SPATIAL SEGREGATION BY INCOME

Concept, measurement and evaluation of 11 Spanish cities

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SUMMARY

Socio-Economic Inequality [SEI] has been of fundamental importance in the birth and evolution of human societies. In essence, it alludes to the different distribution of rights and obligations [and the legitimacy of such distribution/differences] in each society. It is therefore inextricably related to Article 01 of the Universal Declaration of Human Rights.

Within the possible forms of SEI, in this text we focus on revising the one that implies the segregation in the urban space of the inhabitants according to their levels of income, usually designated as Spatial Segregation by Income [SSI].

Individualized study of SSI is interesting for architects because it is possible to act on it from almost all scales of architects' work. From *codes* that regulate cities to *small scale residential projects*, through *urban plans* and different sizes of *urban transformations*.

Our objective with this text is to propose *easy indicators and procedure for assessing SSI in urban areas,* so usual urban transformations can be designed in a way that always directs our cities towards optimum levels of SSI.

Previously, we briefly review the state of the art in Inequality and Segregation, differentiating between general issues regarding SEI and specific issues of Space Segregation. This will allow us to know when it is necessary acting in the urban planning/architectural field and when it is more convenient to implement another type of strategies [mostly political] as limiting housing speculation; improving corporate governance; redistributive policies...

Additionally, we use herein explained indicators to review 11 Spanish cities, both to validate indicators' design and to obtain an overview of current state of Spatial Segregation by Income in Spain. This analysis allows us to propose some strategies to improve Spanish cities' current situation and prevent non-desired scenarios in the future.

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1 INTRODUCTION

The issue of Socio-Economic Inequality [SEI][1] has been fundamental since the beginning of human civilization. In this text we review one of its possible manifestations; segregation of inhabitants in the urban space according to their level of income, i.e.; their Spatial Segregation by Income [SSI].

Individualized study of SSI is interesting because it is possible intervening on it from almost all scales of architects' work. From codes that regulate different aspects of society [and more specifically cities] to small-scale residential projects, through urban planning and different sizes of urban transformations.

Many issues that modify our societies / cities affect to how inhabitants are spatially distributed according to their income, and history has shown us that the issues of inequality and segregation have great importance for defining both the stability of our societies and the rights and freedoms enjoyed by their members.

Thus, our goal with this text is to propose tools to direct our societies towards optimal segregation states; i.e., states which promote social stability as well as optimal distribution of rights / freedoms and duties among citizens.

In order to do so, we review current knowledge on inequality / segregation, and we propose relatively simple indicators to value urban areas' SSI, which provide the necessary information for the design of usual urban transformations so they direct our cities towards optimal levels of Spatial Segregation.

However, not everything that influences SSI is related to architects/urbanists' work. Studies show high correlation between SSI and Economic Inequality [EI]; the greater the EI, the greater the SSI. This advances one of the simplest and more effective tools to achieve adequate values of SSI; achieving adequate levels of EI.

Although addressing this last issue locates mostly beyond the usual professional field of architects, we briefly review some EI's issues in order to know when it is convenient/necessary to act in the urban field and when is necessary to implement political measures of another nature [labor market regulation; controls on real estate speculation; tax redistributive policies; universal access to education...].

We complete above review with some specific issues of Spatial Segregation, focusing on research that takes place since the 20th century, when the first mathematical tools are proposed enabling contrast between theory and facts[2].

The review of both issues will provide us sufficient knowledge for designing several indicators based on some well-accepted formulas to measure EI/SSI.

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[1] It is often considered that Socio-Economic Inequality is composed of three main dimensions (occupation, income and studies) with very high correlation [Moreno et al, 2013; Tammaru et al, 2016].

[2] Research in Spatial Segregation began systematically in the beginning of the 20th century in USA, initially oriented to the study of racial segregation, and valuing also segregation according to income levels from the 1980s.

As a method for testing indicators[3], we use them for assessing 11 Spanish cities. This assessment also serves us to review these cities' SSI status, and detect common contextual issues and patterns.

Finally, we make a recap and draw some conclusions including a description of several strategies to correct undesirable situations and to maintain spatial segregation within appropriate levels, close to the optimum.

The script we follow has four parts:

- Theoretical framework review
    - Economic inequality: concept and measurement
    - Spatial Segregation by Income: concept and measurement
- Proposal of operational indicators to monitor spatial segregation.
- Graphic and quantitative analysis of 11 Spanish provincial capitals
- Conclusions

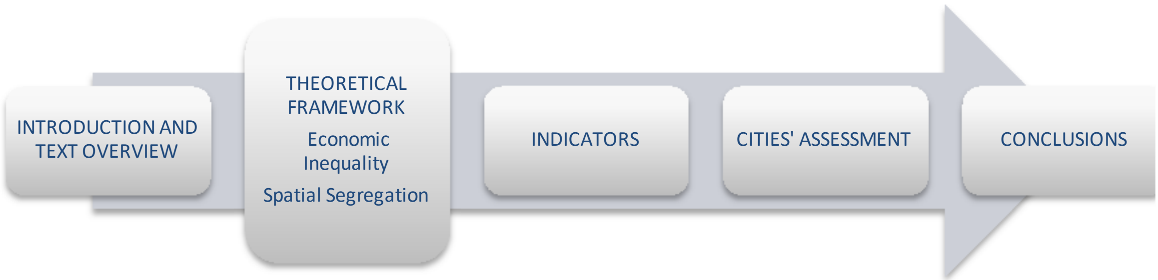


Diagram 01: Text Overwiew

Let us then begin by reviewing the current state of the issue.

[3] In epistemological terms, our approach is framed in the systemic paradigm underlying previous texts by the author, according to which both cities and knowledge are two adaptive systems [Alvira, 2014b], and therefore:

- Our intention is not to design 'final' and immutable indicators, but indicators built on our current knowledge, which can be easily used with information currently usually accessible in most of our cities. We hope that all the indicators we herein propose are improved in the future, as cities' reality or our knowledge regarding them evolves.
- The practical application of the indicators is not intended to be their verification, but a validation of their utility for the sought purposes in a wide range of options.

2 THEORETICAL FRAMEWORK

2.1 SOCIOECONOMIC INEQUALITY

We designate as *society* populations of individuals which present a stable 'structure' of common relations and norms. This structure implies differences between the individuals, and with the term Socio Economic Inequality [SEI] we refer to the differences in several dimensions between the individuals that make up each society.

Noteworthy, *structure* and *differences* are not equal in all societies. Different societies adopt/imply very different models of *Differentiation/Inequality*, and these models define the rights/opportunities and duties that each member of a society has, acquiring thus fundamental importance.

For this reason, *the different models of 'social structure' and the inequality they imply between societies' members have occupied much space in the discourse about 'societies' since the beginning of civilization,* and we find two extreme approaches [Lenski, 1966][4]:

- Those who believe SEI should be minimized, since all humans beings are equal and should have the same rights/opportunities and duties.
- Those who believe SEI is a consequence of the necessary structure for the functioning of societies and therefore differences should not be limited.

Additionally, the justification/legitimation throughout history for socio economic differences between inhabitants is also important, and greatly simplifying, we can differentiate two great periods implying very different paradigms:

- Up to the eighteenth century the main justification has been to consider that not all human beings are equal, and their inequality has been linked to religious [divine] or birth [gender, race, nobility, lineage…] issues.
- From the eighteenth century onwards, the most frequent justification has been to consider that SEI is fundamentally the consequence of the economic and labor structure of societies, in which the necessary specialization of employment to make most talented people occupy the most important positions, leads to differentiated rewards for each individual according his talent, effort and personal value.

Image 01. The Enlightenment [18th century] marks a turning point *in the consideration of the origin and justification of inequality. Illustrated ideas [e.g., Rousseau ...] are incorporated in the 'Declaration of the rights of man and citizen' [National Assembly of France, 1789] which Article 1 states that all men are equal [it is no longer possible to justify Inequality in divine or lineage terms], but accepts that the optimal functioning of societies requires certain amount of inequality. Any inequality which results in the common good is acceptable/just. Rawls will collect and develop this idea in 1971 in his Theory of Justice.*

We have said that there have been two extreme positions in relation to Socio Economic Inequality, and in general, throughout history the vast majority of authors have located in an in-

[4] For an interesting review of approaches to Socioeconomic Inequality since the 18th century see Guidetti & Rehbein [2014].

termediate point; they have considered that *societies* function correctly in certain range of socio economic inequality[5]:

- Reduced inequality values produce insignificant differences; while further reducing inequality could reduce the efficiency of society [it could prevent properly rewarding those who contribute with most effort to the common good].
- High inequality values generate increasing social unrest that can lead to violent events, and increasing inequality no longer increases the efficiency of the system and, from certain thresholds, it greatly reduces it.

These authors have proposed different ways of bringing inequality to the situation they have considered *appropriate*. However, lack of tools to measure inequality means that up to the 20th century its characterization has been mostly qualitative; different states of society are assessed from the –subjective- perception of its effects.

- When an *abundant group of citizens is perceived to be in a situation of extreme injustice/poverty*, some partial measures are proposed to alleviate it[6].
- When *society has become polarized arriving to violent confrontation between the poor and the rich*, a complete redesign of the social structure is proposed including greater distribution [equality] of political, labor and income rights to achieve social peace[7].

And large part of the SEI discourse and actions undertaken to reduce it, focuses on one of its facets; Economic Inequality [EI]. Since ancient times, very unequal distribution of wealth has been observed in many societies, and different theoreticians propose redistributing wealth more justly.

However, from the second half of the 19th century, the effects of industrial revolutions lead some economists to propose the world is in a very different period and distribution problems can also be faced from a quite different logic.

Image 02. Transformation into an Industrial society *leads some authors to propose a paradigm shift. Access of people to the necessary goods no longer requires re distribution of existing goods. It can be solved by producing as many new goods as necessary. Unlimited growth is presented as a path towards a future capable of solving almost all social problems. Few theorists warn early that there are limits to industrial production (e.g., Jevons in 1865).*

[5] We find this advocacy of intermediate states even in authors who accept slavery as Plato [The Laws] or Aristotle [Politics]. The latter stresses the importance of an abundant middle class for societies to be stable; societies where the majority of citizens are placed in extremes [some very rich and some very poor] are very unstable.

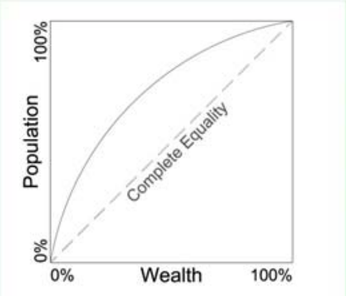
[6] The earliest known example of laws to reduce SEI is the Urukagina Code [ca. 2400 BCE]. Other early examples are Solon's Seisachtheia [594, BCE], several agrarian laws promulgated during the Roman Republic (e.g., Lex Licinia, ca. 350 BCE; Tiberius Gracchus reform, 134 BCE], or the limitation of the percentage of income allocated to pay debts to a maximum of 25% [Lucullus ca. 70 BCE].

[7] As earlier documented examples, we find the complete redesign of Spartan society [Lycurgus, ca. 650 BCE] or the more moderate restructuring of Athenian society [Solon, 594 BCE], the latter being considered by many as the origin of Democracy.

These authors consider that the knowledge of what has happened until then is no longer rele-relevant because the *new economy/society* is radically different. *Unlimited economic growth in a free market environment is advocated by these authors as path for the future evolution of societies to situations in which all individuals can access goods, because as many goods as necessary can be produced*[8].

However, reality does not show this trend towards universal accessibility to goods, but the opposite. With the aim of measuring this Economic Inequality, the first mathematical modelings are proposed by the end of the 19th century. Vilfredo Pareto [1896] proposes valuing the Distribution of Income in each society by counting the number of people in each income step.

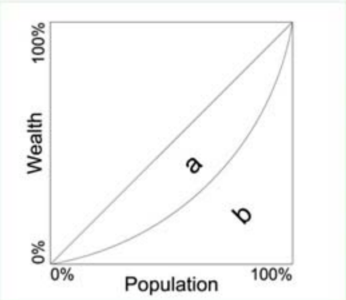
A few years later, Max O. Lorenz [1905] suggests that the previous approach is incomplete, since it is necessary to account for both the changes in numbers of people and in the amount of accumulated wealth. In order to do so, he proposes graphically representing the inequality of societies through a curve: the Lorenz Curve.



To draw the Lorenz Curve *we arrange inhabitants from poorer to richer, and draw the curve that points for each population percentage the percentage of accumulated wealth. The further this line locates away from the square's diagonal [line representing Complete Equality] the greater wealth is unequally distributed in such society. Lorenz does not advise to use the area under the curve as a measure to describe each society, since the same surface can correspond to very different curves/societies.*

From this curve the Lorenz Criterion is defined; if two curves do not cut, the outer curve represents a more unequal society than the innermost located curve.

In 1914, Corrado Gini further develops above proposal, relating the area between the Lorenz curve and the diagonal with the area of half the square, obtaining a coefficient in the range 0-1 that expresses the inequality in every society[9].



The Gini coefficient *is calculated as the ratio of the area between the Lorenz curve and square's diagonal [a] and the total area between the diagonal and square's edges [a + b].*

$$G = \frac{a}{b + a}$$

In addition it can be calculated as sum of trapezoids:

$$G = \frac{1}{2} * \sum_{i=1}^{n} [(p_i + p_{i+1}) * (r_i + r_{i+1})]$$

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[8] Some authors support a different view [Marx, Engels...] but the Western model is derived to a greater extent from the paradigms set forth below. Our present society problems of unsustainability are largely a consequence of this unsustainable paradigm of unlimited growth as a solution to all the problems of society.

[9] Ease of calculation and understanding has led to Gini coefficient being currently used by almost all governments of the world and international organizations linked to economy or development [UN, World Bank, IMF, FAO ...] to assess the Concentration of Income / Wealth [Economic Inequality]. In analysis of spatial segregation Gini coefficient is used in such pioneering texts as Jahn et al [1947].

This Coefficient presents the problem it can provide the same value for income distributions involving very different situations of economic inequality [something Lorenz had already announced]. For this reason, in order to more fully characterize societies' inequality, other complementary proposals appear[10].

Increasing availability of mathematical tools for modelling societies, leads to Inequality analyzes progressively seeking empirical testing.

Towards mid-20th century first economic data become available for some countries, allowing quantitative analyzes of population's income over a sufficiently long period. And from these data, in 1955 Simon Kuznets makes a key contribution to current inequality paradigm.

Kuznets finds a pattern linking economic growth to concentration of wealth, and hypothesizes that economic growth produces states of high concentration of wealth in the beginning, but then self-regulates toward states of reduced concentration[11]. According to Kuznets hypothesis, distribution of wealth follows a U-shaped curve: it is high before the development of societies; reduced during the early stages of development, and then rises again. Western model of Development [built on growth] would involve income equalization.

Image 03: The phrase "The rising tide raises all boats" *is popularized by Kennedy in 1963 when he uses it to refer to the beneficial effect of growth for all citizens.*

A tide has a particular way of raising a set of boats; it places them at the same height. The statement not only suggests growth is a force that elevates all people; it also suggests that in the process, citizens' economic levels are equalized.

However, later evolution of Western societies has refuted the Kuznets hypothesis[12], and the correlation between growth and *Economic Inequality* reduction in the USA from 1900 to 1950 is now considered to be a specific phenomenon motivated by numerous external events [Piketty & Saez, 2006; Stiglitz, 2015a][13].

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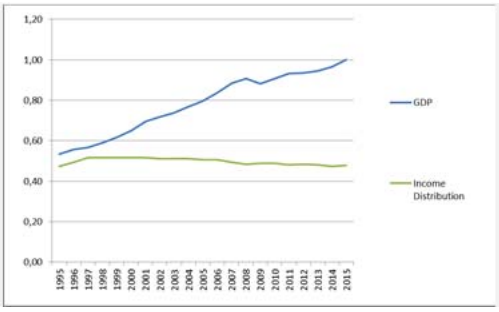
[10] For brevity, we do not review them here. Some examples are those that compare the ratio of wealth or income of a quantile of individuals with lower wealth against the same quantile of individuals with greater wealth [perhaps the origin of these proposals could be placed much earlier in the proposal of Magnesia by Plato -349 BCE- who proposes a maximum inequality ratio of 1: 4]

[11] Kuznets [1955: 26] asserts the speculative character of his work "The paper is perhaps 5 per cent empirical information and 95 per cent speculation, some of it possibly tainted by wishful thinking", and builds his hypothesis from the review of tax data [Piketty, & Saez, 2004 and 2006] from a few countries [US, UK, Germany ...] in the period between late 19th century and 1955. Gallup [2012] indicates that enough information to study a large group of countries only became available from 1970.

[12] From mid-1990s, we find studies that refute the Kuznets hypothesis with empirical data. E.g., Alesina & Rodrik [1994] review 41 countries between 1960 and 1985 and find a negative correlation between concentration of wealth / land ownership and subsequent growth; increasing Gini by 0.16 reduces growth by 0.8%. Piketty & Saez [2006] show that wealth accumulation in US for the whole 20th century only satisfies the Kuznets' hypothesis in the period reviewed by Kuznets.

[13] These events include the two World Wars [which required a tremendous increase in taxes on large fortunes to cope with the cost of war]; the stock market crash of 1929 [which led to a huge reduction in the wealth of the richest]; and the birth of progressive taxes on income and capital as we now know them.

The Western model of economic growth does not self-regulate towards optimal levels of inequality and may well self-regulate in the opposite direction.



The review of Eurozone *data for the period 1995-2015 confirms GDP growth in recent decades has not involved income equalization but the opposite [Pearson=- 0.60]. If we only look at the period 1997-2015, we see sustained GDP growth has been accompanied by steady increase of income concentration, with a negative correlation GDP-Distribution of Income of 0.93 [Eurostat data, access 2017]. Distribution of Income is calculated from the Gini Coefficient [see section 3.1.1].*

Since 1980, in almost all [developed and underdeveloped] countries, economic growth [GDP growth] has involved an increase in Economic Inequality [Galbraith & Kum, 2002; Piketty & Saez, 2006; EC, 2010; Stiglitz, 2015b]. The causes the link Growth - inequality reduction has reversed since 1980 have been [Piketty & Saez, 2006; EC, 2010; Stiglitz, 2015b]:

- Reduction in the social role of the State by modifying public policies that limit economic inequality, e.g.:
  - *Deregulation of the labor market that has led to precarious employment*; much stable employment has been replaced by temporary employment, with lower wages and worse guarantees[14].
  - *Reduction of the maximum rates in progressive taxation*; in many countries, the effort of sustaining the state has shifted from the richest to the poorest[15].
  - Other policies [antitrust, monetary, corporate governance, ...]
- The *increase in the value of the land and its operating income*.
- The *polarization of employment and wages*; very high salaries for high executives/managers and very low salaries for employees with lower qualifications[16].

Most economists state *the relationship between growth and inequality depends on the regulatory/legislative framework. Societies' legislative framework can be designed so it links economic growth with reduced levels of inequality or the opposite*. And the fact negative correlation is observed in most 'Western' countries forces us considering *their legislative/regulatory framework in the last decades does not link GDP growth with income equalization, but the opposite.*

And it is important to highlight that most issues raised by experts depend on societies' structure of political power. In other terms; *there is a strong link between Inequality and*

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[14] This worsening of working conditions has led to the creation of 'working poor'. Currently, one third of workers in the EU are considered at 'risk of poverty' [EC, 2010]

[15] According to Piketty & Saez [2006: 204] data observed in the countries throughout the 20th century "the change in the tax structure might be the most important determinant of long-run income concentration". Achieving optimal levels of differentiation requires adequate progressive taxation structures. The European Commission [EC, 2010] concludes from the analysis of several EU countries that redistributive policies do not reduce growth.

[16] "the polarization of the employment composition impedes career progression and increases the difficulty of redressing the intergenerational transmission of inequality" [EC, 2010: 25]

Governance; between the political and legislative decisions of governments/parliaments and resulting Socio Economic Inequality [UN-Habitat, 2010; Mfom, 2012; Stiglitz, 2015…].

The review of history shows more democratic societies have lower levels of Socio Economic Inequality, and the high concentration of political power in our current parliamentary regimes [and its correlation which high SEI] requires considering that the most effective strategy [and most likely prerequisite] for reducing our societies' inequality, is simply making them [more] democratic.

After this brief review of Socio Economic Inequality, we review one of its possible manifestations; Spatial Segregation by Income.

2.2 SPATIAL SEGREGATION BY INCOME: CONCEPT AND MEASUREMENT

Let us review the research in Spatial Segregation, differentiating between conceptual and quantitative approaches, which allow us to highlight different issues.

2.2.1 CONCEPT OF SPATIAL SEGREGATION; CAUSES AND PERSPECTIVES OF ANALYSIS

"Segregation is the extent to which individuals of various groups occupy and experience different social environments" [Oka & Wong, 2014: 14]

Above definition is important, because although at a semantic level Spatial Segregation refers to any form of separation of inhabitants in the space, the one that interests us is that which implies that *individuals live in different social environments*. As consequence, although cities' space admits different types of segregation[17], in this text we focus our review in the segregation that materializes in the creation of wide social environments [urban areas] internally homogenous and different one from each other.

Therefore, with the term *Spatial Segregation of inhabitants* we refer to the separation in different urban areas of inhabitants with different characteristics, and with *Spatial Segregation by Income to situations in which the relevant characteristic of the 'separated' inhabitants is having different levels of income. The income each inhabitant has defines his greater or lower probability of living in one area or another of the city.*

Let us briefly review the evolution of research in spatial segregation.

Systematic investigation in Space Segregation is usually considered to begin with the **Chicago School** [1915-1940] which analyzes the city from Human Ecology, proposing models inspired by patterns observed in natural environments. In reviewing the growth of American cities these scholars find common demographic dynamics that lead to similar spatial patterns of distribution / separated location of different inhabitants[18].

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[17] In cities, for example, there is often internal segregation in buildings, where most well-off people occupy the highest floors and outer houses, and less well-off people occupy the lowest floors and interior dwellings, yet they share the same social environment.

[18] "There are forces at work within the limits of the urban community […] which tend to bring about an orderly and typical grouping of its population and institutions […] to segregate and thus to classify the populations of great cities. In this way the city acquires an organization and distribution of population which is neither designed nor controlled" [Park, 1925: 1-5]

From this School it is proposed that there is a relationship between the price of land [housing price] and population dynamics / spatial organization of inhabitants in the city, and three important ideas for the present work are stated:

- High land prices in certain areas tend to exclude lower income inhabitants, who must locate in other areas of the city[19].
- Consolidation of residential areas tends to homogeneity of prices, and as consequence to the economic homogeneity of their inhabitants.
- Changes in population produce changes in the economic character of areas that are reflected in land value fluctuations, linking dynamic populations, quality of the environment and land values.

Population dynamics generate differentiated cultural areas which can be characterized in terms of land values, with the greatest value being located at the point representing the geographical, cultural or economic center of the area and the lowest values in the periphery or the boundary line between two contiguous areas. And once these 'homogeneous' areas have been defined, their different character tends to attract/select new 'similar'/compatible inhabitants [McKenzie, 1925; Tiebout, 1956].

In the 1950s the ecological approach evolved towards *deductive sociology*, which is continued in the 1960s by **factorial ecology**. Factor analysis is applied to broad series of data [fundamentally demographic] seeking correlations between variables that allow explaining Spatial Segregation [Muguruza and Santos, 1989].

In the 1970s, emphasis is placed on **behavioral issues**, highlighting the role of individual preferences, perceptions and decisions in Spatial Segregation. The concept of *'place utility'* is proposed as measure of the level of satisfaction of each individual with the place where he lives, and variable that justifies individuals' desire to live in an urban area or moving to another area [van Kemper and Murie, 2009].

This approaches us to environments' desirability as a factor that, given the possibility of choosing on equal terms between various environments, leads each individual to choose the environment he considers 'most desirable'. And as a consequence *if different parts of the city present different desirability, city's inhabitants have sufficiently differentiated levels of income, and the housing market is liberalized [its price is determined by law of supply and demand] Spatial Segregation Space by Income becomes unavoidable[20].*

Additionally, there is an identification of types of inhabitants/nuclei with housing types. Each individual prefers [and in the absence of other limitations, he lives in] the house that best suits his needs/characteristics.

Diversity of housing types [surface, number of rooms, ownership or rent ...] most likely implies different types of households and individuals, and therefore *usual segregation of residential*

[19] Neighborhoods emerge "from which the poorer classes are excluded because of the increased value of the land" [Park, 1925: 6]

[20] Liberalization of the housing market leads to highly differentiated price structure, where the most desirable areas become very expensive and therefore only accessible to citizens with more income. Spatial segregation appears as consequence.

typologies in cities promotes some segregation of types of inhabitants [Van Kemper and Murie, 2009], either because they belong to different households or because their economic capacity is different.

