population is concentrated in one area, then the index of dissimilarity is maximum.

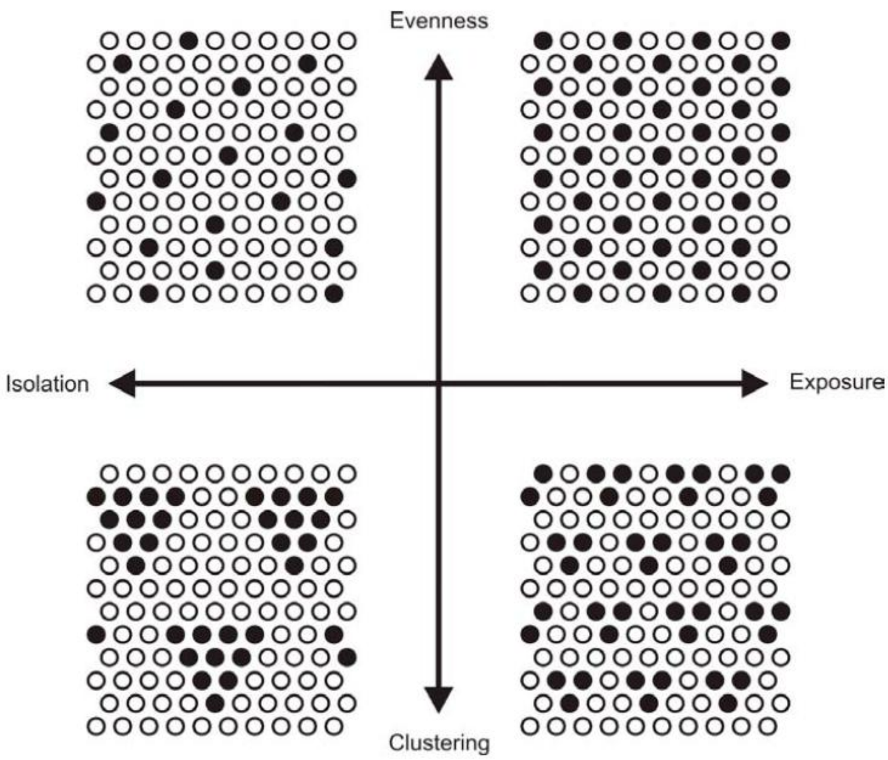
• *Exposure* measures potential contact. To measure the exposure, the most used index is the isolation index. This is the weighted sum of the minority in each district. In the first example, the isolation will be 1 / 3 because we found in each district one third of black people. If all blacks are concentrated in one area (which does not contain whites), both indexes agree that segregation is equal to 1.

• *Concentration* refers to the relative amount of physical space occupied. Concentration is a dimension that takes into account the characteristics of a physical space. A group is considered concentrated if it occupies a small area within the city. Some studies consider a group as being concentrated in a city when the population occupies spatial units where they are the majority, taking into account internal homogeneity and social interactions dimensions.

• *Centralization* indicates the degree to which a group is located near the center of an urban area. This dimension is more adapted to the context of metropolitan U.S. cities, where in most of them the most disadvantaged ethnic minorities are located in the most dilapidated inner city's neighborhoods. In contrast, the image and the place of the historic center is different from one city to another. In France, the center represents many opportunities for jobs and services and households have a preference for central amenities. In this case, the reasoning can be reversed because it is the distance from the center that can be considered a component of spatial segregation.

• *Clustering* measures the degree to which minority group members live disproportionately in contiguous areas. It also takes into account the spatial dimension through the contiguity between the residential units. In general, groups that occupy space adjacent units, forming an enclave, are considered segregated, in contrast to groups occupying more dispersed spatial units

Graphic 1: Dimensions of segregation



Source : Reardon and O'Sullivan, P. 42

2.2. Indexes and properties

In order to measure economic segregation we need to specify some tools which enable us to answer to the problem we exposed in the introduction: How can we say if a city is more segregated than another one? How can we analyze the allocation between different neighborhoods of households or individuals, themselves unequal in terms of income?

Notations

We focus on the distribution of *N* households in *K* neighborhoods inside a global area (city, urban area)

Such as i=1,2,...N the individuals

k=1,2,...,K the neighborhoods. Each neighborhood is inhabited by N_k households.

Each of these household has an income noted x_i and belongs to one (and only one) neighborhood. Let denote the overall distribution of income:

$X = (x_1, ..., x_i , ... x_N)$

We know also that each individual *i* is allocated in a neighborhood *k*.

Each neighborhood k can thus been viewed as the set of individuals who choose to live in this neighborhood: *k* = { *i* : *i* is allocated in neighborhood *k* }.

An alternative notation is:

$X = (X^1 , \dots, X^k, \dots, X^K)$

Where X^k is the vector of incomes in the neighborhood k, $X^k = (x_1^k, \dots, x_i^k, \dots x_{N1}^k)$,$x_{i,}^k$ being the income of the ith individual in neighborhood k.

F(x) is the distribution of income in the global area (a city, an urban area…)

$F_k(x)$ is the distribution of income in the neighborhood k

In order to analyze the dispersion of the income distribution, we first need to calculate the *mean*; as we know the mean for a data set is the sum of the observations divided by the number of observations. The mean of a set of numbers $x_1, x_2, \dots, x_n$ is typically denoted by $\bar{x}$.

We denoted $\bar{x}$ the mean income in the global area (city, urban area)

$\bar{x}^k$ the mean income in the neighborhood *k*

The *variance* enables to characterize the dispersion of a distribution; we record here its formula:

$$VAR(x) = \frac{1}{N} \sum_i (x_i - \bar{x})^2 = \frac{1}{N} \sum_k \sum_i (x_i^k - \bar{x})^2$$

This would be the total variance in our city.

The *standard deviation* is the square root of the variance and is also widely used to measure the variability or dispersion.

Its formula is such as:

$$\sigma = \sqrt{VAR(x)}$$

Another measure of the dispersion is the coefficient of variation, such as:

$$c_v = \frac{\sigma}{\bar{x}}$$

The coefficient of variation is useful because the standard deviation of data must always be understood in the context of the mean of the data. The coefficient of variation is a dimensionless number. So when comparing between data sets with different units or widely different means, one should use the coefficient of variation for comparison instead of the standard deviation.

What interests us here is the allocation between different neighborhoods of households or individuals, themselves unequal in terms of income. In other terms we want to measure *economic segregation* inside an area such as a city.

How could we say whether a city is more or less segregated than another?

Suppose a city with K neighborhoods. We assume by simplicity that $\bar{x}^1 < \bar{x}^2 < \ldots < \bar{x}^k$ ($\bar{x}^k$ being the mean income of neighborhood k), that is, the neighborhoods are ranked by increasing ordered. A city can be considered as totally segregated if :

$\mathrm{Max}(x_{1,}^{k}, \ldots x_{N1}^{k}) < \mathrm{Min}(x_{1,}^{k+1}, \ldots x_{N1}^{k+1})$

That is, a city can be considered as totally segregated if the richest individual of the kth poorest neighborhood is poorer than the poorest individual of the (k+1)th poorest neighborhood (which is the neighborhood immediately richer than the former).

Suppose a city A where the poor household Income=10, median household income=20 and rich household income=30

And another city B where the poor household income=10, median household income=20 and rich household income=50. It should be said that B is more segregated than A.

An index (S) measuring segregation would enable us to rank two cities X and Y would be such as:

S: Rn → R+ more precisely, here, S: Rn → [0,1]

$$X > Y \; if \; S(X) < S(Y)$$

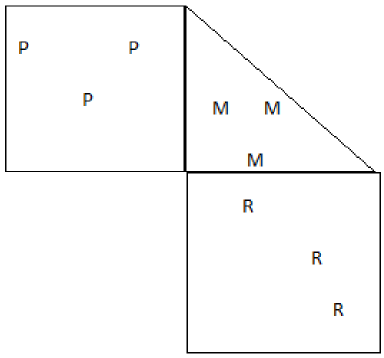
In other terms, the city X is more segregated than Y if the index S is smaller in this city.

Consider, for example, a city divided in 3 neighborhoods where, in each of them 3 inhabitants are located:

N=9; K=3

To simplify the analysis and introduce our concern we suppose 3 levels of individual income per year *r*, *p*, *m* (Rich/ Poor/Median).

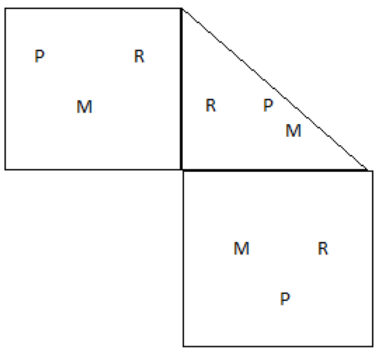
City A : Segregated



At the opposite, a city with no segregation would be composed by heterogeneous neighborhoods where individuals with different incomes are mixed, such as the mean income in each neighborhood would be equal to the mean income in the area.