In the 1980s economic growth in Western countries is accompanied by *increasing economic inequality*, which is also reflected in their cities [Tammaru et al, 2016]. Aiming to explain this phenomenon, towards the end of the decade/early 1990s Sassken proposes the **'Global City'** thesis, which states that globalization of the economy makes most 'global' cities present specific dynamics/qualities:

- The orientation of their economy towards globalized services leads to the creation of a group of highly paid executives and another group of unskilled workers with very low salaries.
- Both issues are two sides of the same process; i.e., the degree to which one class is disadvantaged is linked to the degree to which the other is favored.
- The emergence of these two overly differentiated groups creates two parallel cities.

Many theorists have criticized the proposal of the Global / Dual City as too simplistic to explain the functioning of the city, but this proposal highlights two issues that interest us:

- The awareness that even if the distribution of income and space in cities is usually continuous, excessive differentiation of income/quality of the space makes citizens with extreme values of income live in spaces so different that there seems to be a real and insurmountable gap between them. As a consequence inhabitants' membership of the lowest income groups tends to be perpetuated[21].
- The reference to the *interrelation/linkage/dependence between both dimensions*, which result from the same processes[22]. This implies that acting on one necessarily modifies the other. *Eliminating urban subclasses requires reducing their relative distance to the most favored inhabitants, and thus, to reduce the difference in wealth and privilege of the most favored, which is usually rejected by the latter.*

Image 04. The review of the Global City *"…highlights the growing inequalities between highly provisioned/deeply disadvantaged sectors and spaces of the city, and therefore this approach introduces a new formulation of issues of power and inequality" Sassken, 2005: 40].*

UnHabitat, 2010 highlights that internal inequality in cities is often greater than that of countries as a whole.

[21] The New York report in 2000 [notes that] "a city that was accustomed to viewing poverty as a phase in assimilation to the larger society now sees a seemingly rigid cycle of poverty and a permanent subclass divorced from the rest of society" [New York Ascendant in Mollenkopf and Castells, 1991: 4]

[22] "The 'two cities' of New York are not [two] separate and distinct [cities] but rather deeply intertwined products of the same underlying processes [we must move] away from the idea that the so-called 'underclass' areas are isolated from the larger economy" [Mollenkopf & Castells, 1991: 11/13]

Reality challenges once and again the widely echoed dogma by so-called liberal politicians that economic growth eliminates or even reduces poverty[23], and raises the impossibility of achieving it without acting on *inequality and power issues [Sassken, 2005].*

Also in the 1990s, the **influence of the state model on the issues of spatial segregation** becomes important, and a classification of three welfare state models with different consequences on the residential market and spatial segregation is proposed by Esping-Andersen [1990: 52 cited in Van Kemper & Maurie, 2009: 382][24]:

- *Liberal regimes* that minimize the role of the state [e.g., USA].
- *Corporatist welfare states* that further develop state intervention [e.g., Austria, France, Germany, and Italy].
- *Social democratic welfare regimes* where redistribution and equality are key objective of the welfare state [e.g., Scandinavian countries].

Some studies that review spatial segregation in US and EU cities show very different situations that confirm the relationship between different state models and different situations of segregation[25].

Both issues confirm that welfare state policies reduce SSI and EI and the higher dependence between the two variables in the more liberal states. For this reason, many authors [Tammaru et al, 2016] express their concern about *the growing increase in EI and reduction of state intervention in housing in Europe, which they foresee will increase SSI.*

Also, the independent review of different European cities shows that similar State models admit different policies and treatment of housing; the *analysis of segregation should also review contextuality.*

We arrive to an **importance of contextual issues** [Van Kemper & Murie, 2009, Tammaru et al, 2016]; local traditions; land and housing policies, functioning of the administration and its control capacity ... can lead to significantly different situations in contexts with equal *income concentration*. *Where institutions have greater strength, and there is a greater tradition of urban planning, Spatial Segregation is usually lower*[26].

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[23] It is worth noting that triumphalist statistics that proclaim world poverty reduction thanks to growth, consider a person is not poor if he has $ 1.90 a day / $ 57 a month [worldBank.Org] a threshold inconsistent with most scientific criteria.

[24] Some authors later propose extending the types of state to 12 types.

[25] Results show greater segregation in the US than in Europe and Greater correlation between Economic Inequality and Space Segregation in the US than in Europe. For analysis of US cities, see Watson [2009], who reviews the evolution of US cities between 1970-2000 and finds a 0.4-0.9 correlation between Inequality and Spatial Segregation: "In a statistical sense, the rise in income inequality can fully explain the growth in income sorting over the period in American metropolitan areas" [Watson, 2009: 4]. In his analysis of 180 American cities during the period 1979-2009, Bischoff and Reardon [2013: 23] find "large and highly statistically significant estimated association between income inequality and income segregation of 0.734". For analysis of European cities, see Musterd et al, 2015, Tammaru Et al, 2016.

[26] "The apparently universal and strong correlation between social and spatial divisions is not always existing (Fuijta 2012) … the catalyzing effect of income inequality on residential segregation hinges on context-specific institutional arrangements" [Marcinczak et al, 2016: 368]. For Marcinczak Et Al [2016: 362] their review of segregation in 12 European cities challenges the existence of a universal relationship between class and space.

This last issue makes it interesting to recover previously articulated relationship between *segregation, inequality and power*. In high Inequality environments, richest citizens acquire high political power and exert high influence on State orientation and Urban / housing policies, whose impact on urban spatial segregation is very high [Bischoff & Reardon, 2013]:

- *It conditions the overall orientation of the state within the framework of the welfare model.* SSI allow higher income inhabitants to be less concerned with the living in the less favored areas of the city, dissociating themselves from the welfare model, leading societies towards increasing segregation states.
- *It conditions the orientation of local urban policies*. Higher income inhabitants tend to have higher ability to influence public decisions than lower income people. Excessive income differentiation implies concentration of great capacity to influence public decisions in a small number of individuals.

From different perspectives, we see that one of the most effective strategies to reduce Spatial Segregation is to decouple wealth and political power. *More democratic societies tend not only to lower Economic Inequality states; they also limit EI's negative effects on the whole, by decoupling economic power-public decisions.*

Lastly, it is worth noting that despite the time past from Park's claims, *the cost of housing remains a fundamental variable for Spatial Segregation by Income*, especially when the State does not intervene in its formation, leaving it to the free market laws, housing operating then frequently as investment good.

Once we have reviewed the evolution of the understanding of the causes of spatial segregation, let us review the different ways that have been proposed to measure it.

2.2.2 MEASURING SPATIAL SEGREGATION

Most used indexes to measure spatial segregation have had their origin in [or take borrowed their conceptual basis from] contributions in other scientific fields. And to understand the connection of spatial segregation with these scientific fields, it is important to insist on something already commented; **only what is different can be segregated**, and therefore formulas incorporated from other fields of knowledge are **formulas to measure differentiation**:

- From the field of economics, three proposals are imported:
  - Two proposals for assessing *Economic Inequality*: the Lorenz Curve and the Gini Coefficient.
  - A proposal to assess the degree of economic differentiation of a market: the Herfindahl Hirschman Index [HHI][27].
- From the field of *systems / information modeling*, a formula for measuring uncertainty: Shannon's Entropy.

[27] This index is also proposed in 1949 by Simpson to assess the diversity of ecosystems, so alternatively it can be considered imported from the field of Ecology/Ecosystems Theory

For clarity, we review proposed measures of spatial segregation and problems that have arisen, dividing the study into three periods [Feitora et al., 2004; Reardon & Firebaugh, 2002]:

- a first period when *segregation between two groups* is reviewed [e.g., between white and black inhabitants, men and women, ...]
- a second period when *segregation among various groups* is reviewed [e.g., among white, black and Hispanic inhabitants; different job categories, ...]
- a third period in which the focus is placed on assessing spatial issues

Let us review them.

2.2.1.1 MEASURING SEGREGATION BETWEEN TWO GROUPS

The first indexes for measuring spatial segregation are proposed from 1940 in the USA with the aim of assessing the segregation between two races/groups [black and white population; white and non-white...].

The number of proposed indexes progressively increases and in 1955, with the aim of unifying criteria, Duncan and Duncan review several existing indexes, concluding all of them can be formulated as functions of the "segregation curve". This curve, together with the proportion of people from each group in the city, provides all the information provided by any of the indexes already proposed.

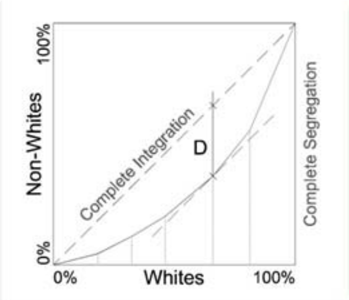


Figure 3. The Segregation Curve is a Lorenz Curve. *To draw it we follow the following process. We value the percentage of the ethnic group X and the ethnic group Y for all the census tracks of the city. We arrange them by increasing value of Xi, and we draw the graph that has as abscissa Yi and as ordinate Xi. The further this line separates from the diagonal of the square [line representing complete homogeneity] and approaches the lower and right edges of the square, the greater the differentiation [heterogeneity] exists between the different areas of the city. This is why they are called 'heterogeneity indexes'.*

Duncan and Duncan [1955] propose the *Index of Dissimilarity or Displacement* [inspired by a proposal by Jahn et al, 1947], so named because it represents the percentage of population of a group in the city that would have to be 'displaced' to achieve their completely homogeneous distribution with the other group in the city. They prove this parameter is the maximum vertical distance D between the curve and the diagonal of the square [complete homogeneity].

$$D = \frac{1}{2} * \sum_{i=1}^{n} \left| \frac{x_i}{X_T} - \frac{y_i}{Y_T} \right| \qquad (1)$$

Being D_ Dissimilarity Index for the ethnicity X in city j; n_ number of areas in which the city is divided; x_i_ number of members of the ethnic group X in each area 'i' of the city 'j'; X_T_ total number of members of the ethnic group X in city j; y_i_ number of inhabitants in area i who do not belong to the x-ethnic group; Y_T_ total number of non-ethnic inhabitants in city j.

At this stage other indices are also proposed / used:

- Some authors use other indexes [e.g. Gini coefficient] to measure the degree of homogeneity in the distribution of groups in the city

- Other authors propose complementary indexes that assess the probability of interaction between different groups in the city [Bell, 1954][28]

Subsequently, several authors refer to the 'improbability' of situations of complete disaggregation and Winship [1977] emphasizes the interest of differentiating two situations:

- If we seek to *review the effects of spatial segregation*, we must compare the concrete distribution of each situation with a pattern of null segregation.
- If we seek to *review the causes of spatial segregation*, the comparison must be made with a random pattern of segregation, which may admit completely homogeneous neighborhoods.

Both objectives and comparisons lead to very different results and *the second one approaches us to the possibility of establishing thresholds different to 0 and 1 to assign 'meaning' to segregation measures*[29].

In 1985, James and Tauber follow the path started by Schwartz and Winship's (1979) proposal for axiomatization of Economic Inequality measures, and enunciate four axioms that should satisfy indices for measuring Residential Segregation:

- *Population symmetry*: segregation does not change if the number of individuals of each type is modified [increased or decreased] by the constant proportion.
- *Group Symmetry*: Segregation does not change if a group is divided into two groups with the same segregation value or if two groups with the same segregation value are jointly assessed.
- *Transfer Principle*: segregation is reduced if individuals are transferred from an area where there is greater proportion of individuals from said group to another in which there is a smaller proportion of members of said group
- *Principle of scale invariance*: segregation is unchanged when all incomes are multiplied by the same factor

The authors state any index satisfying the Lorenz Criterion satisfies the four previous axioms.

2.2.1.2 MEASURING SEGREGATION BETWEEN MORE THAN TWO GROUPS

The previous indexes allow reviewing the segregation between two groups. But in the 1970s the need to assess situations in which segregation occurs between more than two groups becomes evident. It may be racial segregation [e.g., among white, black and Hispanic populations], socioeconomic segregation [e.g., study levels; types of employment, income]...

---

[28] Noteworthy, Bell proposal of index of Exposition P is a generalization of Herfindahl Hirschman Index for the general case where categories may not be equally likely when considering the whole set [they do not comprise the same proportion of individuals].

[29] For example, Massey & Denton [1993] propose that values 30 and 60 constitute reduced / elevated segregation thresholds when the Dissimilarity Index is used to assess Ethnic Segregation. Marcińczak and Al [2015] propose that values 20 and 40 are equivalent thresholds when the index is used to assess Segregation by Income [both cited in Tammaru et al, 17]

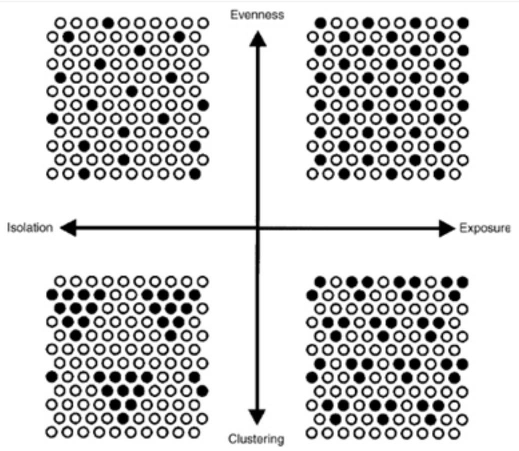
For this purpose, a second group of indexes is proposed, almost in all cases being generalizations of previous indexes [Feitosa et al, 2004]. Also at this time another index is proposed to measure differentiation; Theil [1972] adapts Shannon's Entropy, decomposing it in two terms[30]:

- a characterization of the internal inequality of each group
- a characterization of the existing inequality between two groups

Again, large number of different index proposals has been accumulated, and with the intention of reviewing and comparing them, Massey and Denton [1988] undertake a factor analysis, which leads them to assert that the indexes assess five independent dimensions[31]:

- *Homogeneity*: as a measure of the degree to which the different groups are proportionally distributed throughout the different urban areas.
- *Exposure*: as a measure of the extent to which members of different groups share residential areas in the city.
- *Concentration*: as a measure of the degree to which groups of individuals are concentrated in the city space.
- *Centralization*: as a measure of the extent to which group members reside in the center of the urban area.
- *Grouping*: as a measure of the extent to which minority areas are located side by side.

Subsequently, Reardon & O'Sullivan [2004] show several dependencies between the previous dimensions, and propose to reduce them to the first two:



Dimensions of Spatial Segregation *[Image by Reardon & O'Sullivan, 2004]. Homogeneity/Evenness [complementary of Grouping/Clustering] refers to the equilibrium in the distribution of each group of individuals in the city, and is independent of the composition of the population of the city. Exposure [complementary of Isolation] refers to the probability of interaction between members of different groups in the city, and depends on the composition of the population of the city.*

Authors propose that H [entropy] is the best index to measure spatial homogeneity, and P [index exposure] is adequate to measure exposure.

In addition, the authors emphasize the importance that the spatial units in which the city is divided for review should be 'meaningful', and this gives us the opportunity to revisit an issue that has intermittently but recurring manifested from the origins of the research in Spatial Segregation, and with greater intensity from the 1970s; *the problem of defining spatial areas of measurement/analyzes.*

---

[30] This decomposability of Theil Index is one of the characteristics that make it the most preferred index for several authors [White, 1986; Reardon & Firebaugh, 2002...].

[31] It is worth noting that the first two dimensions allude to the two meanings of segregation proposed by White [1983: 1009]: sociological [interaction between individuals] and geographical [distribution of individuals throughout the space].

2.2.1.3 THE DIFFICULTY OF DEFINING SPATIAL EVALUATION AREAS

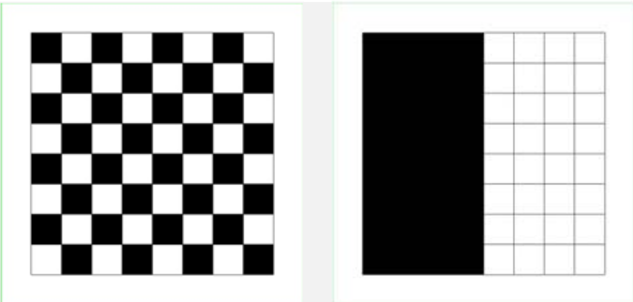
From the first investigations, we find references to the problem of defining spatial areas for assessing segregation. Researchers are aware that the way cities are divided for their analysis, conditions obtained results.

While early studies consider *census tracts* as elemental analytical units [Jahn et al., 1947], soon other authors appear who prefer considering each *block* an elemental analytical unit [Cowgill & Cowgill, 1951]. However, most authors adopt the first approach [Jahn et al, 1947, Duncan & Duncan, 1955...].

By the 1970s interest in this issue intensified, and we find an extensive review of spatial issues in Openshaw and Taylor [1979] which with the denomination **Modifiable Areal Unit Problem [MAUP]**, encompass two issues/problems:

- *The Scale problem*: overall segregation value obtained for the city is modified if the city is reviewed by dividing it into units of different size [e.g., census tracts vs. blocks]. The smaller the areas in which the city is divided, the greater the obtained spatial segregation value [Winship, 1977; White, 1983; Wong, 2003].
- *The Aggregation Problem*, overall segregation value obtained for the city is modified if, without altering the scale, the city is divided into areas of different shape.

Additionally, White [1983] proposes the *Checkerboard Problem*. Using existing indices, if a measure of spatial segregation is calculated from the division of the board into squares, that measurement is not modified even if the squares are reorganized leading to a considerably different global scheme.



***The Checkerboard problem** refers to the fact that indices that assess the city as a whole building on elementary units [e.g., census tracts, blocks, ...] may not differentiate a city in which individuals of two types are completely integrated [Left] from another in which the individuals are totally segregated [right].*

In addition, the majority of studies so far proposed work with census tracts. But these areas are defined using administrative criteria, and several issues arise:

- *They may be describing very different areas in different cities if their density is different* [e.g., Manhattan vs. Los Angeles], denser cities have smaller surface census tracts and therefore show more homogeneous social composition [Rodríguez, 2013] providing hence higher values of Spatial Segregation.
- *They may have been defined with different criteria depending on the time or city in which they were created*; they may have been defined by seeking internal homogeneity of inhabitants or not [Cowgill & Cowgill, 1951]. In the first case, they provide higher segregation values and in the second smaller values.

This means overall segregation values obtained for different cities are not necessarily comparable, making it difficult establishing statistical correlations with other variables. A solution to this problem is defining areas 'meaningful' in relation to the studied phenomenon[32]. Dividing the city into areas for comparative assessment, implies considering these areas can be globally characterized, which in turn requires they show sufficient internal homogeneity.

Subsequently White [1986: 210] also challenges the nature of areas' boundaries; individually analyzing each area implies considering that each area inhabitants interact among them but not with the inhabitants of neighboring areas[33]. To solve this, White [1983] proposes assessing both the composition of each area and the distance between the areas.

In more recent times, enabled by greater technological development, other authors [Wong, 2003] have proposed using Geographic Information Systems [GIS] for modelling cities by considering each block is a different unit, generating diffuse and overlapping zones, and considering that influence of each area on surrounding areas decreases with distance [Wong, 2003; Feitosa et al, 2004, ...].

Currently, there is still an open debate on the MAUP and use of GIS. The theoretical development of proposals is relatively recent, and sufficient validation is lacking [Reardon & O'Sullivan, 2015]. In addition, diffuse modeling with decreasing environmental influence functions with distance has been scarce due to its greater computational difficulty and the need for information that is often unavailable or inaccessible.

Therefore, since our objective with the present text is to provide a methodology and simple tools that can be used with reduced effort using available information almost in any city, we adopt the approach of defining meaningful analysis areas, with 'crisp' limits, and without modeling interaction across areas.

2.3 BRIEF SUMMARY AND JUSTIFICATION OF THE BASES OF THE PRESENT WORK

We have reviewed the state of the art -very briefly in Socio Economic Inequality, and in greater depth in Spatial Segregation of Inhabitants-, and recap is convenient relating above review to the objectives of the present work:

Our objective is to propose indicators and a methodology that can be used with moderate effort and technical knowledge [i.e., that does not require GIS programs or a lot of technical personnel], in almost any city [i.e., that does not require information difficult to obtain], that provides an assessment of the degree to which Spatial Segregation by Income of its inhabitants approaches or distances it from its optimal state, and that can be used for designing urban transformations.

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[32] "Space partitioning systems cannot be independent of the described phenomenon" [Muguruza and Santos, 1989: 90]. The authors analyze Las Rozas [Madrid] by evaluating their census tracts and areas with homogeneous residential typologies, finding that the analysis with census tracts shows a smaller segregation than the real one. Also Openshaw & Taylor [1979] indicate that the criterion of homogeneous areas provides more accurate estimates in correlation and regression analysis.

[33] See Alexander [1965] for a previous explanation of the inconsistency of cities' analysis by dividing them into mutually exclusive areas. In terms of Logic, this issue also relates to the evolution from Classical [Boole, 1854] to Fuzzy Logic [Zadeh, 1965/1973].

This allows us to understand some of the issues we raise differently from previous works:

In the first place, **of all dimensions of Spatial Segregation we only value the one that refers to inhabitants' incomes, i.e. Spatial Segregation by Income.** This allows us a very specific approach to the issue; dividing the whole set of individuals according to certain levels of income [quantiles] that by definition contain the same number of individuals.

As consequence, maximum Exposure / Interaction situations between different types of inhabitants [i.e., inhabitants belonging to different quantiles] and maximum Homogeneity states are coincident, since quantiles are by definition equally likely / contain the same percentage of inhabitants. Therefore, the indicators we propose jointly evaluate Homogeneity and Exposure dimensions.

Second, **we do not seek to measure the spatial segregation of the inhabitants in a city but to assess the effects that each segregation state implies for the city in terms of 'common good' or optimum state of the whole.** The values provided by the inequality indexes do not constitute an assessment of the optimality of the state of each society, and to obtain such valuation, we must transform them[34]:

- We must detect a minimum inequality value capable of creating sufficient differentiation for society to function optimally
- We must detect a maximum inequality value from which increasing differentiation becomes so important that the whole society is on the verge of collapse.
- We must model the transition between the two values.

Equivalently, we must transform spatial segregation measures into measures of systems' position between their optimal / worst states, as states that maximize/minimize the impact of segregation on production of common good. These states will be intermediate states between the maximum differentiation and complete equality. This implies a change from most existing formulas/indicators since:

- In the indicators we propose, the *optimal and worst values of segregation do not coincide with the states of null and complete segregation.*
- In general, *the optimal states are those with the least possible segregation consistent with sufficient urban areas' differentiation*, and their optimality decreases as segregation increases.

Additionally, our objective of using indicators as decision making criteria leads us to design the indicators so their logic matches the usual modeling of the utility[35]: value 1 involves the state that maximizes the collective utility [reduced segregation] and value 0 implies the state which minimizes collective utility [high segregation]. In logical-semantic terms, indicators that we propose do not value Spatial Segregation of Inhabitants [SSI], but the complementary concept: Spatial Integration of Inhabitants [SII], which follows the same logic as collective utility.

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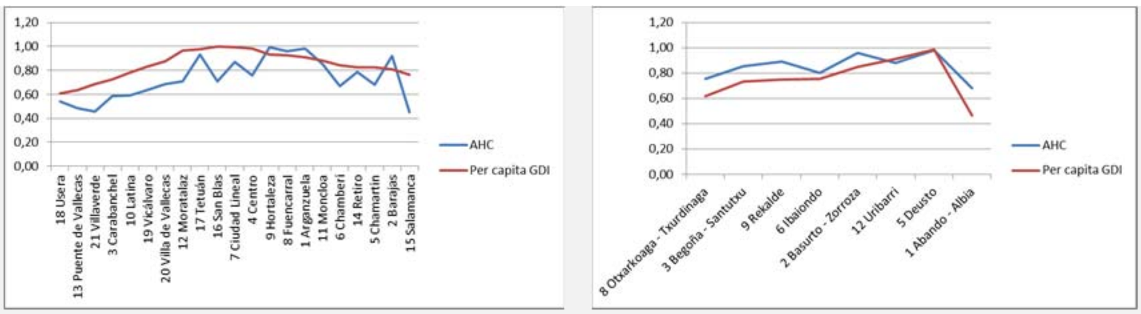
[34] For this we build on Fuzzy Set Theory [Zadeh, 1965], widely accepted for designing utility functions [Goguen, 1967]. In Alvira 2014a we explained a methodology for designing sustainability indicators in the framework of Fuzzy Sets Theory.

[35] As per Von Neumann Morgenstern [1944] axiomatization

The third important issue is that **we want to define an operational methodology that is easy to use even in cities with little information available, using information that is usually accessible, recognizable by architects and relating variables on which it is possible to operate**. This leads us to several specifics regarding previous work:

- Instead of using inhabitants' income as input variable, we use the *Cost of Housing* as a variable that indirectly informs the purchasing power [i.e., income] of each urban area inhabitants.
    - Housing prices are usually available online indicating the location of the property [georeferenced information], so calculation is usually possible even in urban areas with limited information available.
    - Its importance in defining Spatial Segregation by Income has been highlighted by numerous authors from the early days of Spatial Segregation research [Chicago School] to the present day [Marcinzak et al, 2016].
    - It is possible to intervene on it from the usual work of urban architects; it is related to issues of location, environment, building morphology and residential typology.



Comparison of normalized Average Housing Cost, AHC [€/m2] and Per capita GDI *shows, for those cities for which disaggregated Income data is available, high resemblance. In Madrid [left], deviation between values is 0.10 and correlation is 0.72. In Bilbao [right] resemblance is even higher [deviation is 0.07 / correlation 0.91].*

The *relative equivalence between areas with homogeneous Housing Cost and groups of inhabitants with homogeneous income levels* has been emphasized several times in studies on Space Segregation [Park, 1926; Moreno et al, 2013; Tammaru et al., 2016], and in the few Spanish cities for which it has been possible to find this disaggregated information, we have been able to verify this quasi-equivalence. However, there is an important difference between Income and Cost of Housing:

- *Income per capita*, allows us to measure the Spatial Segregation of urban areas at a given point in time while....
- the Cost of Housing on offer [purchase or lease], allows us predicting urban areas' Spatial Segregation in two future moments:
    - In the short term when we evaluate the cost of the homes transferred/leased in recent years
    - In the medium term when we evaluate the Cost of Housing on offer.

This is important for assessing possible deviations between current situation of Income and the Cost of Housing in an urban area.

Additionally, using the Cost of Housing as relevant variable allows us to divide cities into *homogeneous zones according to homogeneity of Cost of Housing*, and to use them as spatial units of analysis. This considerably facilitates the calculation, since it is not necessary to use GIS technologies or software difficult to obtain or use.

For the present work, we use as analytical areas delimitations proposed by a well-known Spanish internet real estate company [idealista.com], whose graphic revision shows several interesting qualities:

- They relate to *urban areas' perception by most people*. Its objective is to facilitate buyers the search of a house, grouping the houses in areas easily 'identifiable' by users [internally homogeneous and different one from another].
- They are linked to *physical design of cities* [e.g., boundaries of areas almost always coincide with elements that exert some limiting/barrier effect as wide high traffic routes, rivers, railways, ...
- In larger cities, *areas have some administrative entity* and therefore some semiautonomous capacity to plan transformations.

Therefore, working with homogeneous areas of housing costs allows us to partly dodge the MAUP since two above qualities allow us to assign sufficient objectivity to their limits, and differently to census tracts they do not depend on urban density, so they are not necessarily smaller in large cities than in small ones.

Let us therefore proceed to review the proposals of indicators for assessing SSI.

3 PROPOSAL OF OPERATIONAL INDICATORS TO VALUE SPACE SEGREGATION

In the present work we propose/use six indicators[36]:

- Two of them value the **global differentiation of the city**, and allow us to contrast the indicators to assess SSI from urban areas. As a basis we use the Gini Coefficient, which we apply both to Income and Cost of Housing.
- Four of them value **Spatial Segregation by Income** in each area of the city, and allow us obtaining an overall value for the whole city.

3.1 INDICATORS FOR VALUING THE OVERALL DIFFERENTIATION OF EACH CITY

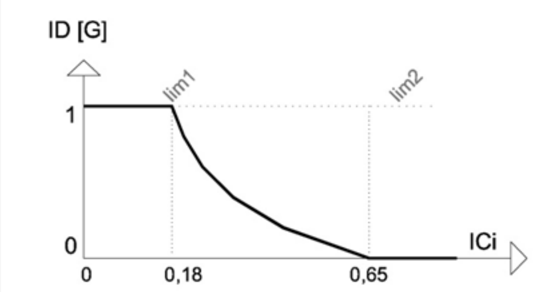
Firstly, we explain two indicators to assess overall differentiation in the city.

3.1.1 INDICATOR 'INCOME DISTRIBUTION'

This indicator values the collective utility that the Income Distribution provides to each society, or alternatively the distance at which it places said society between its optimal and worst states. To calculate it, we use Gini coefficient where the input variable is inhabitants' income and we transform it into an indicator considering the following limits[37]:

- as optimal state threshold: 0.18 [lim1]
- as worst state threshold: 0.65 [lim2]

Indicator Graphic



Indicator Formulation

$$ID[G] = \max\left[\min\left[1 - \frac{[IC_i - lim_1]^2}{[lim_2 - lim_1]^2}\ ; 1\right]; 0\right]$$

Which can be simplified as:

$$ID[G] = 1 - \frac{[IC_i - 0{,}18]^{1/2}}{0{,}47^2} * 100$$

Where DI [G] _ Indicator 'Income Distribution' [Gini]; IC_i_ Gini coefficient applied to inhabitants income in the assessed area

These thresholds provide the following indicator values:

- 0.5 for a Gini value of 0.30, an 'intermediate' situation for many authors
- 0.3 for a Gini value equal to 0.40, a warning threshold according to UN-Habitat [2015].

These are values consistent with the meaning that different sources give to different values of Income Concentration.

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[36] The reason for using several indicators to assess SSI/SII is that it allows us to see that using different formulas we obtain similar results.

[37] In Alvira, 2015a [Indicator E3] several thresholds for Income Concentration proposed by other authors are reviewed. The value 0.18 as an optimal situation coincides with Dagum [2002]. According to the World Bank [access 2012], minimum Gini value in 20th century was values 0,163 [Azerbaijan in 2004] and maximum 0.743 [Namibia in 1993], allowing us to consider those values limit countries' self-regulation range.

3.1.2 INDICATOR 'HOUSING COST HOMOGENEITY'

This indicator values the distance to which the Differentiation of the Cost of Housing [DCV] places each city between its optimal and worst states. To calculate it, we follow two steps:

- First, we calculate the Housing Cost Differentiation, HCD of the urban area.
- Second, we transform the previous value into an indicator that assesses the degree to which HCD places the city between its optimum and worst conditions

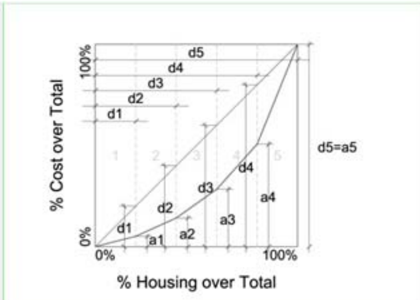
Let us review both calculations in detail.

3.1.2.1 CALCULATION 'HOUSING COST DIFFERENTIATION'

This indicator values the city's Housing Cost Differentiation [HCD]; i.e., how much city's houses differ in terms of cost, and therefore, in terms of income needed to access them. For calculation, we use Gini coefficient following the procedure:

1. We separate households by type and within each type we arrange them from the cheapest to the most expensive[38].
2. We calculate the Gini coefficient for each residential type, then we add them weighted by the percentage each residential type represents in relation to total housing.
3. We obtain a differentiated overall curve for rental and purchase, we add them weighted by the percentage of the total housing each one represents.

In this case, we could not access individualized house's cost data so we have simplified step 1, accounting for each housing typology the global cost of the five quintiles[39]. From these data we calculate the indicator as trapezoids aggregation with the formula:



We have considered five cost intervals *[the five quintiles price/rent] for each residential typology, so indicator calculation can be easily done as 5 trapezoids aggregation.*

$$HCD = \sum_{i=1}^{5} \left[[d_i + d_{i-1}] - [a_i + a_{i-1}] \right] * \frac{1}{2}$$

This involves more reduced values than actual, which is defined by an outer curve to the five points which has a larger area.

Where di_ accumulated percentage for each households quintile 'i' [approx. 20, 40, 60, 80 and 100%], and a_i cumulative percentage of cost for each quintile 'i' related to the total cost of all city's houses.

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[38] Valuing Housing Cost Differentiation requires assessing the different meaning that a same price has if it refers to a one-bedroom or four-bedroom dwelling. This requires differentiating between typologies.

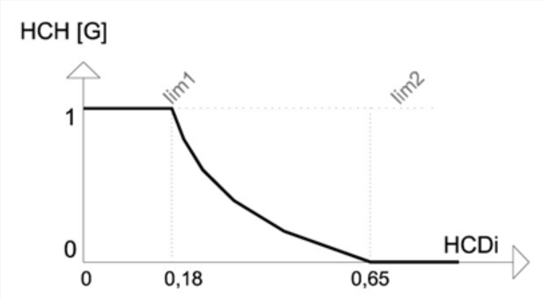
[39] The lack of individual data on housing costs in digital format has forced us two simplifications to calculate HCD. The first is to consider that the cost of housing in each quintile is uniform [i.e., that all dwellings within each quintile have the same price], which implies slightly reducing cities' HCD value. The second is to calculate the price according to the following procedure: In quintile Q1 we have multiplied the maximum cost [upper quintile threshold] by 0.8. In the quintiles Q2, Q3 and Q4 we adopt the average price. In quintile Q5 we multiply the minimum price [lower threshold of the quintile] by 1.4. This transformation reduces the effect of dwellings whose price is not significant because it differs greatly from the others, and is expected to have little impact in cities with little HCD, and greater impact in cities with a higher HCD [being actual HCD value in the latter most likely higher than herein shown].

3.1.2.2 CALCULATION OF 'HOUSING COST HOMOGENEITY'

We transform above value into a collective utility measure considering the following limits[40]:

- as optimal value: 0.18 [lim1]:
- as a worst value: 0.65 [lim2]

Indicator Graphic



Indicator Formulation

$$HCH[G] = \max\left[\min\left[1 - \frac{[HCD_i - lim_1]^2}{[lim_2 - lim_1]^2}\ ; 1\right]; 0\right]$$

Which can be simplified as:

$$HCH[G] = 1 - \frac{[HCD_i - 0{,}18]^{1/2}}{0{,}47^2} * 100$$

Where HCH _ Indicator 'Housing Cost Homogeneity'; HCD_i_ Hosuing Cost Differentiation [Gini coefficient applied to the Cost of Housing]

After reviewing the two Differentiation / Homogeneity [Similarity] indicators, let us review below Integration / Segregation indicators.

[40] We have not found previous research which assessed Housing Cost Differentiation, and therefore we lack previous proposals for thresholds. Due to conceptual resemblance, we use the same thresholds as for the Income Distribution, which provide congruent results. The analysis of the subsequent data has shown correlation values that remain very similar regardless of the thresholds or the use of a linear or quadratic formula for the indicator. However, in the future it seems interesting to further investigate on optimal thresholds/formulation for this indicator.

3.2 INDICATORS FOR MEASURING SPATIAL SEGREGATION / INTEGRATION BY INCOME

For the calculation of the indicators it is necessary firstly to detect the Structure / Profile of the Cost of Housing in the City and in each urban area, which we review below.

3.2.1 DEFINING THE HOUSING COST PROFILE/STRUCTURE FOR EACH URBAN AREA

Definition of this Cost Profile/structure requires two steps:

- We review *all city's houses/dwellings* in order to define city's overall profile/structure.
- We review *houses/dwellings within each area of analysis* in relation to the categories established in the global profile/structure.

Let us therefore review the process for defining Housing Cost Profile/Structure.

3.2.1.1 OVERALL COST PROFILE/STRUCTURE OF THE CITY

To establish **city's Housing Cost Profile/Structure** we conduct two steps:

- We detect which are the *main types of housing* in the city [e.g., 1 bedroom, 2 bedrooms ...] distinguishing between *ownership and lease.*
- We establish *the price/rent structure within each type of housing.* For this we rely on the concept of economic 'quintile' and define five cost intervals for each housing type, each comprising 20% of the total housing of this type in the city.

OWNERSHIP. TYPE: 4D OR MORE			
Quintile cost		units	% total
less than	200.000 €	450	20,22%
200.000 €	320.000 €	900	20,22%
320.000 €	475.000 €	1.323	19,00%
475.000 €	800.000 €	1.771	20,13%
more than	800.000 €	2.226	20,44%

Detecting thresholds of quintiles cost *for residential type '4 bedrooms or more' in category 'ownership' in Palma de Mallorca. Although housing figures never give a totally accurate 20%, generally they lie quite close, and the errors introduced by the differences are small.*

Once city's housing cost profile/structure is defined, it is necessary to define the Housing cost Profile/Structure for each of its areas, which we review below.

3.2.1.2 HOUSING COST PROFILE/STRUCTURE OF EACH URBAN AREA

We review the number of houses/dwellings on offer in the urban area for each quintile cost within each housing typology established in the 'Type Organization' [city's Housing Cost Profile/Structure]. We add the number of houses of each residential typology [weighted by their percentage in relation to total households in that cost quintile] obtaining the percentage of households in each quintile cost in urban areas.

Ownership

$$Q_{oi} = \sum_{j=1}^{n} Q_{oi.j} * P_{oi.j} \qquad (2)$$

Lease

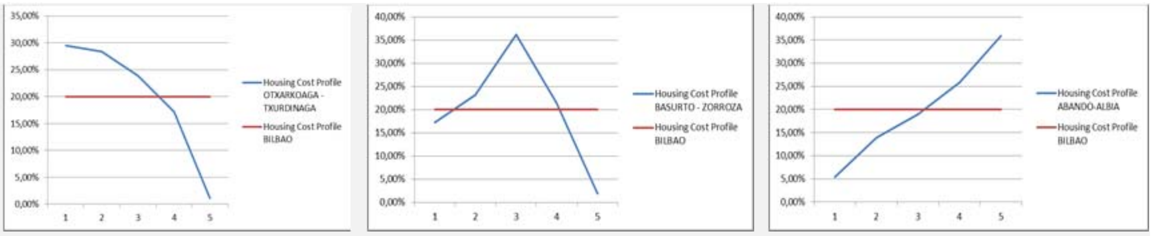
$$Q_{li} = \sum_{j=1}^{n} Q_{li.j} * P_{li.j} \qquad (3)$$

Where Qi_ percentage housing in cost quintile I; n_ number of different residential types considered; j _ each type considered as different housing, Pi.j_ percentage of each type residential housing over total housing in quintile i

Once the percentage of households within each cost quintile is separately calculated for lease and ownership, we add them again weighted by the percentage each of these categories [lease / ownership] represents in relation to total number of households in that cost quintile:

$$Q_i = Q_{li} * P_{li} + Q_{oi} * P_{oi} \quad (4)$$

We thus obtain five values that summarize the percentage of housing within each cost/rent quintile for the urban area, from which we calculate indicators, and which we can graphically represent to easily visualizing what type of area it is:



Housing Cost Profile for three areas of Bilbao. *In the area represented on the left [Otxarkoaga-Txurdinaga] predominates below average cost/rent housing; in the area represented in the center [Basurto-Zorroza] predominates housing with similar cost/rent to the average and in the area represented in the right [Abando-Albia] predominates housing with above average cost/rent.*

Below we explain each indicator's detailed calculation.

3.2.2 INDICATORS TO ASSESS EACH AREA'S SPATIAL INTEGRATION

We explain four alternative indicators for measuring Spatial Integration of inhabitants with different Income, SII [complementary concept to Spatial Segregation by Income, SSI], each based on a particular measure of differentiation. This allow us to later comparing the values obtained using each of them.

3.2.2.1 INDICATOR BUILDING ON HERFINDAHL-HIRSCHMAN/SIMPSON INDEX

The Herfindahl-Hirschman/Simpson Index [HHI] is independently proposed by these authors with two different applications:

- *Economy*: as a measure of market concentration/formation of corporate monopolies [1945 Hirschman / Herfindahl 1950]
- *Ecology*: as a measure of ecosystems' species diversity [Simpson 1949]

It measures the probability of choosing two equal elements within a set, assuming that we chose one item, return it to the set and then choose again:

$$HHI = \sum_{i=1}^{n} p_i * p_i = p_i^2 \quad (5)$$

Being HHI_ Herfindahl-Hirschman/Simpson Index; n_ number of different categories and p_i_ the probability of each of them [equal to its percentage over total]

Its interpretation is different in its usual uses in ecology/economy; while in Ecology is commonly used to check ecosystems' differentiation and to detect frequent / infrequent species, in economics is often used to check the degree of markets' concentration, i.e., to detect monopolies.

The HHI values the probability of interaction between members of each group / isolation of the members of each group in relation to the members of other groups, while its complement values the complementary concept; the Integration/Exposure of the members of each group [i.e., the probability of interaction of two different elements].

Segregation /Isolation

$$HHI = \sum_{i=1}^{n} p_i^2 \tag{6}$$

Integration/ Exposure

$$1 - HHI = 1 - \sum_{i=1}^{n} p_i^2 \tag{7}$$

It is worth noting that the HHI assumes that interaction between each pair of individuals is a random event, but in reality this is not so. Individuals tend to prioritize intra-group relationships; i.e., with their 'alike'. Therefore, HHI gives an isolation value -likely interaction between members of the same group- that is almost always inferior to the real [Bell, 1954].

HHI is widely used today by the US government [and to a lesser extent by the EU] to prevent the formation of monopolies. Applied in the field of Spatial Segregation measurement, we find it in White [1986] and Watson [2009], and in USGBC [2009] as an operational indicator for indirectly assessing social diversity from the Diversity of Residential Typologies.

For the calculation of the indicator, we follow the following process:

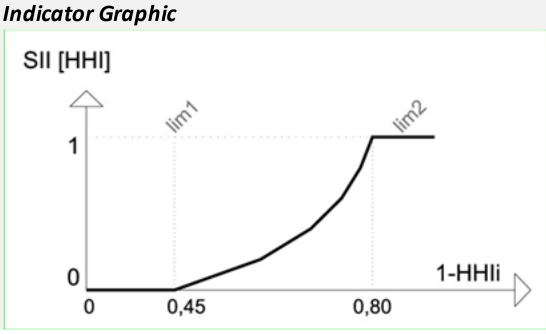
We calculate for each area the Herfindahl-Hirschman Index [HHI] from housing percentages in each cost quintile:

$$HHI = \sum_{i=1}^{5} {Q_i}^2 \tag{8}$$

Being Qi_ percentage of housing in each cost quintile.

We calculate the indicator using the complementary value [1-HHI], normalized by setting 0.80 as optimum value [lim_2] and 0.45 as worst value [lim_1]:

Indicator Graphic



Indicator Formulation

$$SII[HHI] = \max\left[\min\left[\frac{[[1 - HHI_i] - lim_1]^2}{[lim_2 - lim_1]^2}\,;1\right];0\right]$$

Simplified formula for calculation is:

$$SII[HHI] = \frac{[[1 - HHI_i] - 0{,}45]^2}{0{,}35^2} * 100$$

Where SII[HHI]_ Indicator 'Spatial Integration of different Income citizens' [HHI]; 1- HHI_i_ complementary value of the Herfindahl Hirschman Index calculated for housing percentages in each cost quintile [Q_i] in the assessment area.

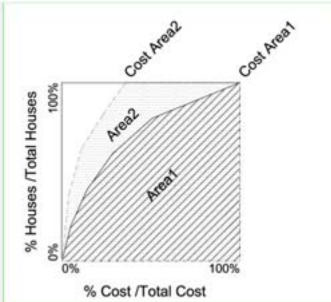
3.2.2.2 INDICATOR BUILDING ON LORENZ'S CURVE

We have characterized each urban area's measure of *Spatial Integration of different Income citizens* as a measure of the degree to which the coincidence of its Housing Cost Profile/Structure with that of the whole city locates the area between its best and worst states.

This comparison involves some difficulty when using the Lorenz Curve. If we compare Lorenz's Curves representing the whole city's housing and each area's housing, we know whether Housing Cost shows little or much differentiation in each area but we cannot characterize each area's structure in relation to that of the city neither we can characterize the Segregation/Integration said structure implies.

For this characterization we need comparing Lorenz's Curves for the whole city and each urban area both calculated for the same total cost matching the higher value of the two [total cost of housing area or an equal number of homes with the cost structure of the city], accordingly adapting the representation of each area:

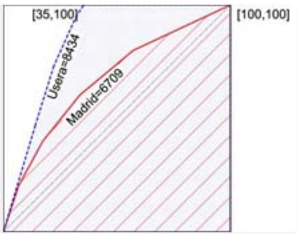
- In *areas where the average cost of housing* [€/house] is lower than city's average, total cost is given by the average dwelling cost [€/house] for the city multiplied by the number of dwellings in the area.
    - Lorenz's *curve for the city* starts at point [0,0] and reaches point [1,1].
    - Lorenz's *curve for the area* does not reach 100% of total cost; it starts at point [0,0] but ends at some point [x,1].
- In *Areas where the average cost of housing* [€/house] is higher than city's average, the total cost is given by the total cost of homes in the area.
    - Lorenz's *curve for the area* starts at point [0,0] and reaches point [1,1].
    - Lorenz's *curve for the city* does not reach 100% of total cost; it starts at point [0,0] but ends at some point [x,1].



Data analysis *leads us to prefer working with Lorenz's curve which shows higher correlation than Gini coefficient with the rest of indicators. We calculate the area under Lorenz's curve for both city and urban area as trapezoids' aggregations.*

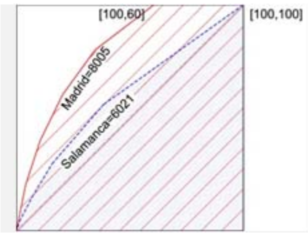
Once these values are obtained, indicator calculation is an easy process [we explain below]

For clarity, let us review the calculation of two Madrid's districts:



Usera district, *average cost €/house is lower than Madrid's average. The red curve representing Madrid goes from [0.0] to [100,100]. The blue dashed curve representing Usera district goes from [0,0] to [35,100].*

Buying 100 houses in this district at each cost quintile requires 65% less budget than buying them for each quintile at the city level.



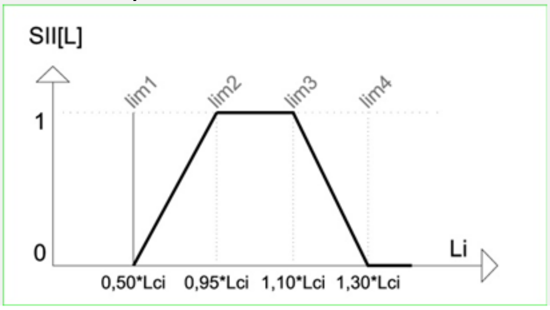
Salamanca district, *average cost €/house is higher than Madrid's average. The blue dashed curve representing Salamanca district ranges from [0.0] to [100,100]. The red curve representing Madrid goes from [0.0] to [60,100]. Buying a home at every percentile of the city requires a 40% total cost less than it costs to buy them at each price percentile in this district.*

The value obtained for the city when assessed in conjunction with area i [Lci], defines the limits of the indicator:

- the limits indicating optimal state are: 0,95*L_{ci} y 1,10*L_{ci}
- the limits indicating worst state are: 0,50*L_{ci} y 1,35*L_{ci}

From these values, we calculate the indicator using the value obtained for the area i [L_i] with the following formula:

Indicator Graphic



Indicator Formulation

$$SII[L] = max\left[min\left[\frac{L_i - lim_1}{lim_2 - lim_1}\ ;1;1-\frac{L_i - lim_3}{lim_4 - lim_3}\right];0\right]$$

Simplified formula for calculation is:

$$SII[L] = max\left[min\left[\frac{L_i - 0{,}50 * L_{ci}}{0{,}45 * L_{ci}};1;1-\frac{L_i - 1{,}1 * L_{ci}}{0{,}20 * L_{ci}}\right];0\right]$$

Where SII[L] _ Indicator 'Spatial Integration of different Income population' [L]; L_ area below the Lorenz Curve drawn for the cost of housing in the area i; L_{ci}_ area below Lorenz's Curve drawn for the city [calculated together with the area i].

3.2.2.3 INDICATOR BUILDING ON SHANNON'S ENTROPY

This entropy measure is proposed by Shannon in 1948 to measure the amount of information that must be transmitted to communicate numeric strings. Entropy is the receiver's uncertainty in relation to the following code of a numeric string, i.e., the information said receptor needs to receive in order to 'know' the string.

Shannon's Entropy is a particularization of Entropy [Boltzmann, Gibbs...] expressed in binary terms, defined on the number of possible [i.e., different] codes and the likelihood each one appears:

$$H = \sum_{i=1}^{n} p_i * log_2[p_i] \tag{9}$$

Being H_ Entropy or Uncertainty; n_ number of different codes and pi_ the probability of each of them

We find it used to assess the differentiation of ecological systems in MacArthur [1955] and to measure spatial segregation in White [1986], Reardon & Firebaugh [2002]; Oka &Wong [2014].

To calculate the indicator, we follow the process:

Firstly, we calculate the Relative Entropy [Shannon, 1948] for each urban area, from the percentage of households in each quintile within such area:

Entropy
$$H_i = -\sum_{i=1}^{5} Q_i * log_2[Q_i] \tag{10}$$

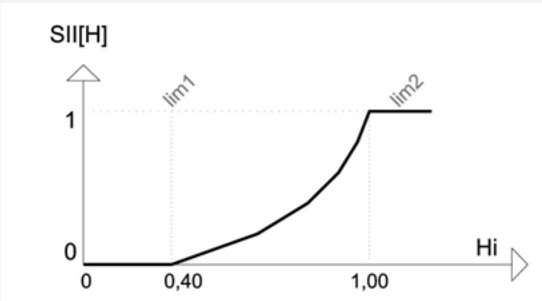
Entropy Maximum
$$H_{max} = \frac{1}{log_2 5} \tag{11}$$

Relative Entropy
$$H_{i\%} = \frac{H_i}{H_{max}} = -\frac{1}{log_2 5} * \sum_{i=1}^{5} Q_i * log_2[Q_i] \tag{12}$$

Where Qi is the percentage of houses in each cost quintile 'i' and n = 5 [number of quintiles]

Secondly, we calculate the indicator by setting two thresholds; value 1.00 as optimum value [lim_2] and value 0.40 as worst value [lim_1].