In our example, city B can be represented such as:

City B: Not segregated

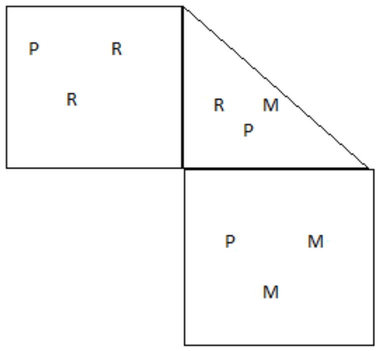


Both cities have the same mean income but face to complete different scenarios concerning the composition of their neighborhood.

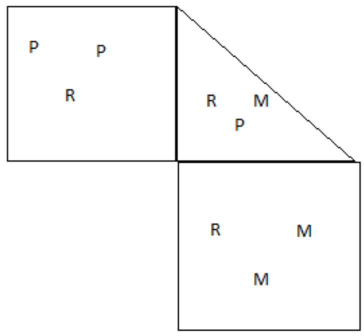
In the city B, the income distributions in the neighborhoods are the same.

But what can we say if we face different scenario such as:

City C:



City D:



We can see that the income distributions intra-neighborhoods intersect or overlap, which means that for instance, the richer in the poorest neighborhood is richer than the poorest household in the closest neighborhood richer.

An analysis of economic segregation thus requires examining the distribution of individual incomes in the neighborhoods and the disparities between the neighborhoods inside the city.

We thus expose in this section the usual tools used to measure income dispersion and present some indexes developed to measure economic segregation. To enable a good measure of segregation, these indexes have to respect some properties that we will also present in this section.

Index

To analyze the spatial segregation, several studies have used the decomposition of inequality of income distribution in the city between inequality between households within spatial units and inequality between households of different spatial units. The level of heterogeneity external and internal consistency defines the degree of segregation of the city (Castells, 1972). Some indicators of inequality at the individual level (I_i) can be easily disaggregated into a component measuring inequality *between* spatial units (I_k) and a component measuring inequality *within* spatial units (I_w).

According to this decomposition, the inequality is the sum of unequal *Inter-units* (districts, municipalities, river of life ...) and inequality *Intra-units*:

$$I_i = I_k + I_w \qquad (1)$$

Spatial segregation can be represented using an index (S) representing the part of the inequality between the spatial units in total inequality:

$$S = \frac{I_k}{I_i} \qquad (2)$$

From (1) and (2) : $\frac{I_k}{I_i} = \frac{Ik}{I_k + I_w}$ such as $0 < I_i \leq 1$

Thus : $S = \frac{1}{\left(\frac{I_w}{I_k}\right)+1}$ such as $0 \leq I_w \leq 1$ and $0 < I_k \leq 1$

This index is closed to 0 when $\frac{I_w}{I_k} \to +\infty$ and $I_k \to 0$ (Very low heterogeneity between spatial units).

However, it is maximum when $I_w = 0$ (Homogeneity of populations within the spatial units.) It thus takes into account both the inter-unit heterogeneity and homogeneity of intra-spatial units.

For instance, we can break down the variance into two components; a variance between (inter) and a variance within (intra), such as in our concern:

$$Var(x)=\frac{1}{N}\sum_{i}(x_i-\bar{x})^2=\sum(\frac{n_k}{N}(\bar{x}^k-\bar{x})^2)+\sum_{k}(\frac{n_k}{N})var(x^k)$$

Variance between Variance within

Where:

$$Var(x^k)=\frac{1}{N_k}\sum_{k}(x_i-\bar{x}^k)^2$$

This generalized principle here is the basis of several studies by economists and sociologists, primarily American, analyzing the spatial segregation from the continuous variable of income. Among the possible decomposable and objective measures of inequality, some rely on the standard deviation (Jargowsky, 1996, 1997, Yang and Jargowsky, 2006) or variance (Mayer, 2000), indices of generalized entropy (Mussard and Al, 2003) , or using a decomposable inequality index proposed by Bourguignon (Ioannides and Seslen, 2002)

We present here measurements based on the standard deviation, the most famous being that of Neighborhood Sorting Index (NSI) developed by Jargowsky (1996).

It is the ratio of standard deviation measures the inequality between the spatial units (σ_K)

On the standard deviation inequality between households (σ_N). This index is written:

$$NSI=\frac{\sigma_k}{\sigma_n}=\frac{\sqrt{(\sum_{k=1}^{K} n_k(\bar{x}^k-\bar{x})^2/N)}}{\sqrt{(\sum_{i=1}^{N}(x_i-\bar{x})^2/N)}}=\frac{\sqrt{(\sum_{k=1}^{K} n_k(\bar{x}^k-\bar{x})^2)}}{\sqrt{(\sum_{i=1}^{N}(x_i-\bar{x})^2)}}$$

The NSI has an intuitive interpretation in terms of the income distribution. As we mentioned before, each household in a metropolitan area has an income, and the distribution of these incomes has a mean and a standard deviation. In addition, each household is located in a neighborhood, we saw that each neighborhood has a mean income, and the distribution of households by the mean income of their neighborhood also has a mean and a standard deviation. (Jargowsky, 1996)

If all neighborhoods have the same mean income (i.e there is no economic segregation, as in the city B in our example) then the standard deviation of the neighborhood distribution is 0 and NSI would be 0 as well.

At the other extreme, if all households live in neighborhoods that have mean incomes identical to their own incomes, then the standard deviation of the neighborhood distribution will be identical to the standard deviation of the household distribution and NSI will be 1.

Therefore, values close to 1 indicate high levels of economic segregation.

The NSI is an ordinal index it enables to rank the cities, if $>_{NSI}$ is a range according to the NSI Index, we can compare two cities such as:

X $>_{NSI}$Y if and only if NSI(X)<NSI(Y)

If the NSI is lower in city X than in city Y thus X is less segregated than Y, according to the NSI criteria.

Desirable Properties

To be a good measure of segregation, we expect that indexes respect some properties. We describe now few intuitive desirable properties.

Property 1: Scale interpretability (Reardon and O'Sullivan)

An index of segregation should have a scale easily interpretable.

As we mentioned before, being equal to zero the NSI indicates all the community mean incomes ($\bar{x}_{k}$) are the same as the total average ($\bar{x}$) , and a value of 1 indicates that all the households reside in strictly homogeneous neighborhoods, with the each household's income exactly equal to the neighborhood's mean income. Thus, NSI is bounded between zero and one and the scale is easily interpretable.

Property 2: Transfers/ Exchanges

If poor households move from poor neighborhood to affluent neighborhoods or if the rich move in the opposite direction, a valid measure of economic segregation should decline.

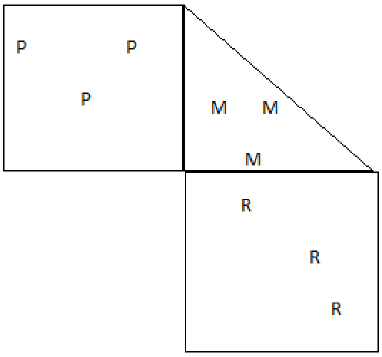
For instance in our city A strongly segregated, if we move an individual i from the rich neighborhood to the poor neighborhood, and an individual j from the poor neighborhood to the rich neighborhood, the NSI should decline.

Suppose a city, X, with N individuals and K neighborhoods. Suppose two individuals i and j such that : i is located in k and j in h ; $x_{i,}^{k} < x_{j,}^{h}$ and $\bar{x}^{k} < \bar{x}^{h}$. If the city Y is issued from X by the following way: $x_{i,}^{k} = y_{j,}^{h}$ and $x_{j,}^{h} = y_{i,}^{k}$ then Y is less segregated than X.

The mean income in the city remains the same, the mean income in the poor neighborhood increases, and the mean income in the rich neighborhood decreases, what would be the effect on the variance between the neighborhoods.

We illustrate numerically this property, in the city A segregated, we suppose the individuals levels of incomes per year such as:

P=10000; m=30000; R=50000



$\bar{x}=30000$

$\bar{x}^r=50000$

$\bar{x}^p=10000$

$\bar{x}^m=30000$

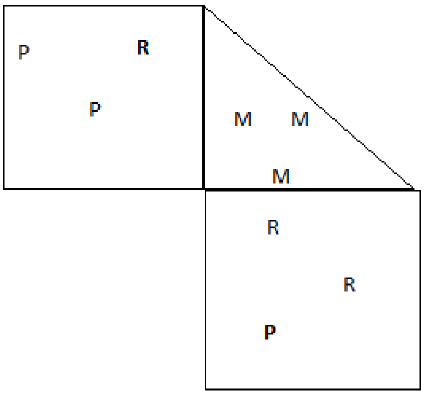
$\sigma_N=16329{,}9316$

$\sigma_k=16329{,}9316$

NSI=1

The standard deviation of the income between the neighborhoods equals the standard deviation of the income distribution of the individuals: $\sigma_K = \sigma_N$

The NSI is thus equal to 1 (property 1), if we exchange a rich individual in the rich neighborhood with a poor individual in the poor neighborhood,



$\bar{x}=30000$

$\bar{x}^r=36666{,}6667$

$\bar{x}^p=23333{,}3333$

$\bar{x}^m=30000$

σN=16329,9316

σk=5443,31054

NSI=0,33333333

Property 3: Organization equivalence and size invariance

James and Taeuber (1985) argued that since a segregation measure should permit comparison of districts that differ in the number of schools and the number of students, the measured segregation level should be unchanged if two organizational subunits with identical population composition and size are combined into a single unit or a single unit is split into two identical units. In our application, it would require that the measured level of economic segregation for a metropolitan area should be unchanged if two identical census tracts are combined.