Indicator Graphic



Indicator Formulation

$$SII[H] = \max\left[\min\left[\frac{[H_{i\%} - lim_1]^2}{[lim_2 - lim_1]^2} \,;1\right];0\right]$$

Simplified formula for calculation is:

$$SII\,[H] = \frac{[H_{i\%} - 0{,}4]^2}{0{,}6^2} * 100$$

Where SII [H] _ Indicator 'Spatial Integration of different Income population' [Entropy]; $H_{i\%}$_ relative entropy for area i

3.2.2.4 INDICATOR BUILDING ON NEGUENTROPY OR ORDER

We use a formula developed by the author for assessing the degree to which a structure of a system matches a type organization for some class of systems [Alvira, 2014a][41]:

$$O = \frac{1}{n} * \sum_{i=1}^{n} O_i * ke_i \tag{13}$$

Being...
$$ke_i = 1 + \frac{1}{n} * \sum_{j=1}^{n} O_j - O_i \tag{14}$$

Being O_ the degree to which the system is order in relation to n equivalents categories and O_i_ the degree to which the system is organized relating a 'type' system for each category 'i'.

To calculate the indicator, we follow the process:

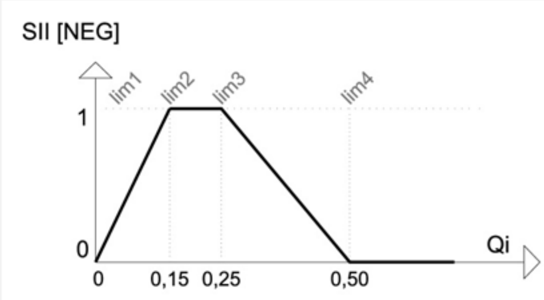
From the percentages in each housing cost quintile, we calculate an indicator using four boundaries:

- we consider values 0.15 and 0.25 as optimal values [lim_2 y lim_3]

[41] Alternatively, it can be interpreted as a formula for adding truth values or partial utility functions.

- we consider values 0.00 and 0.50 as worst values [lim_1 y lim_4]

Indicator Graphic



Indicator Formulation

$$SII[NEG]_i = \max\left[\min\left[\frac{Q_i - lim_1}{lim_2 - lim_1}; 1; 1 - \frac{Q_i - lim_3}{lim_4 - lim_3}\right] * 100; 0\right]$$

Simplified formula for calculation is:

$$SII[NEG]_i = \max\left[\min\left[\frac{Q_i}{0{,}15}; 1; 1 - \frac{Q_i - 0{,}25}{0{,}25}\right] * 100; 0\right]$$

Where SII [NEG] i _ Indicator 'Spatial Integration of different Income citizens' [Relative Neguentropy, Order or degree of organization] for i cost quintile; Qi_ Percentage of households in cost quintile i in the assessed urban area

From the indicators for each quintile cost $SII[Neg]_i$ we calculate the indicator with the formula:

$$SII[NEG] = \frac{1}{5} * \sum_{i=1}^{5} SII[NEG]_i * ke_i \qquad (15)$$

Where...

$$ke_i = 1 + \frac{1}{5} * \sum_{j=1}^{5} SII[NEG]_j - SII[NEG]_i \qquad (16)$$

3.2.3 INDICATOR TO ASSESS CITY'S OVERALL SPATIAL INTEGRATION

Building on each of the four indicators explained above, we can obtain an overall city's Spatial Segregation/Integration of different Income citizens as arithmetic aggregation of Spatial Integration for each area weighted by the percentage its population represents in relation to the city[42]:

$$SII_j = \sum_{i=1}^{n} SII_{j.i} * P_{j.i} \qquad (17)$$

Being $SII_{j.i}$ is the Spatial Integration of different Income citizens in the urban area i of j city and $P_{j.i}$ the percentage of population in urban area i in relation to total city j population.

Once indicators explained, we proceed to use them for assessing 11 Spanish cities, which serves to ascertain their applicability and the similarity of the results obtained. From these results, we review current Spanish cities' situation, detect common patterns and raise improvement possibilities.

[42] Wong [2003] proposes this type of weighted aggregation to add the values obtained for different areas of the city when working on several scales. Furthermore, it seems to us a prerequisite to comply with Group Symmetry principle [James & Tauber, 1985]

4 ASSESSMENT OF SPANISH CITIES

Let us review 11 Spanish cities, which we select according to below criteria:

- Firstly, we limit the sample to 52 province's capitals, which have several interesting qualities:
  - There is more available information about these cities than other cities.
  - They usually have certain population attraction capacity over its environment.
  - They are distributed throughout the national geography, allowing the results to be independent of some particular region's spatial patterns.
- Within these cities, we select a sample of cities that allows us to review the influence of several variables:
  - 7 of the 8 cities having greatest *population,* which are [in decreasing population order]: Madrid [1], Barcelona [2], Valencia [3], Sevilla [4], Zaragoza [5], Málaga [6] and Palma de Mallorca [8].
  - 3 cities with the smallest *Gini coefficient* of 0.25, which are [in decreasing population order]: Bilbao [10] Vitoria [15] and San Sebastian-Donostia [21].
  - A *small size city:* Cuenca [50], which allows us to review Spatial Segregation logic when city's size greatly reduces.

  Of the 11 cities, 6 are coastal, 3 have rivers with strong presence and one is insular.

In turn, we structure the analysis in two parts:

- In the first, we review all cities together comparatively assessing their *Housing Cost Differentiation*.
- In the second, we individually review each city's *Spatial Segregation by Income* dividing it into 'homogeneous' areas.

We have already seen the difficulty of defining analysis areas, since different delimitations often lead to different results [MAUP]. We initially considered 'districts' as analytical units, but we found in some cities their definition is related to administrative matters and they lack inner homogeneity, not being therefore adequate areas for the analysis.

Since this analysis is linked to housing offer, the approach we take is using areas showing certain homogeneity relating housing [offer's type, cost, and number of units][43]. And the big difference in size between the 11 cities, leads us to not revising areas of the same size in all of them. In the largest cities [Madrid and Barcelona] analytical areas are bigger and match administrative districts, while in smaller cities [San Sebastian-Donostia or Cuenca] areas are smaller and only in few cases match administrative units.

As consequence, data below refers to areas which vary considerably from one city to another[44] limiting results' comparability. However, high coherence of results we obtain allows us considering the criterion to be consistent.

[43] For this we rely on the divisions proposed by the company Idealista [www.idealista.com].

[44] E.g. the average Madrid districts' size has five times the total population of Cuenca.

4.1 ANALYSIS OF EACH CITY'S HOUSING COST DIFFERENTIATION

First, we assess each city's Housing Cost Differentiation [HCD] comparing it with 2 dimensions/ 4 variables:

- *City size, which in turn we decompose in three variables:*
  - Population
  - Number of Houses/dwellings
  - Artificialized surface
- *Income Concentration,* we value using the *Gini coefficient.*

For clarity, we include a table detailing obtained Housing Cost Differentiation along with the main characteristics for each of these cities:

TABLE XX_ REVISED SPANISH CITIES

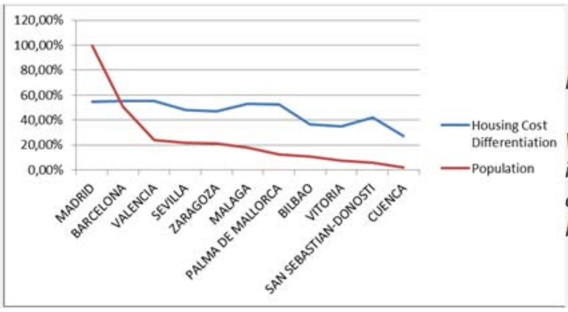
No.	City	Population (1)	No. Houses (1)	Artificialized surface [Ha] (2)	Gini Coefficient (3)	Average Housing Cost [€/m2] (4)	Housing Cost Differentiation (5)
01	Madrid	3.198.645	1.530.955	33.584,10	0,52	2.824	54,62%
02	Barcelona	1.611.013	811.105	7.811,00	0,53	3.347	55,39%
03	Valencia	757.938	419.930	5.510,80	0,50	1.444	55,03%
04	Sevilla	696.320	337.225	8.628,40	0,49	1.753	48,16%
05	Zaragoza	678.115	326.930	14.044,70	0,46	1.400	47,07%
06	Málaga	572.267	254.660	8.543,20	0,47	1.641	53,28%
08	Palma De Mallorca	399.093	182.185	6.028,30	0,48	1.841	52,25%
10	Bilbao	344.443	162.560	1.928,30	0,25	2.747	36,38%
15	Vitoria	240.699	111.245	5.138,40	0,25	1.893	35,17%
21	San Sebastián - Donostia	180.291	88.325	2.296,40	0,25	3.866	42,36%
50	Cuenca	56.472	30.935	2.374,30	0,41	1.079	27,48%

SOURCE: Own elaboration and compiled from the following sources:

(1) INE, Censo Edificación y Viviendas 2011. Accessed October 2015 - February 2016. Except Bilbao, Vitoria y San Sebastian by Eustat, Instituto Vasco de Estadistica [october, 2015]
(2) MFOM, 2010.
(3) Hortas y Onrubia [2014, from 2007data]
(4) Idealista.com [3T/2015]
(5) Own calculation using the Gini coefficient applied to the Cost of Housing. The value we include in this table is not the one obtained directly when applying the Gini Coefficient to the Cost of Housing, but the complementary value of the Indicator Income Distribution [section 3.1.1]. The reason is that it allows better visualization the tendency of the values and their meaning for the cities. Total sample: 143.414 houses/dwellings.

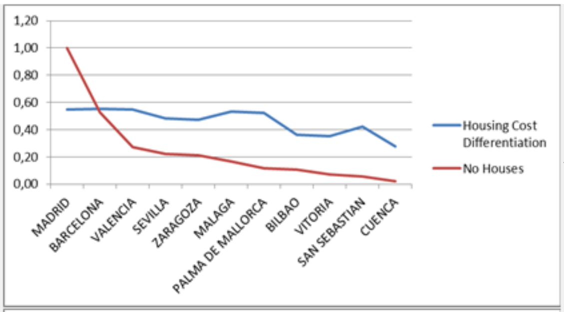
4.1.1 HOUSING COST DIFFERENTIATION AND CITY SIZE

If we compare cities' HCD with their size we see a clear relationship between both variables; the larger the city is [largest Population / Number of Houses / Artificialized area] the larger its HCD is [for clarity, we arrange cities according to decreasing population].



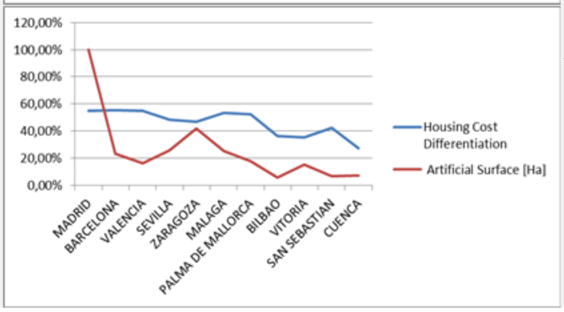
POPULATION

We observe an appreciable correlation [0.58] which indicates that usually, the smaller the city, the less differentiation of its cost of housing [and vice versa]. Population is normalized, setting Madrid value as 100%



NUMBER OF HOUSES/DWELLINGS

Above correlation is maintained [Pearson = 0.59]. Usually, the smaller the city is, the lower its Housing Cost Differentiation is.



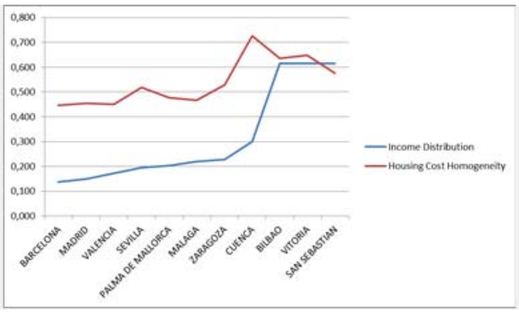
ARTIFICIALIZED SURFACE. The correlation is a bit reduced [0,48] due to two issues:

- *cities comprise very different percentages of the total Functional Urban Area artificialized surface [e.g., Barcelona 3% versus 100% of Vitoria or Cuenca]*
- *housing density can also be very different [e.g., Barcelona with 77 houses /Ha against 24 houses / ha of Palma de Mallorca].*

We see a significant correlation between cities' size and their Housing Cost differentiation. In general, t*he larger the size of the city the larger its HCD is, hence the greater the possibility of Spatial Segregation by Income.* Only what is different can be segregated, and the larger the city, the more difference in housing cost is and therefore the possibility of segregation is.

4.1.2 HOUSING COST DIFFERENTIATION AND INCOME CONCENTRATION

If we compare cities' Housing Cost Differentiation with their Income Concentration, we also find high correlation [0.70]; the greater the Income Differentiation is, the greater the HCD is[45].



Income Differentiation and Housing Cost Homogeneity. *The correlation between the two variables confirms the adaptation of the cost of housing [offer] to the 'economic possibilities of the inhabitants' [demand]:*

- *The more uniform these are, the more uniform housing prices are.*
- *The more diverse these are [greater Income Differentiation] the more different housing prices are.*

This confirms us that housing offer in Spain is largely governed by the law of supply and de-mand, and opens the possibility to intervene on the market in two ways:

- Acting on supply; *increasing the supply of moderately priced/affordable housing and its distribution throughout the city*
- Acting on demand, i.e., *reducing Income Differences [i.e., Income Concentration] stands as a way to reduce Housing Cost Differentiation.*

[45] The city of Cuenca departs from this direct relationship between HCD and Income Concentration, which points the apparent importance of the city size. Spatial segregation not only requires income gap; it also requires sufficient space to segregate.

4.2 ANALYSIS SPATIAL SEGREGATION/INTEGRATION IN EACH CITY

Let us assess Spatial Integration of different Income citizens [SII] in each city, for which we divide them into homogeneous areas whose individual/joint review and comparison with HCD allow us to detect three types of patterns:

- Patterns relating GDI/AHC and SII within each city, and common to all of them, which become apparent by representing both sets of values in a single graph arranging areas in order of increasing GDI/AHC.
- Spatial patterns of both AHC and SII which become apparent when drawing each city's plans showing both values for each area.
- Patterns linking each city's SII with its HCD and Income Concentration.

Prior to presenting obtained data it is necessary to explain some methodological issues concerning normalization of some variables, graphic criteria adopted in the plans, and indicators adaptations made due to some cities' lack of information.

4.2.0 SOME PRELIMINARY METHODOLOGICAL ISSUES…

4.2.0.1 INDICATORS ADAPTATIONS DUE TO MISSING CITIES' INFORMATION

We have explained the calculation that would be optimal for indicators, but for some cities it is impossible to obtain all the information needed to calculate them as proposed, making necessary undertaking some simplifications or substituting variable by others showing enough resemblance. We review them briefly.

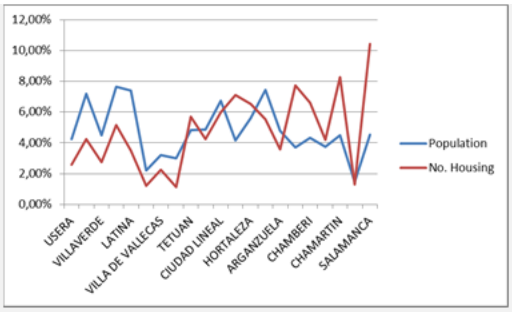
CITIES' OVERALL SPATIAL INTEGRATION CALCULATION

For most Spanish cities it is not possible to obtain disaggregated population data for analytical areas. In fact, this information is only available in Madrid, Barcelona, Valencia and Malaga, where analysis areas match administrative units.

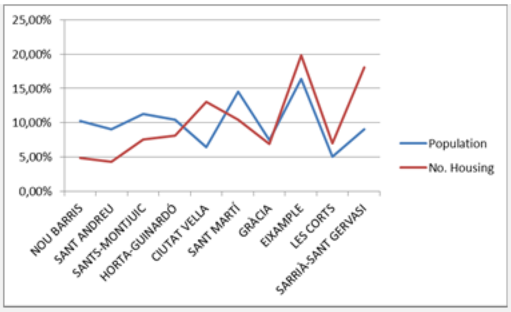
Therefore, in cities where population is not available, as a substitute parameter for calculating overall cities' SII we use the percentage of homes on offer [ownership/lease] in each area in relation to total cities' offer. This value shows some resemblance to the percentage of total population in each area but also some differentiation, with a pattern that repeats in the 4 cities for which we can compare both values:

- In *areas where AHC is lower than city's mean value* [reduced SII values], the percentage of homes on offer is usually smaller than the percentage of population related to total city's offer [average 1:1.4-1.8]
- In *areas where AHC approaches city's mean value* [high SII values], we find different situations. In some cases the percentage of houses on offer is greater, in other cases it is lower and in other cases it is equal to the percentage of population relative to city's total [average 1:1]
- In *areas where AHC is high compared to city's mean value* [reduced SII values], the percentage of homes on offer is usually higher than the percentage of population relative to city's total [average 1: 0.8 to 0.6]

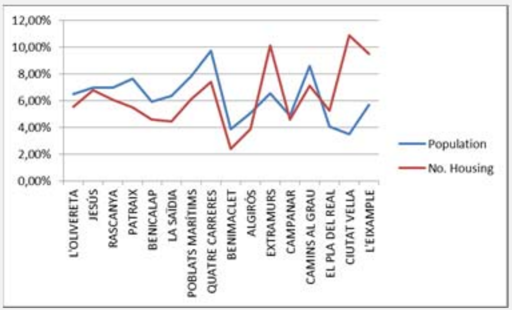
For clarity we graphically represent both values for these four cities:



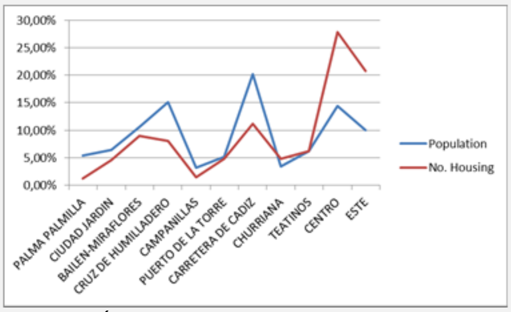
MADRID. Standard Deviation 0.0142



BARCELONA. Standard Deviation 0.0295



VALENCIA. Standard Deviation 0.0141



MÁLAGA. Standard Deviation 0.0330

The average deviation of both values for the four cities is 0.0227. In addition, we see housing supply concentrates in most desirable cities' areas [higher AHC], which usually include central areas. In simple terms, represented pattern implies that in cities where disaggregated population data was not available overall city SII values underestimate low GDI / AHC areas and overestimate high GDI / AHC areas, with not so clear patterns in mid AHC areas.

ARRANGEMENT OF AREAS WITHIN EACH CITY

GDI is a key variable for reviewing Spatial Segregation by Income. However, we have only found GDI data coincident with analysis areas for the city of Madrid. In Barcelona we use RFD[46] as substitute, while in other cities we use AHC as substitute.

For clarity in detecting patterns, we order each city's areas in increasing order of GDI/RFD/AHC and compare their SII with normalized GDI/RFD/AHC values. To normalize GDI/RFD/AHC we use the formula:

GDI[47]
$$GDI_{\%} = min\left[\frac{GDI_{j.i} - 0{,}5 * GDI_j}{GDI_j - 0{,}5 * GDI_j}; 2 - \frac{GDI_{j.i}}{GDI_j}\right] \quad (6)$$

AHC
$$AHC_{\%} = min\left[\frac{AHC_{j.i}}{AHC_j}; 2 - \frac{AHC_{j.i}}{AHC_j}\right] \quad (7)$$

Where:

> $GDI_{\%}$_ normalized GDI; $GDI_{j.i}$_ Average per capita Gross Disposable Income [€/hab] in i urban area of j city; GDI_j_ Average per capita Gross Disposable Income [€/hab] in j city
>
> $AHC_{\%}$_ normalized AHC; $AHC_{j.i}$_ Average Housing Cost [€/m2] in i urban area of j city; AHC_j_ Pre Average Housing Cost in j city

[46] RFD [Family Available Income] Index is proposed by the Barcelona City Council and combines the following variables of resident population: Family Available Income and Per capita Available Income; Level of Studies; Employment situation; Characteristics of cars stock and House prices.

[47] For normalization of per capita GDI when the value is less than average GDI, we subtract 0.50 of average GDI, which we consider approximately equivalent to poverty threshold.

4.2.0.2 NORMALIZATION AND CRITERIA FOR GRAPHIC REPRESENTATION

To detect physical patterns of Spatial Segregation/Integration, we use a min-max normalization criterion:

GDI
$$GDI_{\%} = \frac{GDI_{j.i} - 0{,}5 * GDI_j}{max[GDI_{j.i}] - 0{,}5 * GDI_j} \quad (8)$$

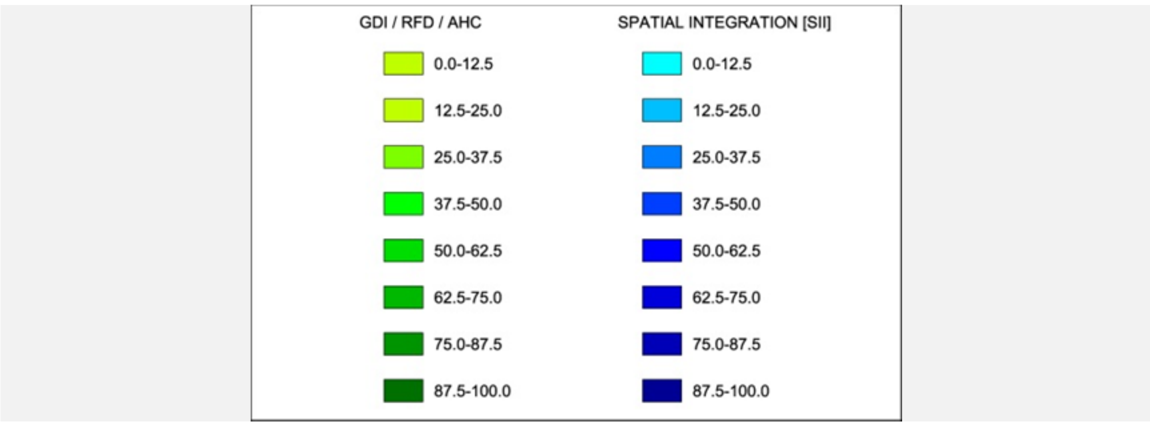
RFD/AHC
$$AHC_{\%} = \frac{AHC_{j.i}}{max[AHC_{j.i}]} \quad (9)$$

Where:

$GDI_{\%}$_ normalized GDI; $GDI_{j.i}$_ Average per capita Gross Disposable Income [€/hab] in i urban area of j city; max $[RBD_{j.i}]$_ Average per capita Gross Disposable Income [€/hab] in area I with higher average GDI per capita in city j

$AHC_{\%}$_ normalized AHC; $AHC_{j.i}$_ Average Housing Cost [€/m2] in i urban area of j city; $max[AHC_{j.i}]$_ _ Average Housing Cost [€/m2] in area i with higher average AHC in city j

We graphically represent normalized values with the following color code:



Let us assess Spatial Segregation/Integration by Income in each of the cities.