In a similar vein, the combination of two identical districts into one should yield the same degree of segregation for the combined populations. For example, if the population of each neighborhood was doubled, without changing the relative distribution of persons on the relevant characteristics, segregation should not change. This is known as size invariance. (Jargowsky, 2005)

Suppose a neighborhood where all individuals have the same income x_{ik} . If we divide this neighborhood in two: The total variance remains the same, and the between-variance (the variance between the neighborhoods) will not be modified. Thus the NSI should stay stable.

Property 4: Homogeneity within neighborhood

If inequality of income decreases within a neighborhood, the city is more segregated.

If we realize a Pigou-Dalton transfer i.e. ceteris paribus if we transfer a part of income from a rich household to a poor household within a neighborhood k the income inequality inside the neighborhood will decrease, thus the Neighborhood will be more homogenous.

The more homogeneous the neighborhoods are, the higher the NSI.

Property 5: Independence of Arbitrary Boundaries

This criterion is related to modifiable aerial unit problem (MAUP).

The 'modifiable areal unit problem' (MAUP) arises in residential segregation measurement because residential population data are typically collected, aggregated, and reported for spatial units (such as census tracts) that have no necessary correspondence with meaningful social/spatial divisions. This data collection scheme implicitly assumes that individuals living near one another (perhaps even across the street from one another) but in separate spatial units are more distant from one another than are two individuals living relatively far from one another but within the same spatial unit. As a result—unless spatial subarea boundaries correspond to meaningful social boundaries—all measures of spatial and aspatial segregation that rely on population counts aggregated within subareas are sensitive to the definitions of the boundaries of these spatial subareas (Reardon and O'Sullivan, 2004).

Although King (1997) argued that MAUP can be solved based on aggregated data, it is largely agreed that MAUP cannot be solved unless all the individual data become available or boundaries are exactly matched to the boundaries of interest (Anselin, 2000).Any measure based data from arbitrary spatial boundaries will suffer from MAUP (Jargowsky, 2005).The application of NSI assumes data based on geographic boundaries, such as IRIS and therefore will not be entirely free from MAUP. But the IRIS are not built arbitrarily, they seem to have meaningful spatial divisions since they are uniform in their habitat type and their limits are based on large cuts in the urban fabric (main roads, railways, rivers ...). (See section 4.1 for an example of territory division in Rennes)

Conclusions:

We can thus conclude that The NSI respects

(1) The property of scale interpretability
(2) The property of transfers, exchanges
(3) Organization equivalence and size invariance
(4) Homogeneity within neighborhood

The NSI does not respect

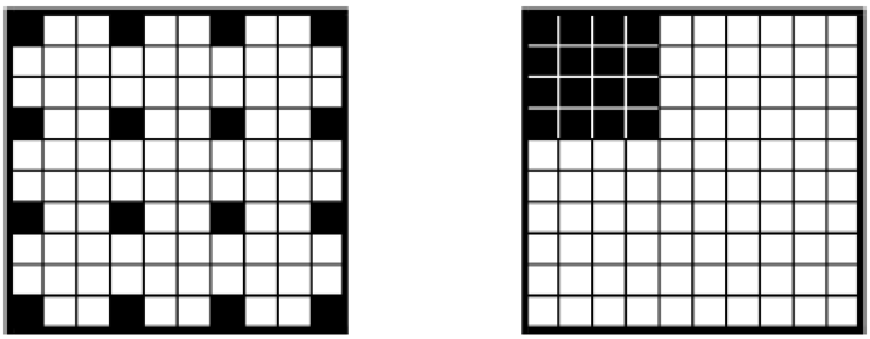
(5) The independence of arbitrary boundaries and is affected by spatial issues.

2.3. Spatial issues

The checkerboard issue

One of the most important issues while measuring segregation has been pointed out recently by scholars who highlights the fact that the most commonly used measures of segregation-such as the dissimilarty index, exposure index- are « aspatial », meaning that they do not adequately
account for the spatial relationships among residential locations. This issue has been called the checkerboard issue.
As explained by Reardon and O'Sullivan (2004) the 'checkerboard problem' stems from the fact that aspatial segregation measures ignore the spatial proximity of neighborhoods and focus instead only on the racial composition of neighborhoods. To visualize the problem, they propose to imagine a checkerboard where each square represents an exclusively black or exclusively white neighborhood. If all the black squares were moved to one side of the board, and all white squares to the other, we would expect a measure of segregation to register this change as an increase in segregation, since not only would each neighborhood be racially homogeneous, but most neighborhoods would now be surrounded by similarly homogeneous neighborhoods. Aspatial measures of segregation, however, do not distinguish between the first and second patterns, since in each case the racial compositions of individual neighborhoods are the same (White 1983). We can imagine the same example for rich and poor neighborhoods in a city, an aspatial index would not be able to give us information concerning the spatial relationships between these poor and rich neighborhoods.

Graphic 2: Illustration of spatial segregation scenarios :



Source: Rey and Folch (2009)

The NSI does not avoid though the checkerboard issue, under the different scenarios below, the NSI would give a same value. So Jargowsky and Kim later developed a generalized version of this index, called Generalized Neighborhood Sorting Index (GNSI)

A response to the checkerboard issue: The GNSI

The GNSI is calculated by means of a spatial weight Matrix that incorporates the spatial structure of the neighborhoods. The GNSI is written as follows:

$$GNSI_k = \frac{\left(\sum_{i}^{K} n_k (m_{\ln} - \bar{x})^2\right)}{\left(\sum_{i=1}^{N} (x_i - \bar{x})^2\right)} = \frac{(x' W'_k W_k x)}{(x' x)}$$

Where

x_{ln} is the mean household income in the lth order-expanded community from a household i.

The order defines the spatial extent of the community, defined either in terms of distance from each household or in terms of the order contiguity.

For example, in the first order contiguity expansion, the moving window for each household consists of directly contiguous neighbors including itself. (Jargowsky, 2005)

X is an N by 1 vector representing the deviations of individual household incomes from the metropolitain mean and W_l is an N by N spatial weight matrix for the lth order expansion.

Recall that H is the total number of households. The (I,j)th element of the weight matrix indicates whether household $i$and household $j$are members of the same community. If they are not, the element is zero. If they are members of the same community, the element is $\frac{1}{N_c}$, where N_c is the total number of households in the lth order-expanded community of individual i. In other words, the matrix is row-standardized, and the numerator in GNSI is the household-weighted sum of squared deviations of the community means from the grand mean (Jargowsky, 2005)

When the order of expansion is zero (no expansion beyond the individual neighborhood), the GNSI is identical to NSI.

3. Empirical study

3.1. Data and method

We present in this section our data set. With have data for household individual income for several years and different geographical scales. The definition of income adopted for our study is the ***taxable income***, that is, income before income tax and social transfer***.***

Geographical levels

To achieve our study we have data on different scales, INSEE has built the finest spatial unit ***IRIS*** (IRIS: Ilots Regroupés pour l'Information Statistique) by grouping adjacent islets forming "small areas" quite homogeneous.

The municipalities of at least 10,000 inhabitants and a high proportion of "*communes*" from 5 000-10 000 inhabitants are cut into IRIS. This division constitutes a partition of their territory. France has about 16,100 IRIS 650 in the DOM.

By extension, to cover the whole territory, each municipality not cut in IRIS is equivalent to an IRIS. There are three types of IRIS:

- The IRIS habitat: their population is in general between 1800 and 5000 inhabitants. They are uniform in their habitat type and their limits are based on the large cuts in the urban fabric (main roads, railways, rivers ...).
- The IRIS activity: they include more than 1,000 employees and have at least two times more jobs than employees of the resident population.
- The IRIS different: there are large specific areas and sparsely populated with a large area (parks, ports, forests ...).

In our study we focus on the first type, ***the IRIS habitat***, that as we mentioned before are meaningful spatial divisions.

This division is closer to the principle of *Tract* in the USA, used in studies of the neighborhood or district, which is relatively homogeneous, and contains 4,000 inhabitants on average, in France, the IRIS are usually composed between 1800 and 5000 inhabitants. However, A comparison with U.S. cities would be difficult because of the difficulty posed by the different spatial scales plus the different kinds of data revenue.