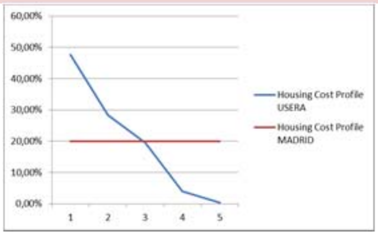
4.2.1 MADRID

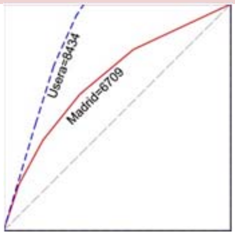
For the analysis of the city of Madrid we have considered its 21 districts whose Housing Cost Profile we list below [we arrange districts in increasing order of per capita GDI]:

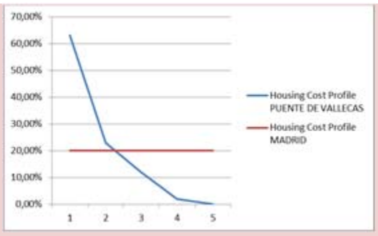
TABLE XX_ HOUSING COST STRUCTURE/PROFILE AND SPATIAL INTEGRATION IN MADRID

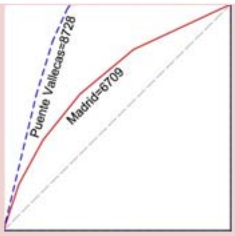
DISTRICT			
USERA	Population	134.181	4,23%
	GDI% (3)	17.907 €	0,61
	No Housing	1.203	2,58%
	AHC	1.519 €/m2	0,54
	SII	Lorenz	33,83%
		Entropy	30,92%
		HHI	33,38%
		Neguent.	35,31%
		Average	33,36%
PUENTE DE VALLECAS	Population	227.601	7,18%
	GDI%	18.208 €	0,63
	No Housing	1.969	4,23%
	AHC	1.373 €/m2	0,49
	SII	Lorenz	15,36%
		Entropy	11,26%
		HHI	5,93%
		Neguent.	20,75%
		Average	13,33%
VIL-LAVERDE	Population	141.811	4,47%
	GDI%	18.766 €	0,68
	No Housing	1.274	2,74%
	AHC	1.285 €/m2	0,46
	SII	Lorenz	12,88%
		Entropy	10,71%
		HHI	4,69%
		Neguent.	21,07%
		Average	12,34%
CARA-BANCHEL	Population	242.616	7,65%
	GDI%	19.215 €	0,72
	No Housing	2.392	5,14%
	AHC	1.654 €/m2	0,59
	SII	Lorenz	28,56%
		Entropy	38,41%
		HHI	38,65%
		Neguent.	42,40%
		Average	37,00%
LATINA	Population	234.731	7,41%
	GDI%	19.846 €	0,78
	No Housing	1.631	3,50%
	AHC	1.665 €/m2	0,59
	SII	Lorenz	32,86%
		Entropy	26,30%
		HHI	23,57%
		Neguent.	31,38%
		Average	28,53%
VICÁLVARO	Population	69.979	2,21%
	GDI%	20.430 €	0,83
	No Housing	559	1,20%
	AHC	1.793 €/m2	0,63
	SII	Lorenz	51,83%
		Entropy	35,75%
		HHI	43,64%
		Neguent.	42,09%
		Average	43,33%
VILLA DE VALLECAS	Population	101.885	3,21%
	GDI%	20.928 €	0,88
	No Housing	1.052	2,26%
	AHC	1.941 €/m2	0,69
	SII	Lorenz	38,27%
		Entropy	50,75%
		HHI	58,61%
		Neguent.	57,28%
		Average	51,22%

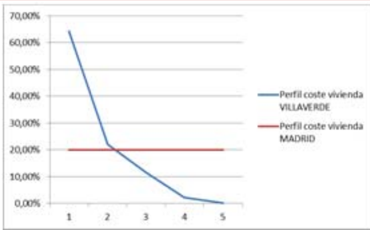
HOUSING COST PROFILE / LORENZ'S CURVE

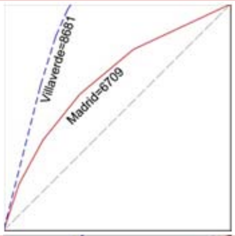


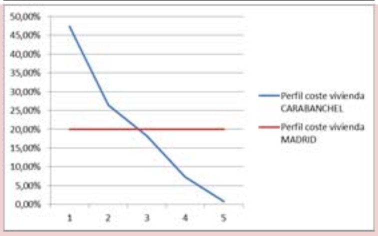


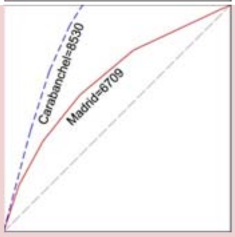


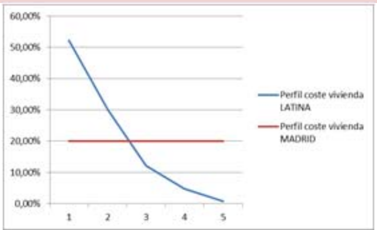


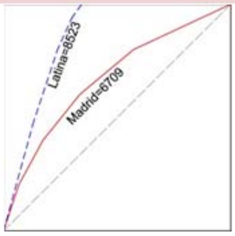


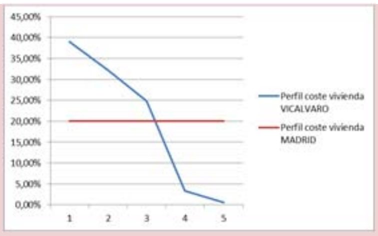


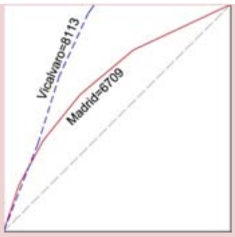


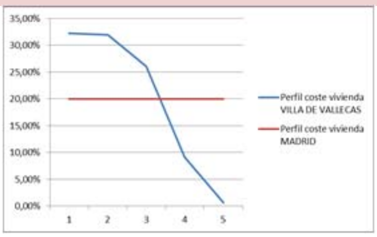


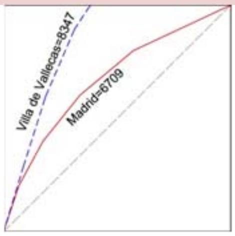




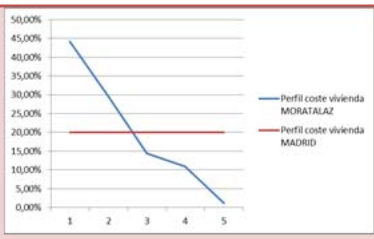


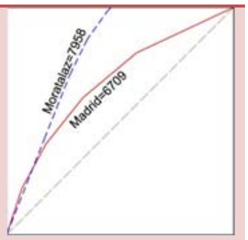




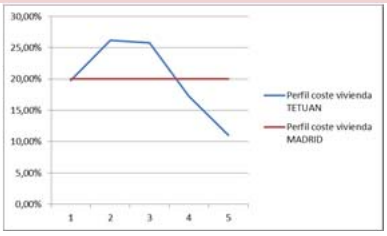


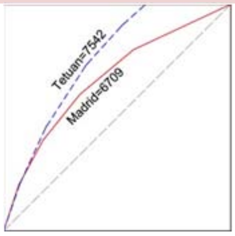
MORATALAZ	Population		94.862	2,99%
	$GDI_{\%}$		21.889 €	0,96
	No Housing		530	1,14%
	AHC		2.008 €/m2	0,71
	SII	Lorenz		65,13%
		Entropy		45,10%
		HHI		45,38%
		Neguent.		51,93%
		Average		51,88%



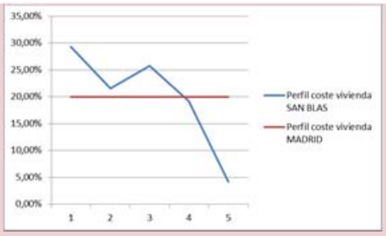


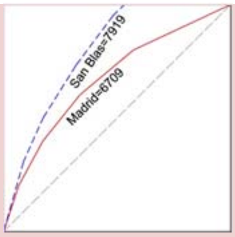
TETUÁN	Population		152.661	4,82%
	$GDI_{\%}$		22.024 €	0,98
	No Housing		2.647	5,69%
	AHC		2.635 €/m2	0,93
	SII	Lorenz		85,70%
		Entropy		91,49%
		HHI		91,16%
		Neguent.		93,66%
		Average		90,50%



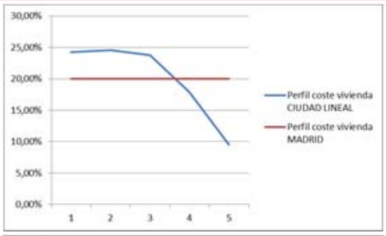


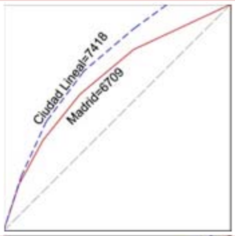
SAN BLAS	Population		153.813	4,85%
	$GDI_{\%}$		22.330 €	1,00
	No Housing		1.980	4,25%
	AHC		2.006 €/m2	0,71
	SII	Lorenz		68,84%
		Entropy		76,59%
		HHI		79,77%
		Neguent.		77,14%
		Average		75,58%



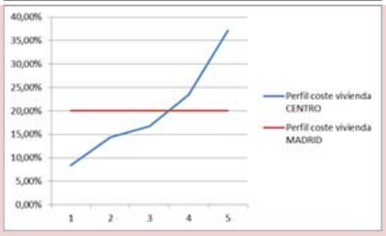


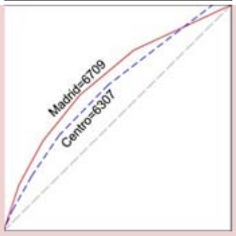
CIUDAD LINEAL	Population		212.908	6,72%
	$GDI_{\%}$		22.443 €	0,99
	No Housing		2.788	5,99%
	AHC		2.466 €/m2	0,87
	SII	Lorenz		97,81%
		Entropy		90,36%
		HHI		90,66%
		Neguent.		90,53%
		Average		92,34%



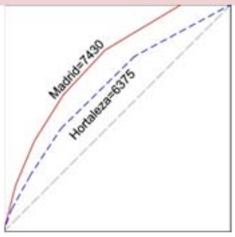


CENTRO	Population		132.428	4,18%
	$GDI_{\%}$		22.663 €	0,98
	No Housing		3.311	7,11%
	AHC		3.498 €/m2	0,76
	SII	Lorenz		79,91%
		Entropy		77,37%
		HHI		74,31%
		Neguent.		81,39%
		Average		78,25%

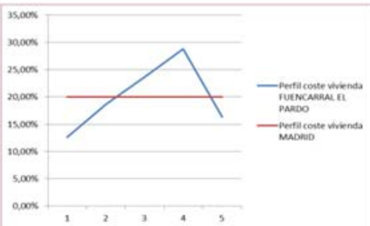


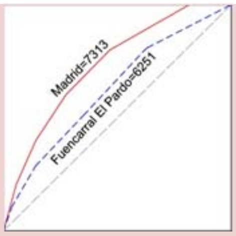


HORTALEZA	Population		177.698	5,61%
	$GDI_{\%}$		23.750 €	0,93
	No Housing		3.040	6,53%
	AHC		2.809 €/m2	0,99
	SII	Lorenz		79,89%
		Entropy		85,16%
		HHI		84,41%
		Neguent.		88,75%
		Average		84,55%

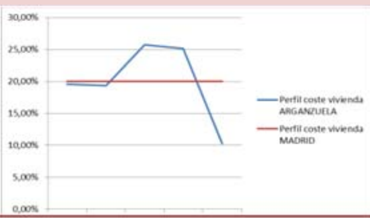


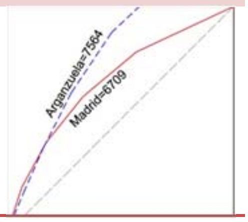
FUENCAR-RAL EL PARDO	Population		235.678	7,44%
	$GDI_{\%}$		23.911 €	0,93
	No Housing		2.578	5,54%
	AHC		2.714 €/m2	0,96
	SII	Lorenz		84,11%
		Entropy		91,86%
		HHI		91,00%
		Neguent.		96,34%
		Average		90,83%

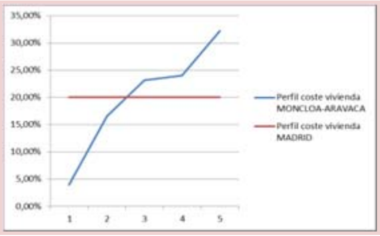
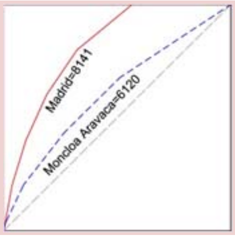
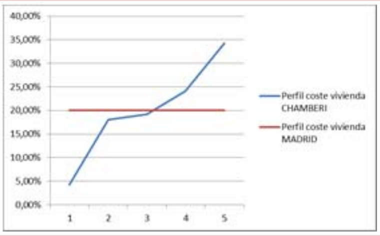
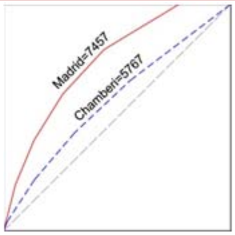
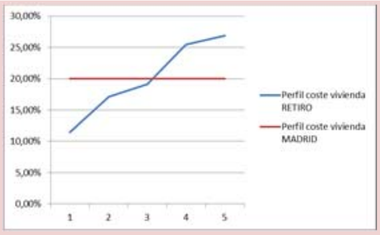
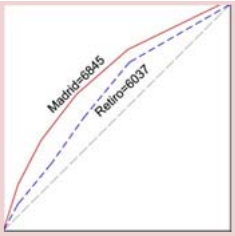
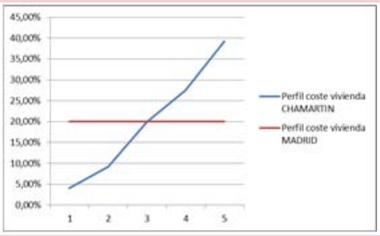
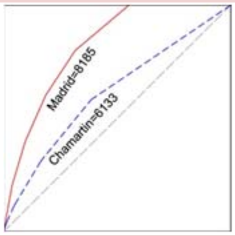
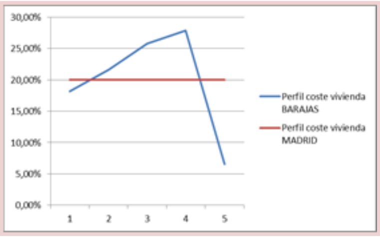
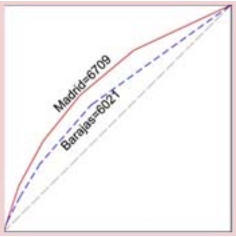
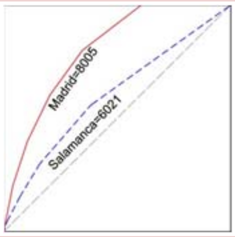




ARGAN-ZUELA	Population		151.414	4,78%
	$GDI_{\%}$		24.304 €	0,91
	No Housing		1.672	3,59%
	AHC		2.773 €/m2	0,98
	SII	Lorenz		89,25%
		Entropy		91,40%
		HHI		91,40%
		Neguent.		92,14%





		Average		91,05%		
MONCLOA-ARAVACA	Population	116.835		3,69%		
	GDI%	24.907 €		0,88		
	No Housing	3.594		7,72%		
	AHC	3.232 €/m2		0,86		
	SII	Lorenz		49,72%		
		Entropy		73,76%		
		HHI		76,26%		
		Neguent.		75,35%		
		Average		68,77%		
CHAMBERÍ	Population	137.665		4,34%		
	GDI%	25.799 €		0,84		
	No Housing	3.068		6,59%		
	AHC	3.761 €/m2		0,67		
	SII	Lorenz		53,28%		
		Entropy		73,41%		
		HHI		74,84%		
		Neguent.		74,61%		
		Average		69,04%		
RETIRO	Population	118.592		3,74%		
	GDI%	26.133 €		0,83		
	No Housing	1.960		4,21%		
	AHC	3.426 €/m2		0,79		
	SII	Lorenz		77,82%		
		Entropy		91,56%		
		HHI		91,08%		
		Neguent.		94,33%		
		Average		88,70%		
CHAMAR-TÍN	Population	142.592		4,50%		
	GDI%	26.196 €		0,82		
	No Housing	3.842		8,25%		
	AHC	3.732 €/m2		0,68		
	SII	Lorenz		51,87%		
		Entropy		60,56%		
		HHI		59,85%		
		Neguent.		63,03%		
		Average		58,83%		
BARAJAS	Population	46.342		1,46%		
	GDI%	26.521 €		0,81		
	No Housing	610		1,31%		
	AHC	2.600 €/m2		0,92		
	SII	Lorenz		100,00%		
		Entropy		83,34%		
		HHI		84,56%		
		Neguent.		83,67%		
		Average		87,89%		
SALAMAN-CA	Population	143.227		4,52%		
	GDI%	27.483 €		0,77		
	No. Housing	4.857		10,43%		
	AHC	4.368 €/m2		0,45		
	SII	Lorenz		45,80%		
		Entropy		58,12%		
		HHI		53,89%		
		Neguent.		61,73%		
		Average		54,88%		

Source: Own Elaboration.

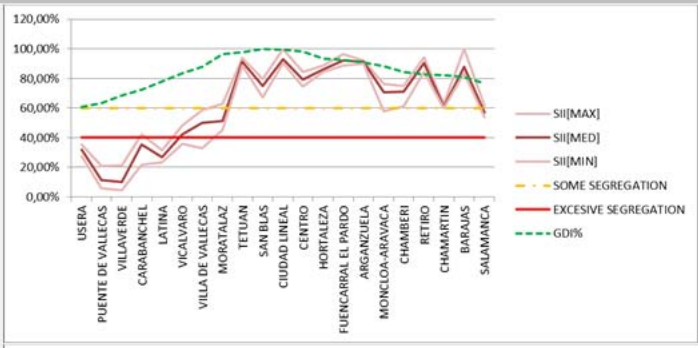
1) Housing Cost Data extracted from Idealista.com page. Total sample: 47,518 dwellings.
2) Population data from Census 2011 [INE].
3) Gross Disposable Income data from Instituto Estadística del Ayuntamiento de Madrid [2009]

For the assessment of urban areas, we consider the following ranges of SII values:

- SII <40%: excessive Spatial Segregation
- 40%<SII<60% intermediate Spatial Segregation [SII<50%: more Segregated than Integrated Areas]
- SII>60%: Sufficient Spatial Integration [SII > 80%: optimum Spatial Integration]

MADRID SUMMARY TABLE

POPULATION	3.169.519 hab	
$AHC_{\%}$	2.824 €/m2	
IC[GINI]	0,52	
HCD [GINI]	0,55	
	Max	70,93%
SII	Average	65,53%
	Min	57,63%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	35,45%	48,38%
<0,50	**26,61%**	**33,16%**
<0,40	25,42%	30,95%



GDI PER CAPITA SPATIAL STRUCTURE

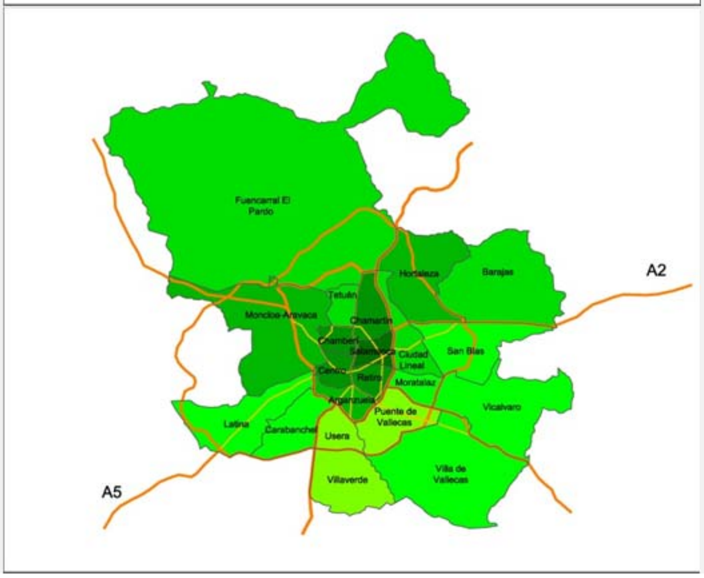
A line is appreciated roughly coincident with the axis A5-A2, which separates higher income citizens [NW area] from lower income citizens [SE area].

This line is blurred in the inner area to M-30, where centrality becomes more importante than NO/SE differentiation.

AHC STRUCTURE

High correspondence is appreciated between AHC and GDI per capita, which talks about the coupling of these variables.

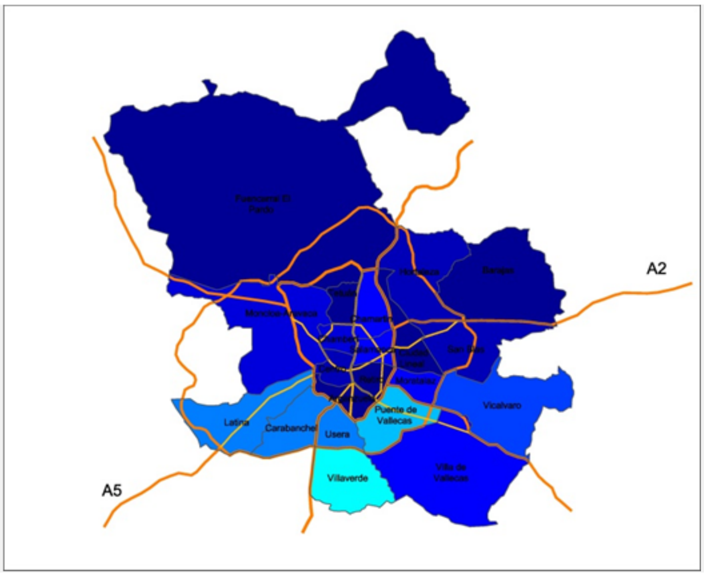
The axis formed by the A5-A2, is also embodied in the structure of AHC, which is higher in the NW and lower the SE area.



SPATIAL INTEGRATION

Areas concentrating lower income citizens are less inclusive/more exclusive [Latina, Carabanchel, Usera, Vicálvaro, Villaverde and Puente de Vallecas], the latter two being Madrid's most exclusive areas.

The inner zone to M-30 shows high integration levels in more peripheral districts [Tetuan, Retiro and Arganzuela], which decrease as GDI / AHC increases [Chamartin, Salamanca and to a lesser extent, Chamberi]. 'Centro' district also has high levels of integration.



We see that areas with intermediate levels of per capita GDI may show more or less spatial integration, depending on each particular environment, while low or high levels of average per capita GDI necessarily involve some spatial segregation, being in this case the lower per capita GDI the less integrative areas:

- Below 40% we only find districts with low per capita GDI: Usera, Puente de Vallecas, Villaverde, Carabanchel and Latina.
- Between 40% and 60% we find both districts with low [Vicálvaro, Villa de Vallecas and Moratalaz] and high [Chamartin and Salamanca] per capita GDI
- Districts above 80% are characterized by high typological diversity and not linked to highest desirability [Tetuan, Ciudad Lineal, Hortaleza, Fuencarral El Pardo, Arganzuela]. Centro district is close to optimal values with SII=78%.

This pattern is characteristic of all Spanish cities, although in some cities most exclusive areas are those with higher GDI.

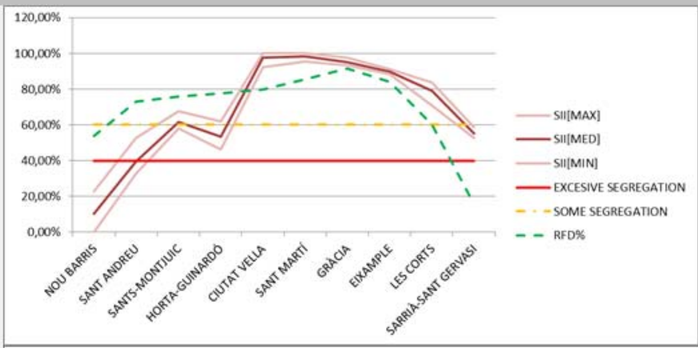
For reasons of limited total extension of the present publication for the following cities we only present overall summary table

4.2.2 BARCELONA

For the analysis of Barcelona we have considered its 10 districts. We present a summary table [we arrange districts in increasing order of RFD indicator]:

BARCELONA SUMMARY TABLE

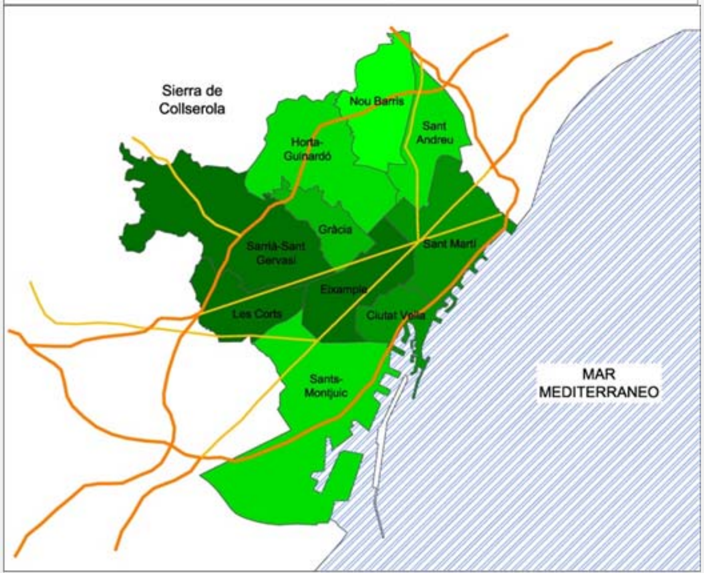
POPULATION	1.614.090 hab	
$AHC_{\%}$	3.347 €/m2	
IC[GINI]	0,53	
HCD [GINI]	0,55	
	Max	78,81%
SII	Average	73,16%
	Min	66,52%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	39,49%	38,79%
<0,50	**25,27%**	**19,35%**
<0,40	11,88%	10,27%



RFD STRUCTURE

RFD structure shows a concentration of high RFD citizens in the Eixample extending along the axis of Via Diagonal towards the mountains [Sarriá - Corts], and to a lesser extent towards the beaches [Ciutat Vella and Sant Marti].