We also use some groups of IRIS called ***TRIRIS*** and ***Grand quartier*** , The TRIRIS exist in municipalities of more than 5,000 people and can match:

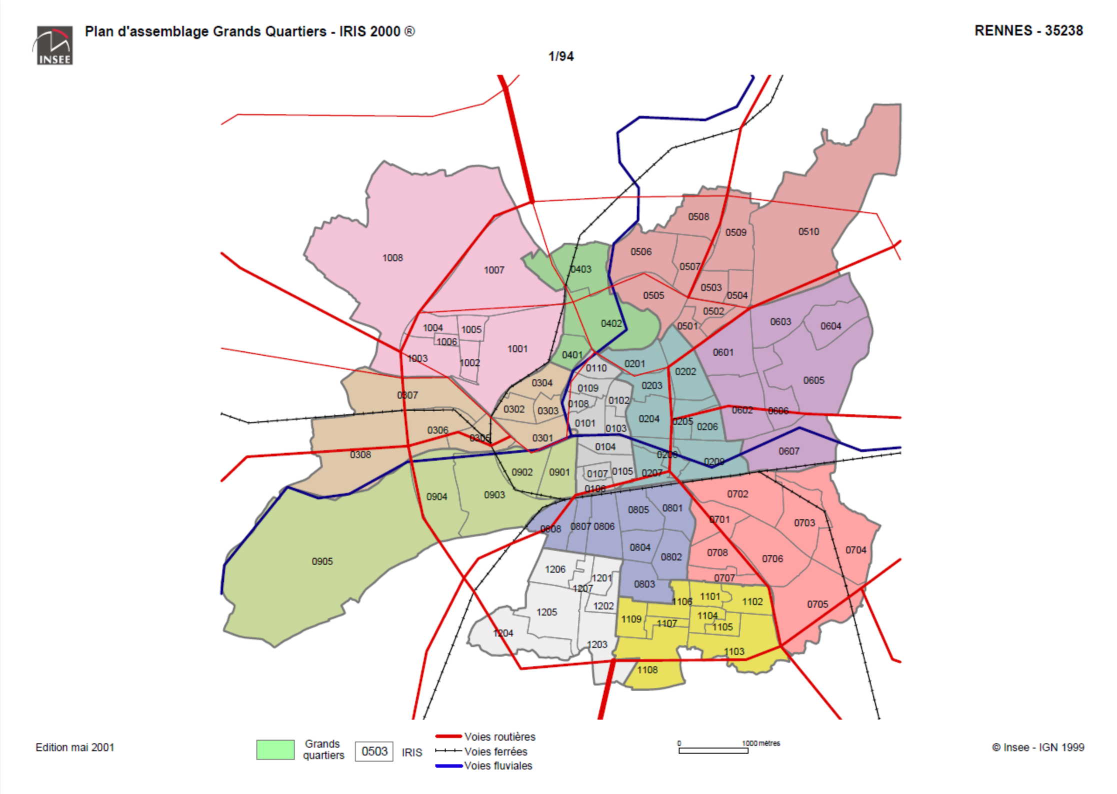
- Either the municipality (commune)

- Or aggregations of at least 3 IRIS-2000

A “Grand quartier” is either a fraction of the municipality or a TRIRIS composed by at least 5000 inhabitants.

As an example of different geographical level inside the city we present the following map of Rennes which represents its divisions in IRIS and “Grands quartiers”.

Map 2: Rennes; IRIS and “Grands Quartiers”

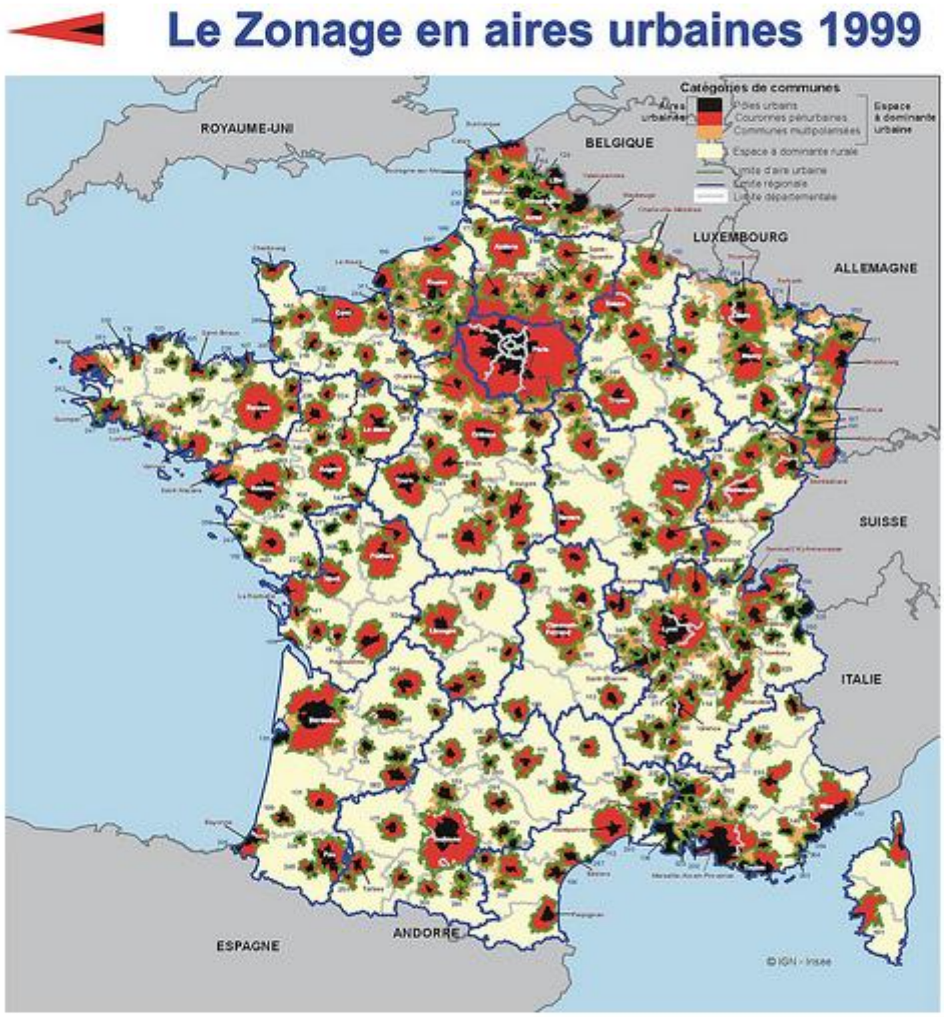


Source: Insee-IGN (1999)

We also have data for ***municipalities*** (commune), as defined by the INSEE The municipality is the smallest French administrative subdivision. On 1 January 2006 there were 36,685 municipalities, including 36,571 in France. (INSEE, definitions and method)

We calculate the NSI for ***urban areas***, defined as all common areas, and with no enclave, formed by an urban center, and rural communes or urban units (suburban crown) with at least 40% of the resident population in employment working in the center or in Commons attracted by it. In 1999, 354 Urban Areas were defined.

Map 3: Urban areas in 1999



Source: IGN-Insee

Income definition

Our data set provide some aggregate statistics related to the distribution of income for each IRIS, municipality and urban area.

The definition of income adopted for our study is the ***taxable income***, that is, income before income tax and social transfer***.***

The household's taxable incomes are established from two different files of the income statement and house tax. The Insee estimates the taxable income for geographical levels finely localized.

First we have to introduce the definition of household adopted:

The "household taxable" is an ordinary household formed by the combination of taxable households listed in the same dwelling. Its existence in a given year is that coincide independent income statement and the occupancy of a housing known to the Housing Tax.

Thus are excluded:

-Households-payers concerned by an event like wedding, death or separation during the reference year;
-Households consisting of people do not have their fiscal independence (mostly students);
-Taxpayers living in community

The income taxable is the amount of resources reported by taxpayers on the "income statement", before any reduction. It is income before redistribution. It is not equivalent to the concept of "disposable income" and therefore does not speak in terms of standard of living.

To speak in terms of standard of living, we should add to this revenue some social unreported income (such as RMI, family benefits, housing assistance) and subtract direct taxes (income tax and housing tax).

The income is expressed in three levels of observation:

-The Consumption Unit

-Household

-the individual

The ***Consumption Unit*** (U.C.) is recommended take the size and structure of household into consideration. Indeed, differences in household structure between areas are sometimes such that the fact of using income per consumption unit offers a different picture of levels and differences in relation to reasoning per household or per person.
This equivalence scale is commonly used by Insee and eurostat to study income and expressed as "equivalent adult"

We realize our study among ***5 years***, from 2001 to 2006, the data in 2003 are not available.

In the following table we precise the different information given in the data base.

Table 1: Indexes in the data set

	Level of observation		
Index	U.C.	Household	Individual
number (household, individuals,U.C.)	X	X	X
Median	X	X	X
decile	x	x	x
Standard deviation	x	x	x
Mean	x	x	x
Gini index	x	x	x
inter-quartile	x	x	x
Inter-decile ratio	x	x	x

Source: Proper elaboration

Method

We calculated the NSI for 5 years (2001, 2002, 2004, 2005, and 2006) for the 30 biggest urban areas. We computed it for different geographical levels inside the urban area, testing different scales of neighborhoods, indeed we first computed the NSI for the IRIS level, then for the TRIRIS level and finally for the “Grand Quartier” level.

We used two different methods to compute the NSI at the IRIS scale according to the availability of the data. We first used the mean income in the Urban Area ($\bar{x}$) and the standard-deviation (σ)in the urban area mentioned in our file, but inside these urban areas we denoted a significant lack of data for the IRIS which composed them. We thus decided to calculate the mean and the variance (using the formula of the variance decomposition) of the urban areas taking into account only the data available.

Table 2: IRIS available in the data set

	Number of IRIS	IRIS available
2001	12775	11606
2002	13289	11994
2004	13300	12049
2005	13301	12076
2006	13302	12086

Source: proper elaboration

The following table gives information concerning the distribution of the income in the 30 biggest Urban Areas mentioning their mean Income and the Gini Index. (Table 3)

Table 3. Mean and Gini Index in the 30 biggest cities										
	2001		2002		2004		2005		2006	
	Mean	Gini	non available	Gini	Mean	Gini	Mean	Gini	Mean	Gini
(Hors espace urbain)	14445,90	0,3275		0,2903	15805,33	0,3251	16375,59	0,3242	17041,96	0,3245
Paris	21766,81	0,3949		0,3269	23047,19	0,4018	23862,94	0,4048	24826,08	0,4103
Lyon	18532,97	0,3481		0,3168	19961,22	0,3532	20685,41	0,3537	21500,36	0,3581
Marseille-Aix-en-Provence	16291,26	0,3908		0,3980	17909,38	0,3963	18638,89	0,3936	19447,77	0,3950
Lille	16342,15	0,3751		0,3663	17690,26	0,3825	18303,21	0,3832	18984,15	0,3873
Toulouse	18291,43	0,3457		0,3369	20008,34	0,3492	20790,62	0,3495	21630,04	0,3500
Nice	17858,21	0,3844		0,3425	19494,47	0,3857	20252,74	0,3839	21172,73	0,3862
Bordeaux	17725,10	0,3407		0,3294	19283,46	0,3426	19980,15	0,3428	20792,05	0,3450
Nantes	17523,15	0,3263		0,3081	19211,45	0,3264	20015,15	0,3293	20769,88	0,3306
Strasbourg	18702,02	0,3434		0,3364	20004,24	0,3566	20478,79	0,3572	21177,67	0,3624
Toulon	16171,08	0,3574		0,3431	17938,49	0,3602	18638,06	0,3587	19377,84	0,3593
Douai-Lens	12854,80	0,3629		0,3933	14052,25	0,3651	14475,87	0,3640	14966,90	0,3660
Rennes	18084,59	0,3154		0,3004	19727,44	0,3147	20318,22	0,3176	21023,77	0,3201
Rouen	16840,97	0,3432		0,3244	18325,57	0,3467	18958,09	0,3459	19693,77	0,3480
Grenoble	18548,09	0,3378		0,3181	20182,77	0,3394	20895,21	0,3382	21821,84	0,3405
Montpellier	16917,51	0,3770		0,3777	18727,00	0,3793	19368,35	0,3777	20225,69	0,3798
Metz	16594,34	0,3373		0,3319	18197,91	0,3434	18777,36	0,3430	19376,04	0,3471
Nancy	17470,75	0,3380		0,3490	18977,81	0,3449	19580,30	0,3455	20313,19	0,3495
Clermont-Ferrand	17605,94	0,3290		0,3189	19249,48	0,3320	19852,97	0,3312	20552,27	0,3318
Valenciennes	13125,86	0,3722		0,3992	14340,88	0,3755	14805,41	0,3743	15376,46	0,3738
Tours	17512,74	0,3257		0,3066	19018,35	0,3302	19711,61	0,3334	20361,36	0,3330
Caen	16866,41	0,3316		0,3219	18459,20	0,3332	19111,47	0,3331	19790,05	0,3331
Orléans	18306,10	0,3187		0,2920	19634,49	0,3246	20207,34	0,3247	20930,35	0,3279
Angers	16538,69	0,3291		0,3122	18068,75	0,3320	18713,35	0,3327	19393,61	0,3334
Dijon	18319,03	0,3202		0,2923	19910,53	0,3240	20480,44	0,3238	21261,07	0,3259
Saint-+étienne	15671,40	0,3418		0,3434	16796,14	0,3477	17330,40	0,3475	17951,62	0,3512
Brest	16528,47	0,3107		0,3145	18107,30	0,3122	18700,60	0,3133	19411,07	0,3150
Havre	15435,41	0,3538		0,3600	16976,13	0,3548	17591,95	0,3533	18270,71	0,3568
Mans	16672,94	0,3120		0,2992	18035,51	0,3178	18564,29	0,3187	19137,79	0,3211
Reims	17329,57	0,3550		0,3377	18904,36	0,3594	19505,24	0,3611	20231,39	0,3627
Avignon	15391,45	0,3784		0,3482	16806,54	0,3788	17355,44	0,3769	18016,38	0,3769

3.2. Results

In this section we present the main results obtained from our computation.

As we mentioned before we calculated the NSI for the 30 biggest French urban areas considering three different geographical areas.

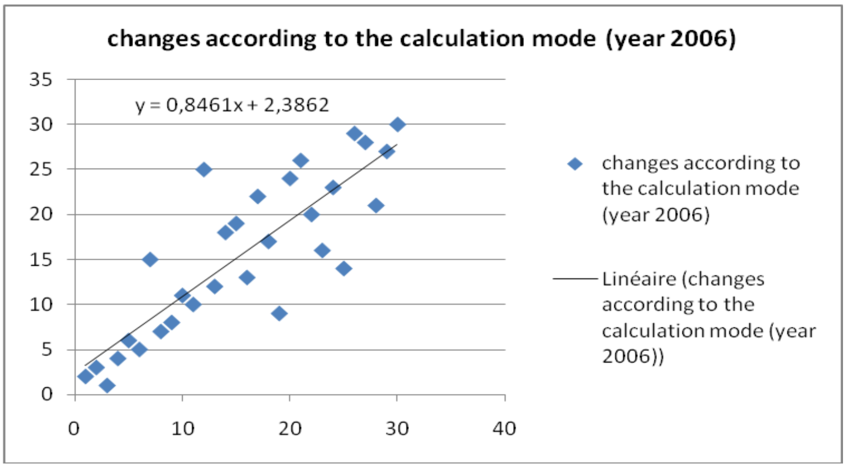
The following table (table 4 p.37) gives the ranking of the 30 biggest cities when we consider the IRIS scale.

Cities are ranked from the more segregated to the less segregated according to our index. As an example of interpretation, the NSI in Lille in 2001 is equal to 0, 45 thus, the between-neighborhood variance accounts for about 20% (0, 45 squared) of the total variance in household income in the urban area.

As an ordinal measure, The NSI is especially useful to classify and rank cities. But it cannot quantify the segregation and indicate whether segregation represents an amount x or y.

According to this table, the most segregated cities are Lille, Le Havre, Marseille and Rouen, we then try to analyze whether some changes are experimented over the years, we also analyze the changes according to the scale of the neighborhood considered. First, we analyze whether our method of calculation brings some changes in the rankings.

Graphic 3: Changes according to the calculation method



Source : proper elaboration

We can observe a linear relation between our two methods used. We do not observe significant change according to the method we use.

Table 4: NSI (IRIS scale)

2001	NSI	2002	NSI	2004	NSI	2005	NSI	2006	NSI
Lille	0,44863737	Havre	0,46102537	Lille	0,43858027	Havre	0,44079618	Havre	0,42873719
Rouen	0,43384596	Marseille-Aix-en-Provence	0,42725212	Havre	0,4300626	Lille	0,43555051	Lille	0,41529638
Marseille-Aix-en-Provence	0,42806907	Lille	0,42097627	Rouen	0,42659857	Marseille-Aix-en-Provence	0,40856363	Rouen	0,39875495
Havre	0,42765794	Rouen	0,41849805	Marseille-Aix-en-Provence	0,41861112	Rouen	0,3825642	Marseille-Aix-en-Provence	0,39867622
Strasbourg	0,39193499	Strasbourg	0,40069946	Nantes	0,37848109	Dijon	0,37678836	Caen	0,37526397
Reims	0,38283667	Dijon	0,39206139	Caen	0,37660471	Strasbourg	0,37591084	Dijon	0,36744118
Grenoble	0,38246175	Caen	0,37590412	Reims	0,36610344	Caen	0,36428748	Reims	0,35391175
Nantes	0,38244438	Reims	0,37565837	Strasbourg	0,36466478	Lyon	0,35847856	Strasbourg	0,34264432
Angers	0,37497988	Lyon	0,37388665	Dijon	0,36266788	Reims	0,35359304	Angers	0,33900658
Lyon	0,37150406	Grenoble	0,36670644	Tours	0,35938318	Angers	0,34665032	Avignon	0,33461187
Caen	0,37125447	Angers	0,36218209	Angers	0,35640189	Metz	0,34300659	Tours	0,3333393
Montpellier	0,36291238	Tours	0,3618676	Lyon	0,35236537	Avignon	0,33817276	Metz	0,32695842
Mans	0,35995931	Mans	0,36041943	Mans	0,34967778	Mans	0,33691513	Paris	0,32261415
Metz	0,35530091	Montpellier	0,35877346	Grenoble	0,34924248	Paris	0,3334808	Toulon	0,32260585
Tours	0,35317036	Avignon	0,35153989	Montpellier	0,34829678	Grenoble	0,33242033	Rennes	0,32189099
Avignon	0,34851232	Nancy	0,34975348	Metz	0,34700267	Tours	0,32919433	Grenoble	0,32182741
Nancy	0,34359513	Nantes	0,34736667	Rennes	0,34630648	Toulon	0,32829296	Lyon	0,31198129
Orléans	0,34260103	Metz	0,34544994	Avignon	0,34420869	Nancy	0,32652051	Nantes	0,31091773
Toulon	0,34038944	Rennes	0,34472821	Paris	0,34174828	Brest	0,32505242	Mans	0,30789514
Rennes	0,32862272	Paris	0,33490029	Nancy	0,33946833	Rennes	0,32433649	Orléans	0,30780919
Paris	0,32776358	Orléans	0,33333475	Brest	0,33480431	Orléans	0,31228992	Brest	0,30779906
Dijon	0,32430814	Brest	0,33027926	Toulon	0,32281294	Valenciennes	0,3106952	Valenciennes	0,30296085
Valenciennes	0,32150895	Toulon	0,32436407	Saint-Étienne	0,31722017	Montpellier	0,30983729	Toulouse	0,29625765
Brest	0,31371348	Valenciennes	0,3242711	Orléans	0,31414357	Saint-Étienne	0,30966295	Clermont-Ferrand	0,29531428
Toulouse	0,30956551	Toulouse	0,32095379	Toulouse	0,31308642	Nantes	0,30391177	Nancy	0,29203478
Douai-Lens	0,30503262	Clermont-Ferrand	0,31284425	Douai-Lens	0,29409501	Toulouse	0,30192289	Montpellier	0,29036922
Saint-+étienne	0,30246885	Bordeaux	0,29932857	Valenciennes	0,29150499	Douai-Lens	0,28683683	Saint-Étienne	0,28867851
Bordeaux	0,28824936	Douai-Lens	0,29170056	Bordeaux	0,28711428	Clermont-Ferrand	0,28544968	Douai-Lens	0,28017057
Nice	0,28768143	Saint-Étienne	0,28299743	Clermont-Ferrand	0,27490952	Bordeaux	0,27924477	Bordeaux	0,27944506
Clermont-Ferrand	0,18848591	Nice	0,2808191	Nice	0,25570504	Nice	0,25886481	Nice	0,26090099