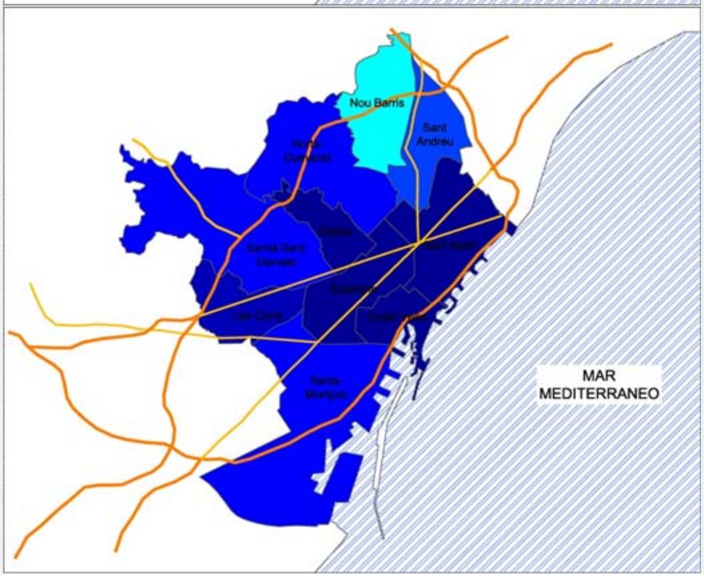
The areas that deviate from this axis north progressively reduce their AHC with distance, as does Sants-Montjuic, whose access to the sea is hampered by the mountain and cargo port.



SPATIAL INTEGRATION

We see higher spatial integration in districts with intermediate RFD/AHC, decreasing as RFD/AHC approach limiting values [very low or very high].

Draws attention the relatively acceptable values of most districts, which only reduces when we move far from the center [Nou Barris and Sant Andreu].

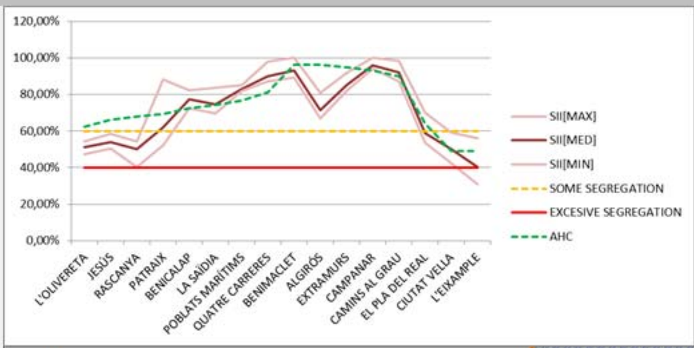


4.2.3 VALENCIA

To assess Valencia we consider 17 of its districts [we arrange districts in increasing order of AHC, criterion we use for the remaining cities]. We present a summary table:

VALENCIA SUMMARY TABLE

POPULATION	757.938 hab	
$AHC_{\%}$	1.444 €/m2	
IC[GINI]	0,50	
HCD [GINI]	0,55	
	Max	74,94%
SII	Average	67,90%
	Min	62,89%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	50,39%	33,70%
<0,50	**41,93%**	**9,18%**
<0,40	38,17%	5,70%



AHC STRUCTURE

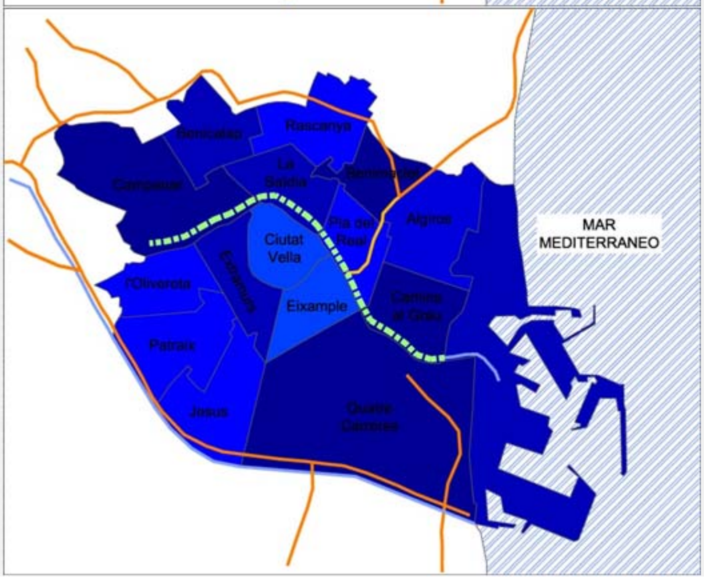
We see a strong centrality in which AHC decreases as we move away from a center integrated by Ciutat Vella, Eixample and Pla del Real.

Areas near the sea and those located along the former Turia river bed [green dashed line], show somewhat higher AHC than other areas, due to the distinctive character of both elements.

SPATIAL INTEGRATION

Greater spatial integration in districts with intermediate AHC, which decreases as AHC values depart from te mean [AHC very low or very high].

The maximum spatial segregation is located in Ciutat Vella and Eixample, the two districts with highest AHC, the latter a bit below 0.40 threshold.

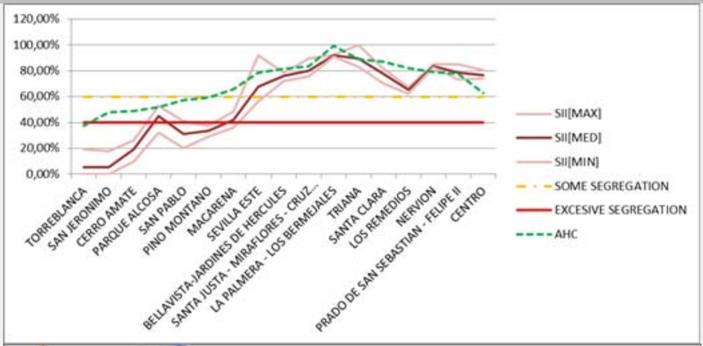


4.2.4 SEVILLE

For the city of Seville we have considered 17 areas. We present a summary table:

SEVILLA SUMMARY TABLE

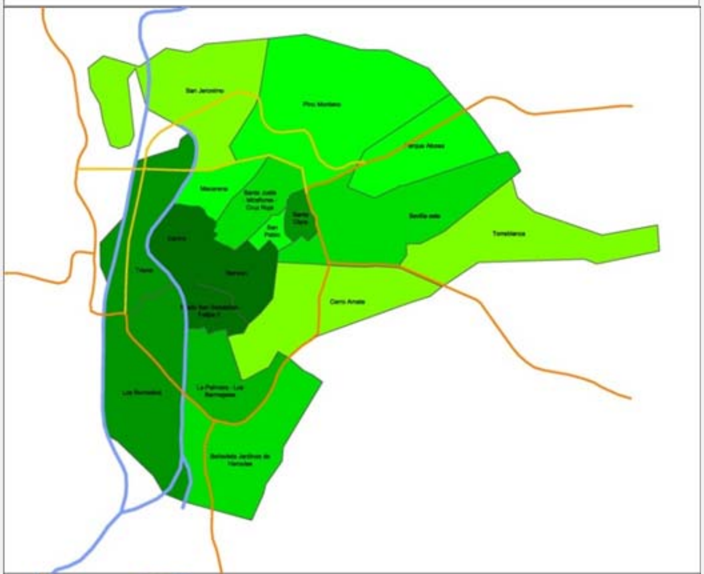
POPULATION		696.320 hab	
$AHC_{\%}$		1.753 €/m2	
IC[GINI]		0,49	
HCD [GINI]		0,48	
	Max	72,43%	
SII	Average	66,26%	
	Min	60,95%	
POPULATION IN SEGREGATED AREAS			
	SII [Mean]	% Pop.	
<0,60	31,01%	23,54%	
<0,50	**31,01%**	**23,54%**	
<0,40	23,11%	14,63%	



AHC STRUCTURE

Higher AHC is determined by centrality [Centro, Nervión and Prado de San Sebastián-Felipe II] and proximity to the river [Triana and Los Remedios].

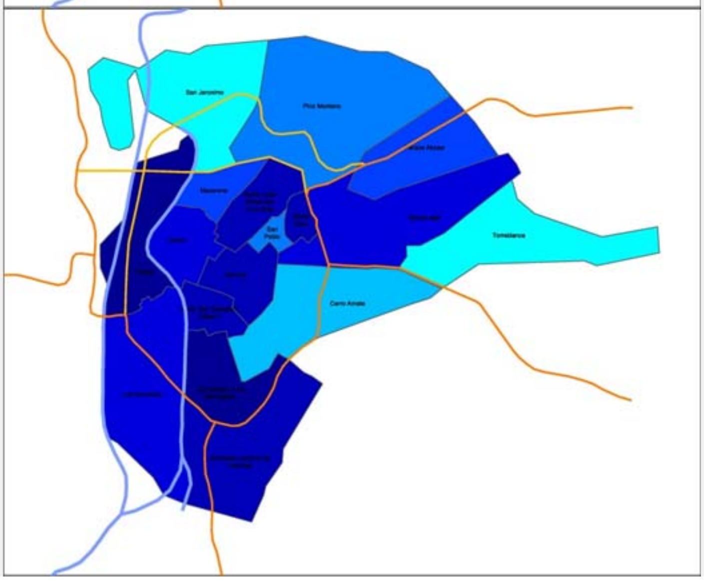
But it is also determined by morphology / residential typology, as we can see in Santa Clara area, where the location of a single family houses colony leads to higher AHC than surrounding areas.



SPATIAL INTEGRATION

We see high values in areas with AHC close to city's mean and even in some districts with highest AHC [Nervion, Prado de San Sebastian / Felipe II, Triana].

SII very low in districts with lower AHC [Torreblanca, San Jeronimo and Cerro Amate]

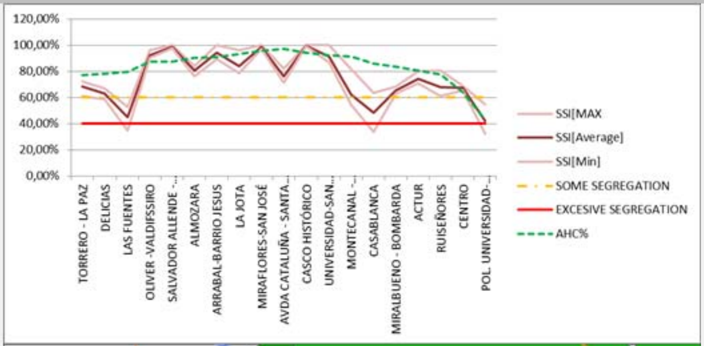


4.2.5 ZARAGOZA

To review the city of Zaragoza we consider 19 areas. We present a summary table:

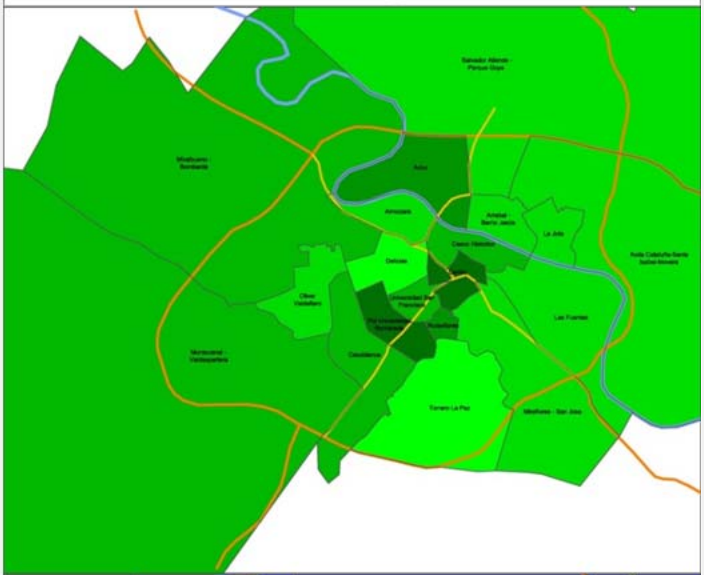
ZARAGOZA SUMMARY TABLE

POPULATION	667.062 hab	
$AHC_{\%}$	1.400 €/m2	
IC[GINI]	0,46	
HCD [GINI]	0,47	
	Max	80,19%
SII	Average	76,30%
	Min	72,51%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	45,16%	8,65%
<0,50	**45,16%**	**8,65%**
<0,40	39,86%	1,79%



AHC STRUCTURE

Centrality has moderate importance, with highest AHC located at Romareda University and lowest AHC at Delicias and Torrero.

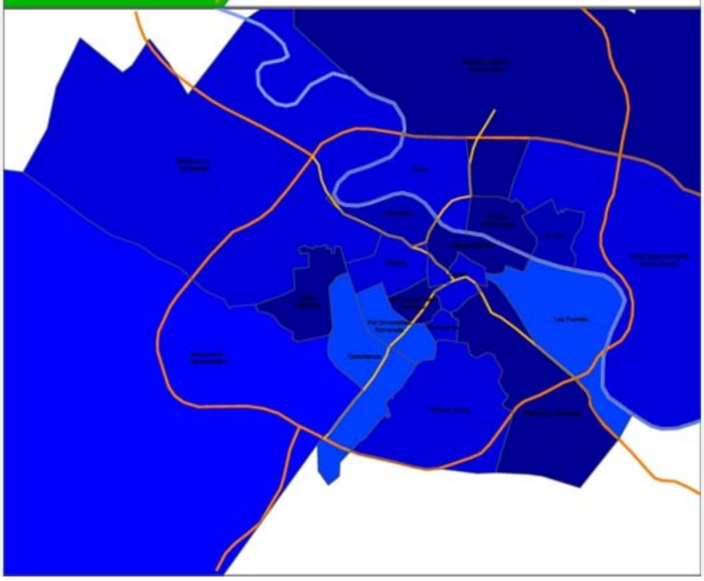


SPATIAL INTEGRATION

Zaragoza stands as high integrated city. All areas have SII values higher than 0.40, being the most inclusive areas Casco Historico, Salvador Allende Goya Park and Miraflores-San Jose.

The smaller range of variation makes some above listed patterns lose intensity.

Only University-Romareda area with AHC almost 1.6 times higher than average city's AHC has SII below 0.40.

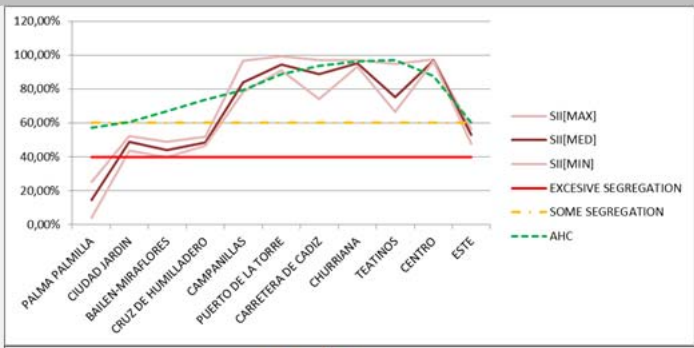


4.2.6 MALAGA

To assess the city of Malaga we have reviewed its 11 districts, obtaining the following results:

MÁLAGA SUMMARY TABLE

POPULATION	572.267	
$AHC_{\%}$	1.641 €/m2	
IC[GINI]	0,47	
HCD [GINI]	0,53	
SII	Max	78,13%
	Average	72,81%
	Min	68,36%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	45,12%	47,51%
<0,50	**43,55%**	**37,48%**
<0,40	16,61%	5,37%
Sample: 9,266 houses		



AHC STRUCTURE

We see some centrality of the historic area and higher 'value' of proximity to the sea.

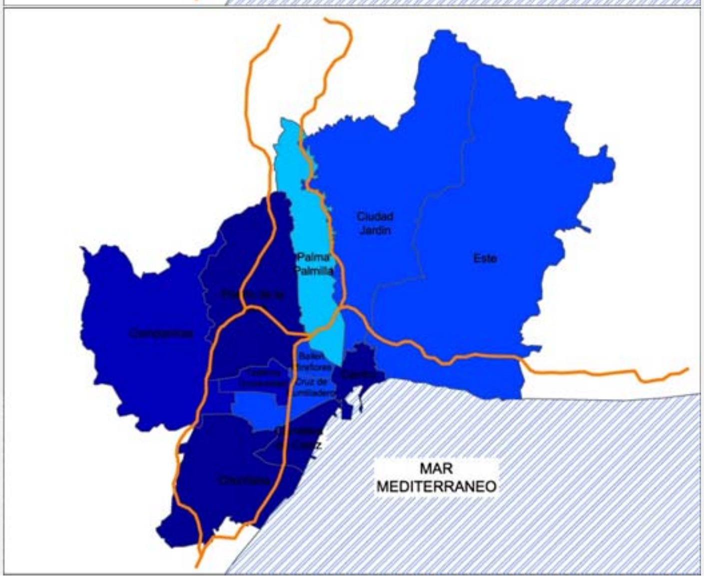
'Este' area stands out due to the great presence of detached houses with garden and pool, which appreciably raises its AHC.

SPATIAL INTEGRATION

Above patterns repeat again. Greater spatial integration in districts with intermediate AHC, which decreases as areas' AHC depart from mean city's AHC [they become very low or very high].

We see two districts with very different AHC [Ciudad Jardin and Este] presenting very similar segregation/integration values.

Lower income citizens are relegated to Palma Palmilla district, which stands as the least integrative of all.



4.2.7 PALMA DE MALLORCA

To review the city of Palma de Mallorca we consider the following 15 areas:

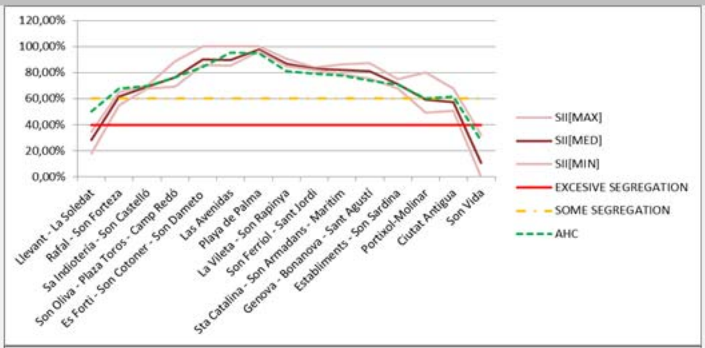
PALMA DE MALLORCA SUMMARY TABLE

POPULATION	399.093 hab	
$AHC_{\%}$	1.841 €/m2	
IC[GINI]	0,48	
HCD [GINI]	0,52	
	Max	82,21%
SII	Average	75,22%
	Min	69,79%

POPULATION IN SEGREGATED AREAS

	SII [Mean]	% Pop.
<0,60	44,55%	19,54%
<0,50	**27,41%**	**7,69%**
<0,40	27,41%	7,69%

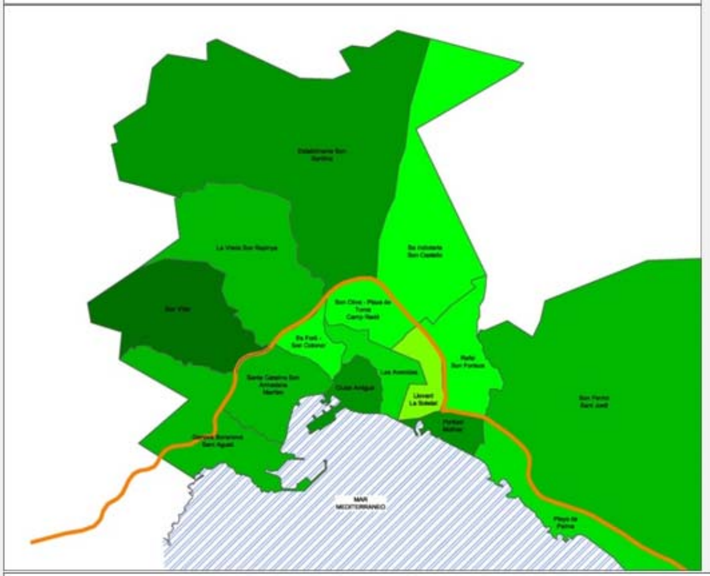
Sample: 8.011 houses.



AHC STRUCTURE

AHC structure reflects historic city's centrality and importance of the proximity to the sea, being the latter higher valued in areas facing beaches than in those facing the harbor.

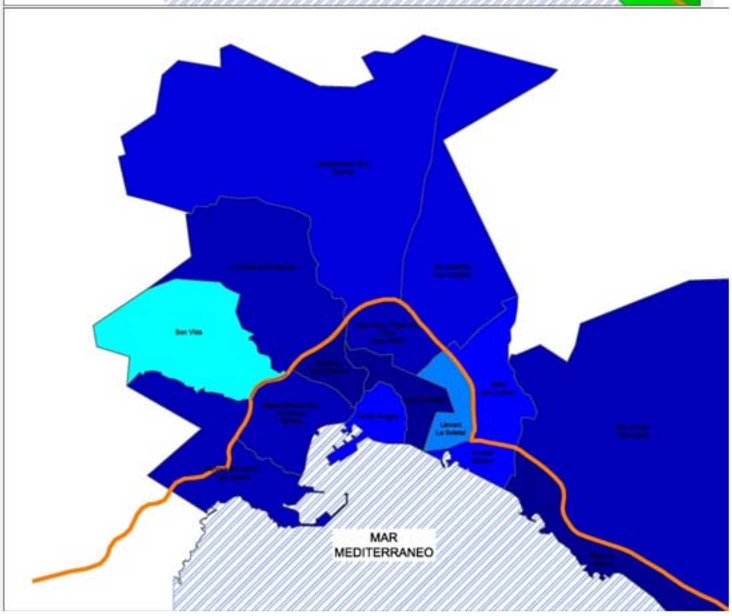
A bit further away from the center, Son Vida's area shows again the higher AHC associated to garden and pool detached houses colonies.



SPATIAL INTEGRATION

We see repeated above patterns; intermediate AHC result in high SII values, while high or low AHC generate very exclusive environments.

Llevant- La Soletat and Son Vida's areas stand as exclusive areas, the latter being the most exclusive / less inclusive area of Palma.

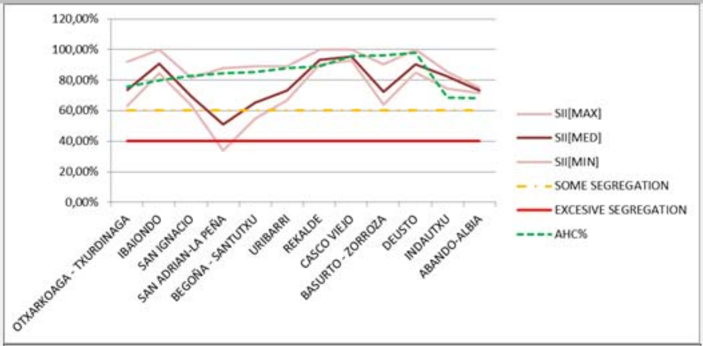


4.2.8 BILBAO

To review the city of Bilbao we consider 12 zones, which summary we present below:

BILBAO SUMMARY TABLE

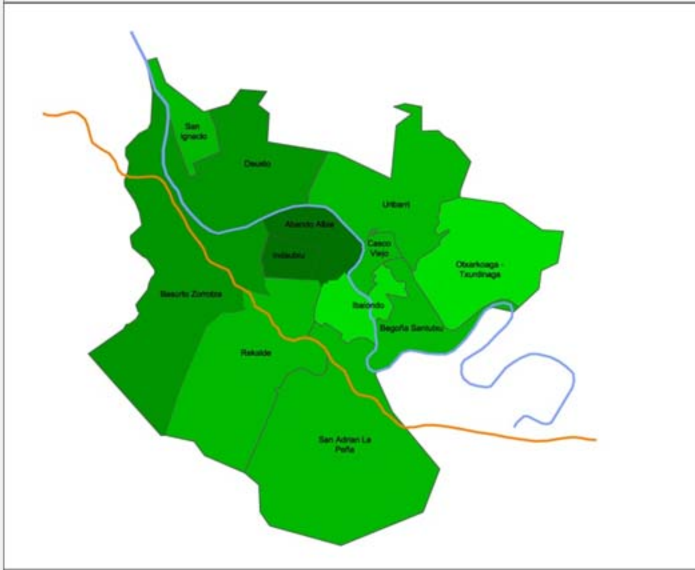
POPULATION	344.443 hab	
$AHC_{\%}$	2.747 €/m2	
IC[GINI]	0,25	
HCD [GINI]	0,36	
SII	Max	89,45%
	Average	79,76%
	Min	73,22%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	49,05%	1,47%
<0,50	**0,00%**	**0,00%**
<0,40	0,00%	0,00%
Sample: 8.864 houses.		



AHC STRUCTURE

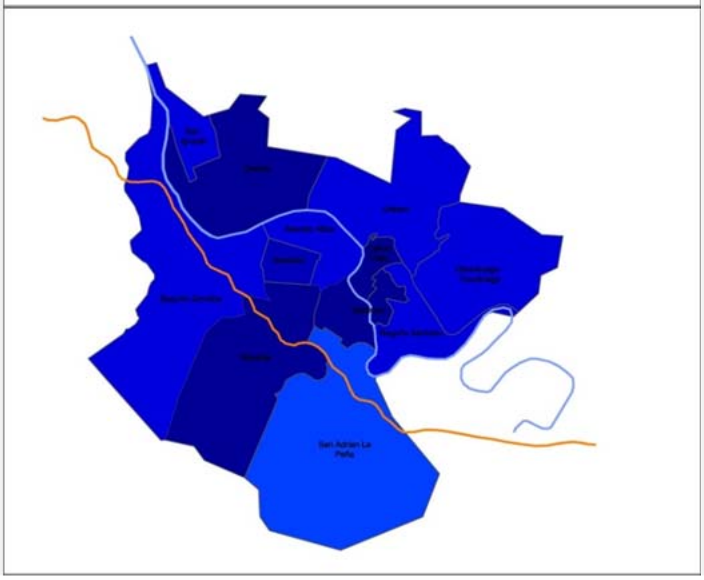
Centrality is located in Abando-Albia and Indautxu areas projecting into Basurto Zorroza, Deusto and Casco Historico areas.

Prices progressively reduce as distance increases, standing Otxarkoaga-Txurdinaga as lowest AHC area. Ibaiondo area, show surprisingly low AHC contrasting with its high centrality.



SPATIAL INTEGRATION

Generally high, presenting lower values in central areas with higher AHC, and in the most peripheral area of San Adrian-La Peña.

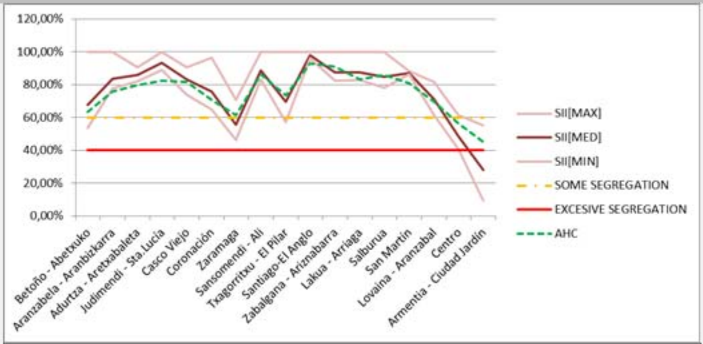


4.2.9 VITORIA- GASTEIZ

To review the city of Vitoria-Gasteiz we consider 17 areas, we summarize below:

VITORIA- GASTEIZ SUMMARY TABLE

POPULATION	240.699 hab	
$AHC_{\%}$	1.893 €/m2	
IC[GINI]	0,25	
HCD [GINI]	0,35	
SII	Max	89,24%
	Average	77,05%
	Min	70,27%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	45,43%	18,95%
<0,50	41,01%	13,43%
<0,40	25,85%	3,62%
Sample: 4.606 houses.		



AHC STRUCTURE

The spatial structure appears to be mainly the result of housing policies and morphology design of each area:

- *Areas concentrating social housing developments [1960-1970] have reduced AHC [e.g., Zaramaga]*
- *Areas developed using 1980-1990’2 ‘Ensanche Isla’ morphologies have medium-high AHC [e.g., Lakua - Arriaga]*
- *Areas concentrating detached house with garden and pool have the highest AHC [e.g., Armentia-Ciudad Jardin]*

SPATIAL INTEGRATION

We see above pattern repeated again; AHC intermediate areas show high SII values, while areas with extreme AHC [low or high] value have lower SII values.

The area of Armentia-Ciudad Jardin [with abundant detached house with garden] stands out as most 'exclusive' area of the city.

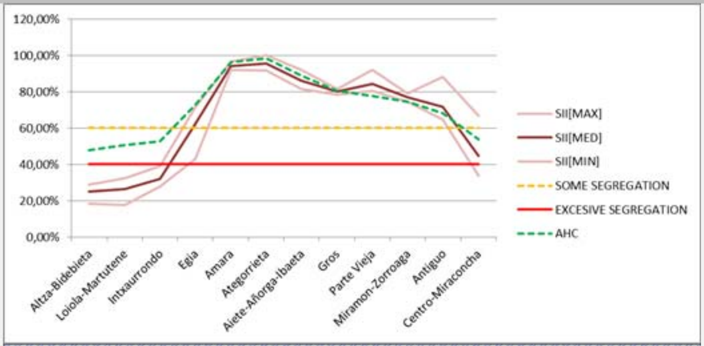
4.2.10 SAN SEBASTIAN- DONOSTIA

To review the city of San Sebastian-Donostia we consider 11 areas:

SAN SEBASTIAN-DONOSTIA SUMMARY TABLE

POPULATION	180.291 hab	
$AHC_{\%}$	3.866 €/m2	
IC[GINI]	0,25	
HCD [GINI]	0,42	
SII	Max	79,91%
	Average	70,85%
	Min	62,72%
POPULATION IN SEGREGATED AREAS		
	SII [Mean]	% Pop.
<0,60	34,12%	47,04%
<0,50	**34,12%**	**47,04%**
<0,40	28,48%	28,49%

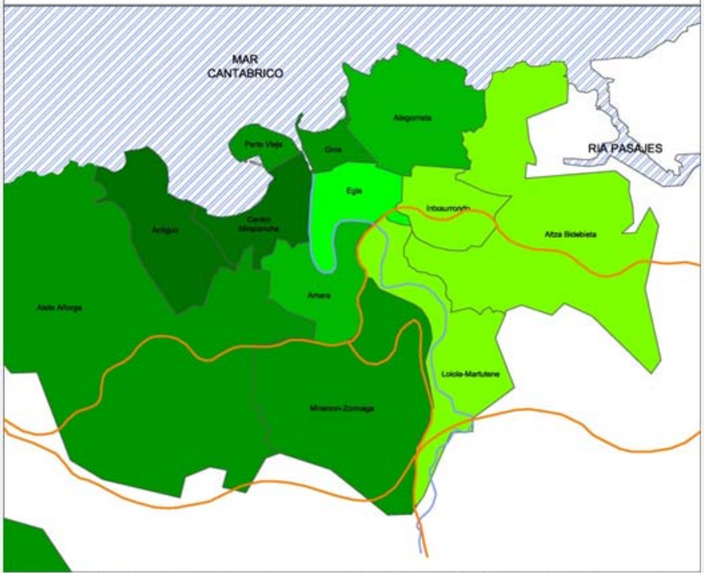
Sample: 3.429 houses.



AHC STRUCTURE

Highest desirability focuses on areas facing the beaches, especially Centro-Miraconcha and Antiguo areas, which concentrate single-family housing typologies [further the first] and 'Ensanche Isla' [further the second].

The river stands as the beginning of a barrier separating a higher AHC West area from an lower AHC Eastern area, which includes some industry and it's closer to the industrial and cargo area of Pasajes estuary.

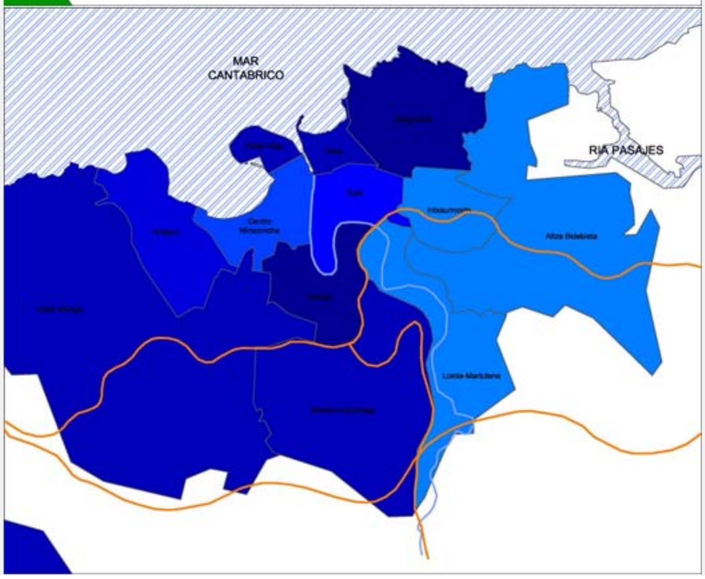


SPATIAL INTEGRATION

We see the same pattern repeated again; intermediate AHC areas show high SII values, while areas with extreme AHC values show lower SII values.

12% higher Centro-Miraconcha's AHC in relation to Antiguo contrasts with the fact that its SII is 25% lower. This shows again the more exclusive character of detached housing compared to other residential housing typologies.

With very low SII values stand the three more eastern areas, almost reaching Pasajes' Ria: Intxaurrondo, Loiola Martutene and Altza-Bidebieta



4.2.11 CUENCA

To review the city of Cuenca we consider the following 6 areas[48]:

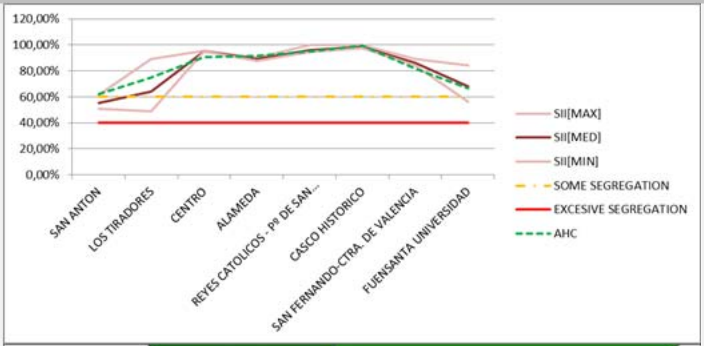
CUENCA SUMMARY TABLE

POPULATION		56.472 hab
$AHC_{\%}$		1.079 €/m2
IC[GINI]		0,41
HCD [GINI]		0,27
	Max	93,73%
SII	Average	90,75%
	Min	88,30%

POPULATION IN SEGREGATED AREAS

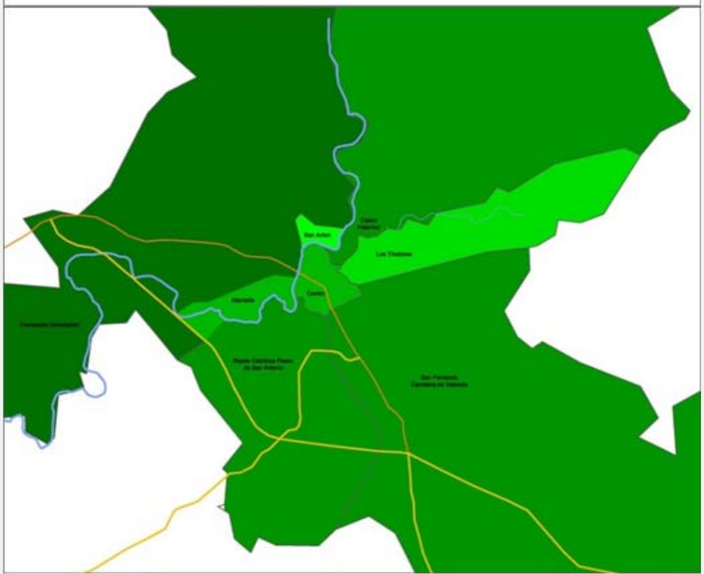
	SII [Mean]	% Pop.
<0,60	59,36%	51,42%
<0,50	**0,00%**	**0,00%**
<0,40	0,00%	0,00%

Sample: 821 houses.



AHC STRUCTURE

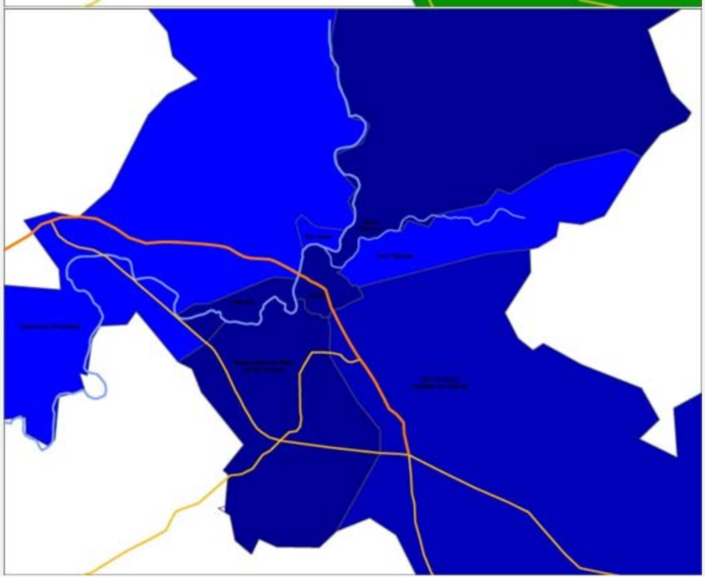
The low Housing Cost Differentiating [HCD] is reflected in reduced AHC differentiation among city's areas.
The strong presence of the orography and the two rivers give a privileged position to the historical center, with a medium- high AHC. The two other oldest areas [Tiradores and San Antón] have much lower AHC.
The outer areas have fairly homogeneous AHC, standing out the residential area adjacent to the University, with newer buildings, some 'Ensanche Isla' type.



SPATIAL INTEGRATION

Spatial integration is high, with no area which SII is below 0.5.

The assessment of this issue in conjunction with the Gini coefficient and Housing Cost Differentiation seems to show the higher importance of city size for the definition of Spatial Segregation / Integration of inhabitants by Income.
Still, a review with more data [e.g., percapita GDI structure] would be required to verify or rebut this hypothesis.



[48] For the city of Cuenca AHC for each area was not available, so we have made an approximated calculation from the geometric interpretation [centroid] of Housing Cost Profile.

5 RECAP AND CONCLUSIONS

We have reviewed two issues, which recapitulation and evaluation are equally important:

- We have conceptualized Spatial Segregation by Income, and proposed several indicators to assess its impact on cities.
- We have used said indicators to assess current situation of Spanish cities.

Let's review both issues starting with the last one.

5.1 SPATIAL SEGREGATION BY INCOME IN SPANISH CITIES

The review of 11 Spanish cities has allowed us to show/detect the existence of some important correlations in the two proposed/revised scales:

5.1.1 HOUSING COST DIFFERENTIATION

The analysis has shown a high resemblance of HCD with two cities' dimensions:

First resemblance is with **Income Differentiation/Concentration,** showing us that *housing prices behave according to Supply-Demand model. Housing prices perfectly adapt to the economic possibilities of houses potential leasers/buyers.* The higher the difference in income is, the higher the difference between housing prices is[49].

This coupling implies an e*conomic paradigm where housing is considered a commodity /investment good,* challenging Spanish Constitution which states that housing is a citizens' right and real estate speculation an activity the State must prevent [CGE, 1978][50].

The second dimension that has shown high correlation with the HCD is the **size of the city.** The larger the city is, the larger its HCD is, and consequently its potential for Spatial Segregation by Income, which materializes in most of reviewed cases. We thus confirm theses by previous authors [e.g., Bischoff & Reardon, 2013].

This relationship between Spatial Segregation by Income and cities' size we have confirmed from several dimensions implies that *when a city increases its size/population it tends to increase its Spatial Segregation by Income.*

This seems to confirm that *individuals tend to seek greater physical separation the greater the difference between them* is [Parks, 1925; Marcinczak et al., 2016), so this search for physical segregation according to income levels [Spatial Segregation by Income] requires both sufficient economic inequality between individuals and sufficient city size to allow sufficient physical distance:

- When an individual seeks housing, he seeks an environment with an identifiable pattern of inhabitants that matches his preferences.

[49] This speaks about the possible negative impact of globalization on local housing markets, by making people with very different incomes compete for the same housing market. In this sense, in Spain it seems urgent to begin proposing measures that place citizens'/residents' housing needs above their use as investment goods [i.e., vacation homes].

[50] Article 47. Right to housing. Land use: "All Spaniards have the right to enjoy decent and adequate housing. The public authorities shall promote the necessary conditions and establish the relevant rules to give effect to this right, regulating the use of the land in accordance with the general interest to prevent speculation".

- Individuals prefer living in an environment whose inhabitants share their values, ideology and possess similar income. High values of inequality imply the tendency of citizens with higher incomes to group in localized areas of the city. This effect can be enhanced the larger the city is.

As a consequence of the above, two issues arise:

- Reducing Economic Inequality implies reducing the need for physical distance between inhabitants, while increasing it implies the opposite[51].
- Planning polycentric cities allows the articulation of smaller functional units, allowing less segregation/higher exposure[52].

This coupling of Cities' size/Spatial Segregation by Income approaches us to increasing importance of Spatial Segregation by Income. *Unless adequate preventive measures are taken, in a world that expects to continue increasing its Inequality Levels and urbanization rates / population concentration in cities, Spatial Segregation by Income will increase and involve a growing percentage of world's population that will [increasingly] live separated according to their level of income.*

One last important issue when assessing Housing Cost impact is the **percentage of spent allocated to housing in relation to per capita GDI**[53]:

- if reduced [<25%GDI] segregating effect of the Cost of Housing is moderate.
- if high [>35/40% GDI] the Cost of Housing constitutes a barrier which separates inhabitants, if Housing Cost Differentiation is high.

And if we look at the particular situation in Spain, we see a non-optimal percentage of disposable income allocated to housing, which rises to unsustainable levels when we review people below the in-danger-of-poverty line [ca. <60% Average Equivalent Income, AEI].

TABLE XX_ PERCENTAGE OF DISPOSABLE INCOME ALLOCATED TO HOUSING ACCORDING TO INCOME

	INCOME < 60% AEI	INCOME > 60% AEI	TOTAL (1)
Spain	45,9%	22,6%	33,0%
European Union	37,6%	20,6%	25,2%

Source: Own elaboration based on Eurostat data, access May 2016.

(1) An average Spanish citizen needs to spend more of his disposable income than the average European citizen to satisfy his housing need, especially if his income is low [below 60% AEI]. This issue, in addition to producing SSI, has the opportunity cost that such money is no longer available to invest in other more sustainable economic activities [e.g., R & D] and shows the inefficiency of the Spanish housing system, which requires Greater economic expenditure to provide the same utility [a Spanish home is no better than a home in Sweden or Germany].

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[51] "Although socio-economic residential mixing may occur, this is limited to groups with a status that is not too far apart from each other. This corroborates the findings by Musterd et al. (2014), who showed that the tendency to move increases with the social distance between an individual and the [...] neighborhood (s)he is living in; larger social distances imply larger propensity to move and subsequently [the larger] chance to end up in a socially more similar neighborhood" [Marcinczak et al, 2016: 365]

[52] We have found scarce references to polycentric design in authors who review SSI. Its positive effect is that areas reduce their AHC with the greater distance to desirable elements. A network of equally distributed [and desirable] centers minimizes the distance to desirable elements and therefore limits the possible reduction of the AHC by distance. Besides, increasing the number of nuclei [with higher AHC] multiplies the contact surface and shared environment by inhabitants with different income

[53] Thresholds of expenditure considered by Eurostat. USHUD [US Department of Housing and Urban Development] considers somewhat higher spending levels [30% and 50% respectively].

From the point of view of the inhabitants, it indicates that

… Access to housing implies greater effort for Spaniards than for the average European inhabitant, and therefore *the ability of the Cost of Housing to spatially segregate Spanish inhabitants is greater.*

… Economic effort/burden for accessing housing is extremely high for lower income citizens [45.9% vs. 22.6%].

The latter implies that *the inhabitants with less income can hardly choose which part of the city to inhabit*; they necessarily are relegated to areas with lower AHC, and therefore in cities with high Economic Inequality and high Housing Cost Differentiation, their spatial exclusion and as a consequence, the Spatial Segregation by Income of the whole community, is inevitable.

Above highlights the importance of reducing the percentage of income allocated to housing in Spain, which can only be achieved through a major change in the economic paradigm which requires action in several interrelated dimensions:

- Reducing Economic Inequality so HCD is reduced; in turn reducing citizens' economic effort needed to access housing at rates near or lower to 25%.
- Reducing the profitability of housing as investment good, to decouple the right to housing from market dynamics:
    - Increasing the stock of housing not subject to such dynamics[54].
    - Progressively taxation on the benefits of real estate capital.
    - Increasing the supply, penalizing ownership of unoccupied housing.
- Redesigning the Spanish economic structure by reducing percentage of economic growth and employment linked to the construction sector, which should be lower than in previous periods and be maintained in *similar values to that of comparable European Union countries [i.e. similar values to the current ones in Spain]* [55].

[54] Several authors suggest at least 30% of affordable housing [e.g., MFOM, 2012]. Moreover, the objective of avoiding segregation requires evenly distributing this provision of affordable housing throughout the city. However, this points to a possible rejection of people with higher income. Once again, reducing inequality between people is presented as a requirement and a simpler [and economic] solution for integration, by reducing both HCD and the need for 'physical distance' between inhabitants.

[55] The Construction Sector in 2006 represented as average 6.38% of economic activity [Gross Added Value, AV + Intermediate Consumption, IC -arithmetically weighted-] and 6.05% of employment in EU countries that have better withstood the 2008 crisis [Austria, Belgium, Germany, Sweden] versus 16.88% of [GAV + IC] and 12.58% of employment in Spain [Eurostat data, accessed 2015]. This allows us to understand the great impact of the crisis in Spain. The crisis was a market critical self-regulating mechanism to correct a completely unsustainable labor/economic structure. In fact, after self-regulation, contribution of construction sector to the Spanish economy in 2012 almost perfectly matches that of stable countries: 6.64% of GAV+IC and 6.19% of Employment versus 6.73% of GAV+IC and 6.25% of employment in stable countries. Spain's future growth should be done searching for a stable structure, which can be designed reviewing that of the countries that have better withstood the crisis. For example, professional, scientific and technical activities in 2006 in Spain represented 3.22% of GAV+IC and 4.44% of employment compared to 5.74% of GAV+IC and 6.27% of employment in stable countries.

5.1.2 SPATIAL SEGREGATION BY INCOME IN REVIEWED CITIES

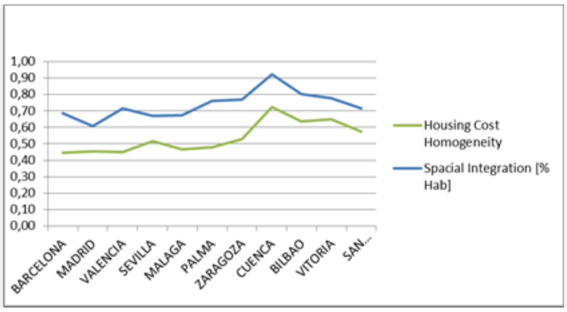
The analysis of the cities from their homogeneous areas has allowed us to also detect common patterns whose review is interesting. We group them into five dimensions:

5.1.2.1 PATTERNS RELATED TO COST OF HOUSING

The analysis has shown that *integration is usually higher/segregation lower in areas with AHC near city's AHC, and decreases/increases as AHC departs from city's mean value:*

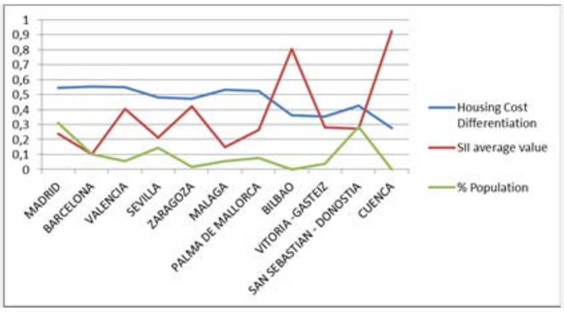
- Concentrating high income citizens in areas with higher AHC [thus excluding low income citizens from this areas]
- Concentrating low income citizens in areas with lower AHC [thus excluding high income citizens from this areas]

It is a pattern we see repeated in every city, and since urban areas' AHC of can only distance from overall city's AHC if there is sufficient Housing Cost Differentiation, we confirm the relationship between HCD and SSI.



If we compare Housing Cost Homogeneity *with Spatial Integration of different Income citizens [SII], we see high correlation [0.83] and reduced deviation [0.014].*

The revision shows that the greater Housing Cost Differentiation is, the greater Spatial Segregation by Income is, allowing us to insist again that a key strategy to promote spatial integration of inhabitants is acting on Housing Cost structure. *Cities with lower HCD have higher integration and lower rates of population [sometimes zero] in exclusive areas.*



The percentage of population living in very exclusive areas *[SII <0.40] is generally smaller, the lower the city's Housing Cost Differentiation is.*

In addition, the smaller the Housing Cost Differentiation, the higher the average value of SII of most exclusive areas is [correlation of 0.72].

However, SII and AHC do not hold an implication relationship. An area's AHC can be close to overall city's AHC because the area has a balanced representation of houses within each cost quintile of city's Housing Cost Profile or because all its houses have this cost and are equal. The first area would be highly inclusive while the second would be highly exclusive.

And this relates largely to another dimension of urban areas; their morphology and residential typologies, an issue we review below.