Changes over Time

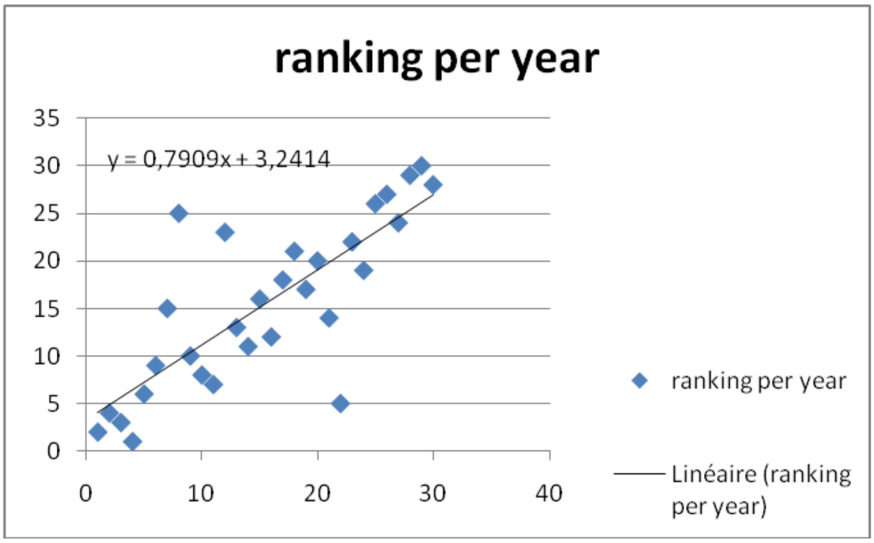
We established the ranking of the cities according to the year (considering the IRIS scale).

Table 5: Ranking among the year

Ranking By the city size	VILLE	2001	2002	2004	2005	2006
1	Paris	21	20	19	14	14
2	Lyon	10	9	12	8	8
3	Marseille-Aix-en-Provence	3	2	4	3	3
4	Lille	1	3	1	2	2
5	Toulouse	25	25	25	26	26
6	Nice	29	30	30	30	30
7	Bordeaux	28	27	28	29	29
8	Nantes	8	17	5	25	25
9	Strasbourg	5	5	8	6	6
10	Toulon	19	23	22	17	17
11	Douai-Lens	26	28	26	27	27
12	Rennes	20	19	17	20	20
13	Rouen	2	4	3	4	4
14	Grenoble	7	10	14	15	15
15	Montpellier	12	14	15	23	23
16	Metz	14	18	16	11	11
17	Nancy	17	16	20	18	18
18	Clermont-Ferrand	30	26	29	28	28
19	Valenciennes	23	24	27	22	22
20	Tours	15	12	10	16	16
21	Caen	11	7	6	7	7
22	Orléans	18	21	24	21	21
23	Angers	9	11	11	10	10
24	Dijon	22	6	9	5	5
25	Saint-Étienne	27	29	23	24	24
26	Brest	24	22	21	19	19
27	Havre	4	1	2	1	1
28	Mans	13	13	13	13	13
29	Reims	6	8	7	9	9
30	Avignon	16	15	18	12	12

Source: proper elaboration

Graphic 4: ranking per year



Source : proper elaboration

The previous graph shows the correlation between the ranking of the cities (at the IRIS level) and the time, we observe few changes over the time between the cities, which seems coherent, indeed segregation is a long-run process thus we do not expect strong variations for such a short time period.

The most segregated cities according to our results when we decompose the urban areas in IRIS are Le Havre, Lille, Marseille and Rouen.

We thus analyzed the changes in the ranking according to the scale considered.

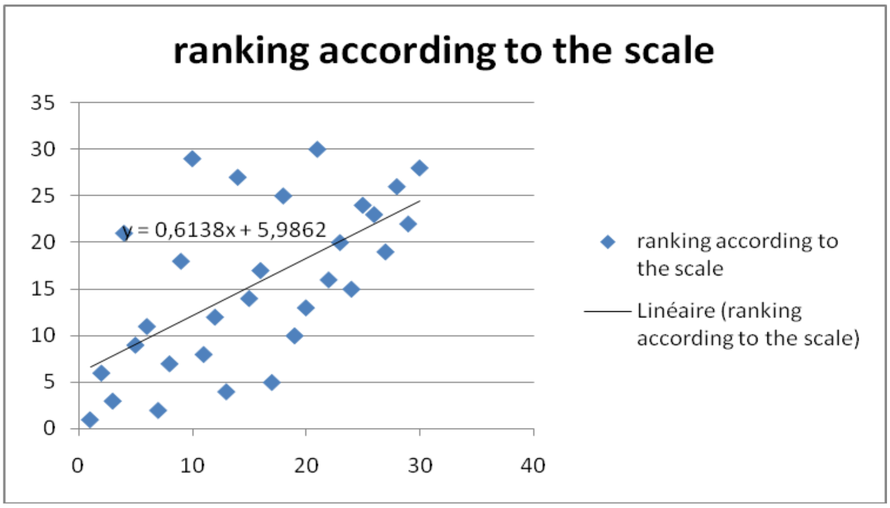
Changes according to the scale

Table 6: ranking according to the scale

	Ranking according to the scale		
VILLE	IRIS	TRIRIS	Grand Quartier
Paris	13	4	3
Lyon	17	5	8
Marseille-Aix-en-Provence	4	21	20
Lille	2	6	5
Toulouse	23	20	19
Nice	30	28	27
Bordeaux	29	22	18
Nantes	18	25	22
Strasbourg	8	7	7
Toulon	14	27	21
Douai-Lens	28	26	23
Rennes	15	14	10
Rouen	3	3	2
Grenoble	16	17	11
Montpellier	26	23	25
Metz	12	12	12
Nancy	25	24	28
Clermont-Ferrand	24	15	26
Valenciennes	22	16	17
Tours	11	8	9
Caen	5	9	15
Orléans	20	13	13
Angers	9	18	16
Dijon	6	11	4
Saint-Étienne	27	19	29
Brest	21	30	30
Havre	1	1	1
Mans	19	10	14
Reims	7	2	6
Avignon	10	29	24

Source: proper elaboration

Graphic 5: Ranking according to the scale



Source : proper elaboration

We can expect that expanding the observation scale our index will indicate lower levels, considering that the bigger the area is the more heterogeneous will be the individuals which compose the area.Indeed, It would seem logical that the inter-area inequality would be larger and closer to total inequality if the space is cut finer.

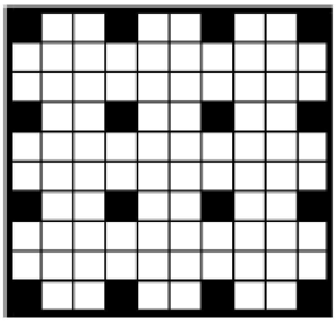
We observe significant situations according to the scale considered, some urban areas among the most segregated at the neighborhood scale (IRIS) present low levels of segregation when we focus on a bigger scale. Such as Marseille, where the change is particulary significant (From the 4^{th} place when the scale considered is the IRIS to the 20^{th} place when we consider the “grand quartier”.)

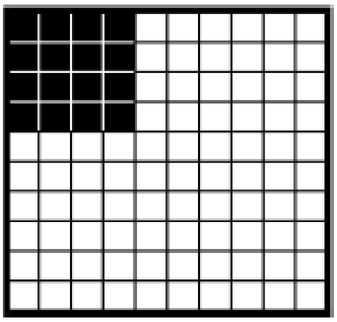
The IRIS are thus probably homogeneous (poor households in one neighborhood, Rich household in another one). Which enable us to think that the neighborhoods are more segregated between IRIS.

At the opposite, we observe than Paris is more segregated when we consider the TRIRIS or the “Grand quartier” scales.

This result can highlight the chekerboard issue;

Marseille *Paris*

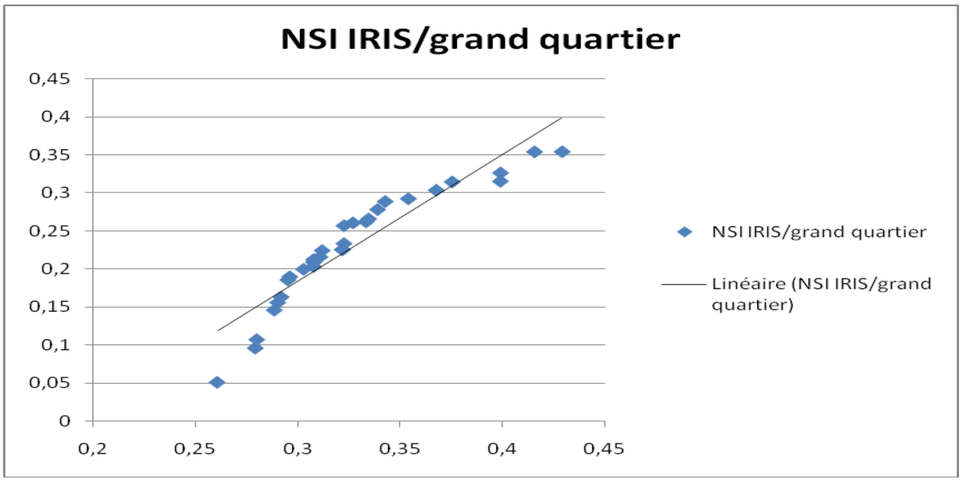




However some cities remains highly segregated, such as Le Havre which is the most segregated city according to all the scales considered, or Rouen.

We present in the following graphic the different levels of the NSI according to the scale considered (between IRIS and Grands quartiers).

Graphic 6: Levels of NSI according to the scale



Source : proper elaboration

In value, the NSI does not change a lot according to the scale considered, but as we saw the rankings do. A deeper study of the composition and spatial arrangements in the cities would be require in order to specify the mechanisms and compare more precisely the cities between each other.

Conclusions

We defined in this study what economic segregation is, presenting the issues and the magnitude of this phenomenon.

We proposed a methodological analysis in order to measure economic segregation and specify the tools which could help us to say whether a city is more segregated or not.

We presented an index developed by Jargowsky, the NSI and analyzed its properties in order to justify its use in our empirical study.

We conclude that the NSI respects several properties, which are:

(1) The property of scale interpretability
(2) The property of transfers, exchanges
(3) Organization equivalence and size invariance
(4) Homogeneity within neighborhood

However the NSI does not respect the independence of arbitrary boundaries.

As we mentioned, this NSI is an ordinal index which enables us to establish some rankings and compare cities between them. We computed the NSI among several years and observed that there are no significant changes between the years in the ranking of the cities. This is quite coherent with the fact that segregation is a long run process.

We proposed to analyze the behavior of the NSI under different scenarios, whether the neighborhoods are IRIS or grouping of IRIS (TRIRIS, Grands quartiers).

We observed significant differences in the rankings according to the scale of the neighborhood taken into account, such as some cities appear more segregated if we consider a small scale of neighborhood but are less segregated in a larger scale. This result can be an illustration of the checkerboard previously mentioned.

The NSI is a measure of spatial segregation only to the extent that it tells us how much information about variation in household income is lost by aggregating data to a non-overlapping spatial lattice in neighborhoods, such as IRIS.

But it fails to capture larger scale features on the spatial arrangements of the neighborhoods.

The GNSI could be a response to this failure and the object of a further work.

Moreover, we saw that segregation is a major concern for public policy makers and measuring segregation aims to provide them some tools and to evaluate the results of the policies set up. This also could be the object of a further work.

Appendix

Information given in the data base

Indicateurs	Niveaux d'observation des indicateurs			Seuils de diffusion Personnes
	Unités de consommation (UC)	Ménages	Personnes	
18 indicateurs de distribution				
nombre (ménages, personnes, UC) *	x	x	x	50 ménages
1er quartile *	x	x	x	2 000 habitants
médiane *	x	x	x	50 ménages
3ème quartile *	x	x	x	2 000 habitants
1er décile *	x	x	x	2 000 habitants
2ème décile *	x	x	x	2 000 habitants
3ème décile *	x	x	x	2 000 habitants
4ème décile *	x	x	x	2 000 habitants
6ème décile *	x	x	x	2 000 habitants
7ème décile *	x	x	x	2 000 habitants
8ème décile *	x	x	x	2 000 habitants
9ème décile *	x	x	x	2 000 habitants
écart-type *	x	x	x	2 000 habitants
moyenne	x	x	x	2 000 habitants
indice de gini *	x	x	x	2 000 habitants
intervalle inter-quartiles *	x	x	x	2 000 habitants
rapport inter-déciles *	x	x	x	2 000 habitants
Part des ménages imposés	X	X	x	2 000 habitants
5 indicateurs de structure				
part des revenus d'activités salariées *	S.O.	S.O.	S.O.	2 000 habitants
Part des indemnités de chômage *	S.O.	S.O.	S.O.	2 000 habitants
part des pensions/retraites/rentes *	S.O.	S.O.	S.O.	2 000 habitants
part des revenus d'activités non salariées *	S.O.	S.O.	S.O.	2 000 habitants
part des autres revenus *	S.O.	S.O.	S.O.	2 000 habitants

* : A partir de 10 000 habitants, les indicateurs sont déclinés suivant la **taille des ménages** et l'âge du **référent fiscal** et dès 2000 habitants, les indicateurs sont déclinés selon le **statut d'occupation du logement**.

S.O. : Sans Objet

Rankings

NSI (scale IRIS)

CODE	VILLE	2001	2002	2004	2005	2006
1	Paris	0,32776358	0,33490029	0,34174828	0,3334808	0,32260585
2	Lyon	0,37150406	0,37388665	0,35236537	0,35847856	0,34264432
3	Marseille-Aix-en-Provence	0,42806907	0,42725212	0,41861112	0,40856363	0,39875495
4	Lille	0,44863737	0,42097627	0,43858027	0,43555051	0,41529638
5	Toulouse	0,30956551	0,32095379	0,31308642	0,30192289	0,29036922
6	Nice	0,28768143	0,2808191	0,25570504	0,25886481	0,26090099
7	Bordeaux	0,28824936	0,29932857	0,28711428	0,27924477	0,27944506
8	Nantes	0,38244438	0,34736667	0,37848109	0,30391177	0,29203478
9	Strasbourg	0,39193499	0,40069946	0,36466478	0,37591084	0,36744118
10	Toulon	0,34038944	0,32436407	0,32281294	0,32829296	0,31198129
11	Douai-Lens	0,30503262	0,29170056	0,29409501	0,28683683	0,28867851
12	Rennes	0,32862272	0,34472821	0,34630648	0,32433649	0,30780919
13	Rouen	0,43384596	0,41849805	0,42659857	0,3825642	0,39867622
14	Grenoble	0,38246175	0,36670644	0,34924248	0,33242033	0,32189099
15	Montpellier	0,36291238	0,35877346	0,34829678	0,30983729	0,29625765
16	Metz	0,35530091	0,34544994	0,34700267	0,34300659	0,3333393
17	Nancy	0,34359513	0,34975348	0,33946833	0,32652051	0,31091773
18	Clermont-Ferrand	0,18848591	0,31284425	0,27490952	0,28544968	0,28017057
19	Valenciennes	0,32150895	0,3242711	0,29150499	0,3106952	0,30296085
20	Tours	0,35317036	0,3618676	0,35938318	0,32919433	0,32182741
21	Caen	0,37125447	0,37590412	0,37660471	0,36428748	0,35391175
22	Orléans	0,34260103	0,33333475	0,31414357	0,31228992	0,30779906
23	Angers	0,37497988	0,36218209	0,35640189	0,34665032	0,33461187
24	Dijon	0,32430814	0,39206139	0,36266788	0,37678836	0,37526397
25	Saint-Étienne	0,30246885	0,28299743	0,31722017	0,30966295	0,29531428
26	Brest	0,31371348	0,33027926	0,33480431	0,32505242	0,30789514
27	Havre	0,42765794	0,46102537	0,4300626	0,44079618	0,42873719
28	Mans	0,35995931	0,36041943	0,34967778	0,33691513	0,32261415
29	Reims	0,38283667	0,37565837	0,36610344	0,35359304	0,33900658
30	Avignon	0,34851232	0,35153989	0,34420869	0,33817276	0,32695842

NSI (scale TRIRIS)

CODE	VILLE	2001	2002	2004	2005	2006
1	Paris	0,2562203	0,26118026	0,25786809	0,27162918	0,259404
2	Lyon	0,30280273	0,31234695	0,29220065	0,31546788	0,2911713
3	Marseille-Aix-en-Provence	0,34614997	0,36165465	0,33957845	0,34497626	0,33132264
4	Lille	0,37951098	0,35109743	0,37135632	0,34626488	0,3432812
5	Toulouse	0,23318256	0,22612962	0,21982927	0,21106714	0,20385624
6	Nice	0,19859433	0,19397004	0,17909008	0,189836	0,18434048
7	Bordeaux	0,20146569	0,21451088	0,19924694	0,19618833	0,18458557
8	Nantes	0,32091669	0,27485353	0,32823475	0,21548071	0,21294586
9	Strasbourg	0,34104671	0,34367873	0,31815385	0,32911988	0,31899012
10	Toulon	0,26424554	0,25241305	0,24436891	0,25560914	0,24717178
11	Douai-Lens	0,22417205	0,21439508	0,2131227	0,20358596	0,19888009
12	Rennes	0,26352784	0,26217552	0,26524106	0,24853993	0,24497872
13	Rouen	0,37883694	0,34818078	0,35271738	0,33819812	0,32538555
14	Grenoble	0,32259323	0,30416274	0,28100856	0,2688931	0,25504156
15	Montpellier	0,29466147	0,28464843	0,2792695	0,23189253	0,22936028
16	Metz	0,29105877	0,26625482	0,27070301	0,28356706	0,27053906
17	Nancy	0,27205015	0,27494946	0,25379295	0,25031135	0,24713927
18	Clermont-Ferrand	0,11158175	0,22422091	0,19738243	0,19883767	0,19349867
19	Valenciennes	0,24454965	0,23091913	0,20940267	0,23607966	0,23198895
20	Tours	0,28060368	0,29656066	0,30104898	0,26035294	0,25143636
21	Caen	0,30138354	0,32763925	0,32033096	0,31838367	0,30319461
22	Orléans	0,27047188	0,26066031	0,23887645	0,24477399	0,24198342
23	Angers	0,30544638	0,30414152	0,30008033	0,28839569	0,27136409
24	Dijon	0,25225952	0,33571191	0,30787678	0,33815557	0,32502508
25	Saint-Étienne	0,219355	0,19702994	0,23972123	0,22429951	0,21479058
26	Brest	0,24360592	0,25427268	0,25083884	0,24914073	0,24639542
27	Havre	0,3451391	0,38839366	0,35553417	0,37314451	0,35605899
28	Mans	0,29190921	0,2899175	0,28534509	0,27793615	0,26763167
29	Reims	0,33837042	0,31935245	0,31833785	0,2940504	0,28104011
30	Avignon	0,27525614	0,28344827	0,26003085	0,28207326	0,26926913

NSI Grand Quartier						
CODE	VILLE	2001	2002	2004	2005	2006
1	Paris	0,21850904	0,23259317	0,22714764	0,23679461	0,23315075
2	Lyon	0,30345886	0,29938562	0,26326999	0,29231101	0,28846505
3	Marseille-Aix-en-Provence	0,3463523	0,37248467	0,3328667	0,32613951	0,32609811
4	Lille	0,37639051	0,34307722	0,36110166	0,34931611	0,35373578
5	Toulouse	0,17933222	0,17969515	0,19442565	0,15258996	0,15562459
6	Nice	0,08304166	0,05031575	0,05178524	0,05413923	0,05089118
7	Bordeaux	0,12111503	0,13622695	0,10996789	0,09543914	0,09582278
8	Nantes	0,31608392	0,23850757	0,33092183	0,16297241	0,16296346
9	Strasbourg	0,33490279	0,34085023	0,3030793	0,31907997	0,30329577
10	Toulon	0,23247941	0,20170103	0,21553478	0,22288921	0,22395735
11	Douai-Lens	0,15722775	0,11240275	0,16587928	0,14586277	0,14576129
12	Rennes	0,22552238	0,23504104	0,2317933	0,21924949	0,20857531
13	Rouen	0,35203788	0,34116367	0,35011383	0,32544587	0,31505126
14	Grenoble	0,32012049	0,29612237	0,24704452	0,23226363	0,22553566
15	Montpellier	0,27835089	0,25243288	0,2425168	0,20310749	0,18957224
16	Metz	0,25080896	0,23572636	0,2399955	0,27208535	0,26175724
17	Nancy	0,23717565	0,2467833	0,21804874	0,22061827	0,2154579
18	Clermont-Ferrand	0,04961572	0,17735117	0,0991245	0,10628992	0,10692854
19	Valenciennes	0,197838	0,19605218	0,14518912	0,20927251	0,19933369
20	Tours	0,2442138	0,27817135	0,29167545	0,22566652	0,22499524
21	Caen	0,28245533	0,31305099	0,31975262	0,31714746	0,29201405
22	Orléans	0,23337287	0,22955899	0,20171861	0,2145519	0,20305681
23	Angers	0,30454566	0,28271643	0,28155883	0,28338618	0,26553748
24	Dijon	0,19838155	0,32381176	0,30105989	0,32343984	0,31414997
25	Saint-Étienne	0,14269463	0,08902798	0,20222284	0,2024301	0,1855048
26	Brest	0,19615087	0,20947054	0,21752395	0,21999217	0,21209638
27	Havre	0,33506945	0,38952153	0,35371764	0,36211065	0,35383892
28	Mans	0,2636137	0,27523952	0,25701721	0,25844478	0,25676199
29	Reims	0,33043424	0,31106325	0,30902387	0,28396373	0,27789303
30	Avignon	0,24177161	0,25050387	0,22905364	0,27203191	0,26043738

References

Atkinson T. Glaude M., Olier Piketty, T (Eds)(2001) *Inégalités économiques,* rapport pour le Conseil de l'Analyse Economique, Paris : La Documentation Française

Benabou R. (1993). Working of a city: Location, Education and Production*. Quaterly Journal of Economics*, 108, 619-652

Bourguignon F. (1979), Decomposable Income Inequality Measures, *Econometrica*, Vol 47, N°4

Castells M.(1972), *La question Urbaine*, Paris : Maspero

Cutler D. & Gleaser E.(1997) Are ghettos good or bad ? *Quaterly Journal of Economics* , 112(3), 827-872

Cutler D. & Gleaser E.&Vigdor J. (1999). The Rise and Decline of the American Ghetto, *Journal of Political Economy. 107(3), 455-506*

Donzelot, J. (2004). La segregation ethnique au college et ses consequences.*Revue française de sociologie,* 44(3), 413-4477.

Duncan O.&Duncan B.(1955) A Methodological Analysis of Segregation Indexes*, American Sociological Review,* Vol 20. N°2, 210-217

Fitoussi, J-P. Laurent E. &Maurice J. (2004) *Ségrégation urbaine et intégration sociale.* Rapport pour le Conseil de l'Analyse Economique . Paris : La documentation Française.

Gravel ,N. & ThoronS. (2007) Does endogenous formation of jurisdictions lead to wealth-stratification?, Journal of Economic Theory, 569-583

Ioannides& Seslen (2002). Neighborhood wealth distributions, *Economic Letters*. 76, 357-367

Jargowsky, P. A(1996). Take the money and Run: Economic Segregation in U.S. Metropolitan Areas. *American Sociological Review*, 61, 984-998.

Kim J.& Jargowsky, P.A. (2005). A measure of Spatial Segregation: The Generalized Neighborhood Sorting Index. National Poverty Center

Kim J. and Jargowsky P.A.(2005) The Gini coefficient and segregation on a continuous variable. *Document de travail n°05-02*. National Poverty Center

Massey, D.S & Denton N.A. (1998a). The dimensions of residential segregation. Social Forces. 67, 281-315

Maurin, E. (2004), *Le ghetto français : Enquête sur le séparatisme social.* Paris : La République des idées, Le Seuil

Mussard S. Seyte F. & Terraza M. (2003) Decomposition of Gini and the Generalized Entropy inequality Measures. Economics Bulletin, 4(7), 1-6

Reardon S. F. & O' Sullivan (2004), Measures of Spatial segregation, *Sociological Methodology*, 34:121-162.

Rey S.J. & FolchD.C.(2009) What can 70 million or so neighborhoods tell us about the performance of Income segregation measures? , Working Paper

Schelling T.C . (1969) Models of Segregation. *American Economic Review*, 59(2)488-493

Selod H. (2004) La mixité Sociale et économique in F. Maurel A. Perrot, J.C. Praguer& J-F Thisse (Eds), *Villes et économie* (pp. 129-156).Paris : La documentation Française

Shorrocks A.& Wan G.(2005) Spatial Decomposition of Inequality, *Journal of Economic Geography*, 5, 59-81.

Tiebout, C. (1956), A Pure Theory of Local Expenditures, *Journal of Political Economy* . 64 (5): 416–424

White Michael J. (1983), The measurement of Spatial Segregation. *American Journal of Sociology*, 88(5) , 1008-1019

Zenou Y&Boccard N. (2000) Labor Discriminations and Redlining in Cities. Journal of Urban Economics, 48(2), 260-285