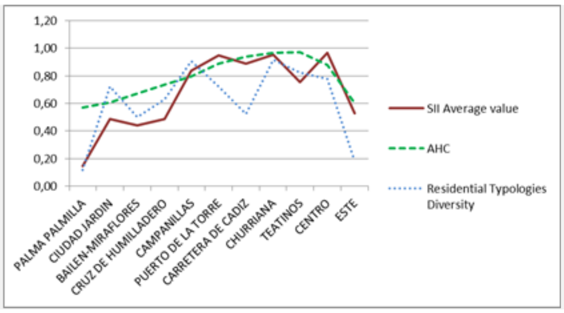
5.1.2.2 PATTERNS RELATED TO RESIDENTIAL TYPE AND MORPHOLOGY

We have compared SII and AHC for each city's area, noting their generally high resemblance but also some differences between these values, which may be due to several reasons:

- We have used AHC values which are not expressed in €/house but in €/m2 and therefore two zones with equal AHC values may involve very different Income of their inhabitants if the average area of dwellings is very different[56].
- For most cities disaggregated leasing cost data for housing is not available; assessed AHC only considers the supply of housing for ownership, but leased housing can represent up to 25-30% in some areas of the cities. In contrast, SII values assess both ownership and leased housing
- Also, *an equal AHC value can describe very different areas*, for example:
    - An area consisting of 20% houses in each quintile cost
    - An area comprising 50% of very cheap and 50% very expensive homes
    - An area consisting of 100% of households with the same price matching AHC.

If we review this last issue, it is evident that the three areas described above attract very different types of people.

And this difference between areas can be indirectly assessed by reviewing their **Residential Typologies Diversity, RTD**. An area with high RTD has, in general, high diversity of Housing Cost and as consequence high inhabitants' diversity. And if we review urban areas' Residential Typologies Diversity we see it can explain SII variations that differ from AHC variations.



The analysis of the city of Malaga *shows high similarity between the value of SII indicator [average for the four proposed indicators] and Residential Typologies Diversity, RTD [average deviation 0.10 and correlation 0.74]. The latter variable allows us to understand the sections in which the change in SII values does not follow the logic of AHC changes. We see confirmed the RTD-SSI relationship proposed by some authors [Muguruza and Santos, 1989; Van Kemper and Murie, 2009; USGBC, 2009 ...]*

Although not all cities show the high resemblance appreciably in Malaga, generally RTD helps explain at least some of the sections in which AHC and SII follow different logic. Special influence have shown morphologies that tend to homogeneity [e.g., colonies of detached houses], which produce high Spatial Segregation by Income.

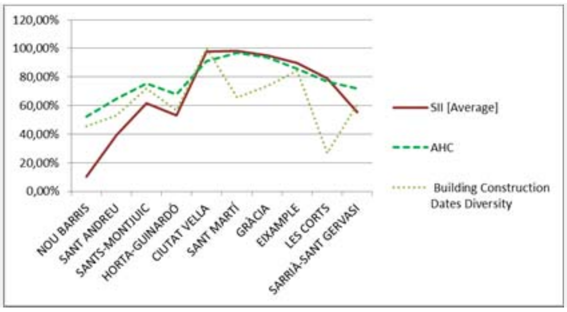
5.1.2.3 PATTERNS RELATED TO CONSTRUCTION BUILDING DATE

Another variable that reveals high influence on AHC is building construction date. Buildings constructed in different time moments/eras are associated with different services and current condition, appearing a correlation with the AHC and SSI.

In general, newer buildings have higher Average Housing Cost [AHC] while older buildings have lower AHC, meaning buildings' AHC is progressively reduced over time, a tendency that can be

[56] For example, if the average surface of an apartment is 60sqm in one area and 90sqm in another, the income required to buy/lease a home in the second area is 1.5 times the income required in the first zone.

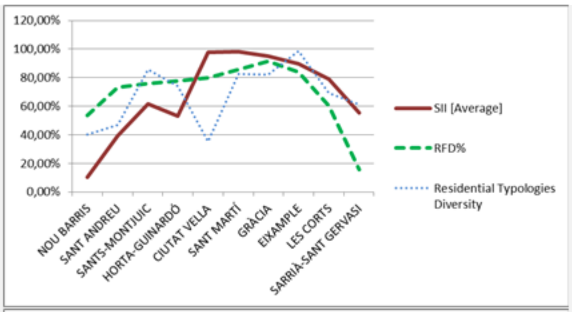
mitigated by partial rehabilitation and in a more palpable way when building substitution processes happen.



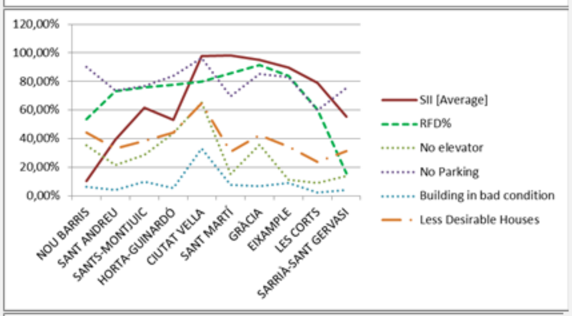
Comparison of Barcelona's normalized AHC *with SII shows an almost complete correlation [0.98], and medium-high with Building Construction Dates Diversity [0.59]. The latter value has been calculated using HHI grouping all pre-1900 houses in a category, and thereafter considering each decade as a different category.*

Since rehabilitation does not usually take place before 30-50 years, and replacement before 75-100 years [sometimes more], this implies that more recent residential urban developments generally have a decreasing AHC with Building date. Recent [less than 75-100 years] large extension developments, built in a short space of time, generally present reduced diversity and their AHC has been uniformly modified. Their high initial high homogeneity has most likely been preserved over time.

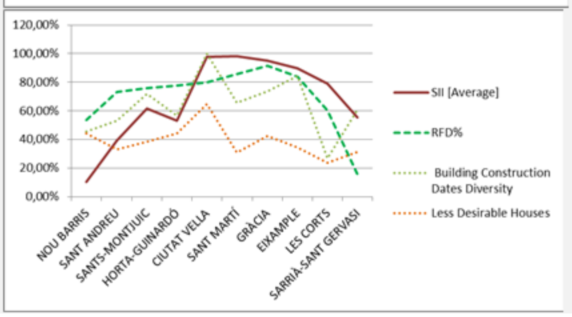
Conversely, the longer existence of historical fabrics has allowed many transformations, including replacing some buildings, renewing other, mixing housing programs ... *The mixture of buildings / houses with different utilities, and / or in different condition promotes the coexistence of different people.*



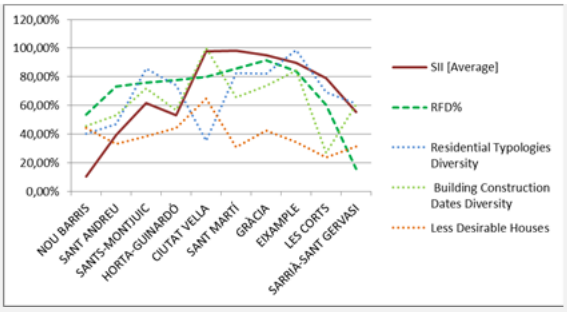
The comparison of the variation of SII values and the Diversity of Residential Typologies *is significant for many areas of Barcelona, but it strongly contrasts the variation of both parameters in the area of Ciutat Vella, where one abruptly grows while the other abruptly decreases. Understanding what happens requires revising building construction dates and desirability of houses.*



In reviewing building characteristics, we see in Ciutat Vella there is high percentage of Less Desirable Housing [houses in 'buildings with no garage, no elevator or in poor condition']. This allows us to understand that income diversity in Ciutat Vella is not achieved by the diversity of housing types, but because the different 'desirability' of similar types of housing attracts different people.



In addition, if we calculate the diversity of buildings' construction date, it also shows some correlation with SII [0.54] which rises when we compare it with the variable 'Less Desirable Housing' [0.66].



The joint review of the above variables allows us to understand the differences that may exist between environments with similar SII values. For example, if we compare Ciutat Vella and Sant Marti, we see that their high SII value is based on very different variables:

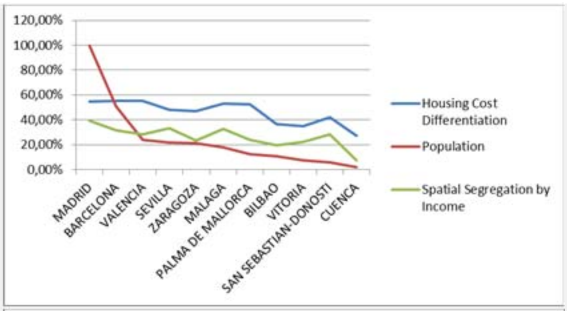
- *In Sant Marti, high SII coincides with a near average RFD, high Residential Typologies Diversity and a small percentage of Less Desirable Homes. These variables altogether speak of a relatively 'stable' middle-income people environment.*
- *In Ciutat Vella, high SII coincides with a somewhat lower RFD than Sant Marti's, a reduced Residential Typologies Diversity and high percentage of Less Desirable Homes. These variables altogether speak of an area very susceptible to gentrification, i.e., an area which can easily concentrate an increasing percentage of medium-high income citizens as houses are 'updated'*

The evolution of RFD value in both environments confirms above issue. While Sant Marti has maintained roughly stable RFD since 2000, and even more since 2005 [following International Forum's and Diagonal Mar area rehabilitation], Ciutat Vella is experiencing a steady RFD growth [61.8 to 79.7] that speaks of a process where low income residents are progressively substituted by higher income residents. If current Ciutat Vella's trend is not moderated, its current high SII will progressively reduce.

Data seem to confirm that the quality, condition and maintenance of the dwellings are linked to the income of their owners/occupants [Van Kempen & Murie, 2009]. In central areas the coexistence of inhabitants with different income is obtained by occupying the people with lower income the worst quality [or in worst condition] houses[57], *and if these homes are renewed, gentrification starts.*

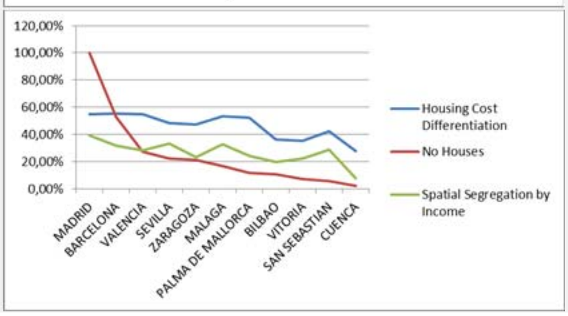
5.1.2.4 PATTERNS RELATED TO THE SIZE OF THE CITY

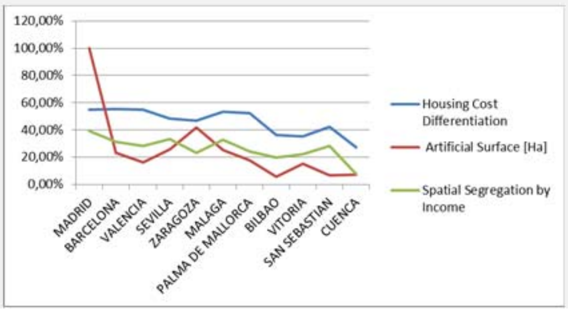
We have previously seen that the size of the city has high correlation with HCD, and this correlation is transmitted to cities' overall Spatial Segregation by Income:



Comparison of cities regarding the variables that characterize their size shows an even higher correlation than already revised regarding the HCD. The smaller the city is, the lower its Spatial Segregation by Income is, showing the following correlations:

- *SSI / Population = 0. 687*
- *SSI / No Housing = 0. 684*
- *SSI / Artificialized Surface = 0. 611*





Again the *high correlation shows us the greatest importance of Spatial Segregation by Income [and its higher probability of occurrence] as cities' size increases.* But the fact that this correla-

[57] Relating to immigration, we find similar statements in Maloutas [2007]

tion is not complete also shows us the importance of contextual issues and specific policies, confirming previous authors' assertions [e.g., Tammaru et Al, 2016].

5.1.2.5 SPATIAL PATTERNS

There are some spatial patterns that greatly influence each area's AHC that can be seen in cities' graphical representation. These patterns relate to several variables we group into two dimensions:

The first refers to **physical elements involving desirability,** among which the following have shown high importance:

- The presence of rivers [e.g., Seville, Bilbao]
- The marine coastline, especially if there are beaches that can be used by people [e.g., every costal city].
- Mountains with high landscape quality [e.g., historic center of Cuenca], privileged microclimate or abundant vegetation... Sometimes detached houses colonies constitute high environmental quality areas within the city.

But there are also elements that involve *very small desirability or 'undesirability',* such as manufacturing or industrial environments... [e.g., Pasajes' Ria in San Sebastian].

The greater the proximity to 'desirable' elements is the higher the AHC is, while the closer to 'undesirable elements' is the lower the AHC is, both reducing as distance increases. And AHC/SII correlation indicates that both areas next to 'highly desirable' items and areas remote from desirable elements [or next to 'undesirable' elements], have reduced SII values, which are higher in intermediate areas.

The second refers to the **centrality/connectivity.** In most cities AHC gradually decreases as we move away from the center, while SII shows a pattern: medium-high values in the center; maximum values in adjacent areas to the center and progressively reduced values as we move away from these areas.

In addition, spatial analyses show the importance of the elements that connect/divide parts of the city, which is reflected in the AHC structure:

- In some cities AHC is structured in relation to certain longitudinal elements [e.g. Via Diagonal in Barcelona; Old basin of the Turia river in the city of Valencia...].
- In other cities we see elements that become boundaries dividing very different zones [e.g. Old route M-30 in Madrid; River Urumea in San Sebastián, ...]

This confirms the importance of centrality and connectivity as strategies to increase integration; polycentric cities with reduced distance between centers, which maximize connectivity between its parts, will most likely reduce spatial segregation.

It is worth noting that *centrality, connectivity, desirability* combine in several manners in different cities, giving rise to diversity of spatial patterns.

5.1.3 RECAP

We have reviewed different variables that influence Spatial Segregation by Income, and it is interesting a brief recap focusing on the strategies to optimize from usual practice of architects/urban planners[58]:

Moderating **'desirability'** *differentials between areas of the city;* all areas of the city should be sufficiently desirable, desirability that can be monitored in two dimensions:

- … *in the perception of each urban environment by its inhabitants [subjective dimension].* For this purpose, indicators can be used that value inhabitants' perception of the urban environment[59].
- … *in the dimensions that are mostly accepted report the quality of each urban environment to meet the average needs of any inhabitant [objective dimension*]. Numerous existing models can be used for this purpose (e.g., Breeam, 2012; JSBC, 2011; Mfom, 2012; Alvira, 2015a ...]

This monitoring of urban areas allows detecting excessive differences in quality / desirability of areas, in which case urban policies should reduce this 'difference of desirability' by acting more intensively in 'less desirable' environments [i.e., usually areas with low income inhabitants] until all areas of the city are 'desirable'[60].

Avoid segregation of areas that generate **different employment types,** which in turn often leads to two other types of segregation[61]:

- One that refers to the *search for spatial proximity to one's employment place,* and relates the concentrated location of each employment type generator spaces, with the segregation these types of workers. As different employment type is associated to different income levels, the above usually leads to Spatial Segregation by Income.
- One that refers to the *search of environmental quality* and leads to higher income citizens locating away from production areas that generate more pollution [industries, warehouses, power plants ....].

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[58] However, we have also reviewed the great importance of Economic Inequality in SSI. Moderating SSI in a society with high EI, is almost impossible without first reducing EI. Since many strategies to deal with EI locate outside the work of urban planning architects, we detail them in ANNEX II ECONOMIC INEQUALITY AND THE SOCIOECONOMIC PARADIGM / STATE MODEL

[59] For example, Eurostat, Indicator "Percentage of the population that qualifies their satisfaction as high, medium or low" [ilc_pw05] related to Housing, Green areas and Leisure spaces, and Environment in which they live.

[60] "the social and physical upgrading of neighborhoods, as well as the reverse trend of social and spatial decay of neighborhoods, plays an important role in shaping new social geographies of segregation" [Marcinczak et al, 2016: 378]. E.g., one of the hidden dangers of the city of Madrid at present are two projects of urban transformation [Plaza de España-Gran Vía and Paseo del Arte] that threaten to greatly increase the desirability of the central zone, leading to increased processes of gentrification, displacement of inhabitants and spatial segregation by income, if appropriate measures are not taken to prevent it.

[61] For example, in his proposed extension project for Madrid in 1860, Castro places elements linked to freight traffic and industries in the Arganzuela District [South area], which leads to residential spatial segregation for two reasons:

- These productive spaces produce various types of pollution [air and noise] that reduce environmental quality and desirability of the environment, making higher income citizens seek locating in other areas of the city.
- Workers seek housing in Arganzuela in order to being close to their employment facilities, and these jobs are low-wage employment. Spatial Segregation by Employment/Labor becomes Spatial Segregation by Income.

Promote urban areas **connectivity**.

- At overall city level:
    - *Optimizing displacement*, e.g., by planning transport networks including express routes that minimize the effective distance [therefore the 'perceived distance'] of every part of the city with respect to the other parts, and especially to those that generate greater attraction.
    - *Reducing the need to travel through* the design of mixed use urban areas and networks of sufficiently distributed centers throughout the city, accessible in reduced time from all areas.
- At local level:
    - eliminating physical barriers [railways, highways ...] with adjacent areas
    - creating functional and attractive pathways [mixed use lined-trees streets, good quality pavements, moderate traffic levels...] connecting central points of adjacent areas

Promoting urban developments and interior transformations that integrate a diversity of residential typologies [both in type and in surface], **ensure a sufficient percentage of affordable housing [equal or superior to 30%], and develop progressively over time,** resulting in a diversity of prices and inhabitants:

- *Avoid large developments that are built at once and have high homogeneity of residential typologies.* They tend to concentrate similar people [it can be high income citizens -e.g., detached houses colonies-, low income citizens –e.g., areas of large housing developments 1960/1970- or middle-income -1990/2000 'Ensanches Isla'].
- *Not locating new social housing developments in areas that already concentrate people with reduced GDI, as this would increase Spatial Segregation by Income.* Subsidized housing should be planned distributed by the city precisely to promote Spatial Integration of people with different Income[62].

In summary, the **compact and diverse city model** advocated by most urban architects [Rueda, 1996; Frey, 1999; Rogers, 2000; Higueras, 2009…] with polycentric structure, moderate size lots, mix of building morphologies, typologies and uses, with some increase in open/green spaces provision [Hernandez Aja, 2000] stands as the best to achieve integrated cities.

Urban areas where building process more gradually happens allow the formation of much more diverse residential stock [in size, residential program, services and condition], diversity that is transmitted to its price and as consequence to its inhabitants' income.

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[62] An interesting proposal to monitor adequate distribution of protected housing throughout the city is MFOM [2012: 611. Indicator CHS.07.49], which values the presence of protected housing in the different areas of the city using Dissimilarity Index, setting threshold ≤0.10 as optimal state and ≥0.30 as unacceptable state.

5.2 ASSESSMENT OF PROPOSED INDICATORS

Once reviewed current condition of Spanish cities, let us now review the indicators from three perspectives: *conceptual, formal and factual*:

From a **conceptual perspective**, proposed indicators value one of the dimensions of Socioeconomic Segregation; Spatial Segregation by Income.

To assess it, we have adopted a very specific approach; dividing the population into categories that comprise the same percentage of population [i.e., quantiles]. As consequence, the proposed indicators inform of both dimensions of segregation Homogeneity and Exposure [if the approach were different, they should be independently valued]:

- The design of the indicators matches the concept of *homogeneity measures*, since they compare the situation of each urban area with that in which all the inhabitants are homogeneously distributed throughout the city.
- In addition, HHI index is a particularization of an *exposure/interaction measure* for the case where all groups comprise the same percentage of population. Its high resemblance to the other indicators confirms the equivalence between these two dimensions for the approach used here.

Dividing the population into categories with the same number of members leads to both dimensions becoming coupled/ dependent.

Additionally, *similarity between the results obtained using the four indicators is significant* since indicators have been designed from **formulas proposed within different fields of knowledge** which are sufficiently accepted by experts in spatial segregation:

- The Lorenz Curve [Lorenz, 1905] basis of the Gini Coefficient [Gini, 1914] / Segregation Curve [Duncan & Duncan, 1955], which underlies any measure that fulfills the 4 axioms of James & Tauber [1985].
- The Herfindahl-Hirschman Inverse Index [Herfindahl, 1945; Simpson, 1949 and Hirschman, 1950], which is an Exposure Index adapted to a society with n groups when the frequency of all groups is equal to 1 / n.
- Relative Entropy [Shannon, 1948], which is an measure of relative information that is the basis of Theil Index, considered by several authors as most consistent index for assessing spatial segregation [White, 1986, Reardon & Firebaugh, 2002; ...]

Therefore, we can support herein explained indicators in this interdisciplinary consistency frequently found in systems' sciences, where arriving to similar results from different perspectives allows us greater certainty in the conclusions.

From the **formal perspective**, we can revise them in relation to the 4+1 'axioms' frequently demanded by indices for assessing spatial segregation [James & Tauber, 1985 + Reardon & Firebaugh, 2002:37-38]:

- *Group Symmetry [Organizational Equivalence]*: If an area of the city is divided into k sub-areas, each with the same proportion of groups as the original area, the overall segregation of the city does not vary.

- *Size invariance*: If the number of persons in each group m in each area j is multiplied by a constant factor p, the overall segregation of the city does not change.
- *Invariance to composition*: If we multiply the income of all the inhabitants [or the cost of the houses] by a same factor, spatial segregation by income does not change.
- *Transfers*: if an individual in a group m is transferred from an area i to an area j, the proportion of people in group m being greater than i than in j, the segregation of the city is reduced.
- *Exchanges*: If an individual of a group m is exchanged in an area i with an individual of group n in an area j, the proportion of people in group m being greater in i than in j and the proportion of people in group n greater in j than in i, the segregation of the city is reduced.

All the above axioms are satisfied by the proposed indicators, since all of them comply with the Lorenz Criterion [James & Tauber, 1985].

Additionally, transformation of above Spatial Segregation measures into indicators has been made following the procedure explained in Alvira [2014a] which is a formal or tautological proposal based on two formal frameworks: fuzzy logic [Zadeh, 1965/1973] and axiomatization of probability [Kolmogorov, 1933].

From an **empirical perspective**, the *high resemblance of the results obtained using the four indicators* allows us to assign them high validity and state that all of them can be used to assess the extent to which Spatial Segregation by Income places each city among its optimal and worst states.

TABLE XX_ CORRELATION AND DEVIATION BETWEEN INDICATORS

	PEARSON CORRELATION					STANDARD DEVIATION				
		Lorenz	Entropy	HHI	Neg.		Lorenz	Entropy	HHI	Neg.
11 CITIES	Lorenz	-	0,779	0,797	0,788	Lorenz	-	0,059	0,062	0,054
	Entropy	-	-	0,989	0,995	Entropy	-	-	0,012	0,018
	HHI	-	-	-	0,986	HHI	-	-	-	0,024
	Neg.	-	-	-	-	Neg.	-	-	-	-
	PEARSON CORRELATION					STANDARD DEVIATION				
		Lorenz	Entropy	HHI	Neg.		Lorenz	Entropy	HHI	Neg.
7 LARGER CITIES	Lorenz	-	0,891	0,895	0,882	Lorenz	-	0,050	0,053	0,047
	Entropy	-	-	0,992	0,996	Entropy	-	-	0,011	0,019
	HHI	-	-	-	0,989	HHI	-	-	-	0,025
	Neg.	-	-	-	-	Neg.	-	-	-	-

SOURCE: Own Elaboration

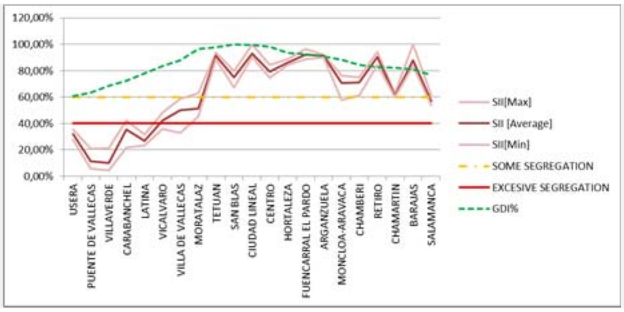
(1) We see that in all cases correlation between indicators based on Entropy, HHI and Neguentropy is close to 1, and their deviation is lower than or equal to 0.025. This allows us considering them practically equivalent to assess Spatial Segregation by Income.

(2) Correlation between the indicator using the Lorenz curve and the other three indicators is somewhat smaller [yet still high] for the 11 cities, approaching the value 0.9 and a deviation around 0.05 when we only review the 7 bigger cities. The reason is that in smaller cities [with lower housing supply], it is sometimes difficult to define precise economic quintiles for one or more housing types. This affects the values provided by indicators based on Entropy, HHI and Neguentropy. By contrast, the indicator designed from the Lorenz curve is independent of cost quintiles definition, since it values the Cost of Housing as a continuous variable.

(3) It should be noted that since the first quantitative analyzes of spatial segregation, high correlations were found between different indices [e.g., Jahn et al., 1947; Duncan & Duncan, 1955...]

This **'empirical' validation** is also supported by two additional high resemblances:

The first is that between indicators and normalized GDI / AHC:

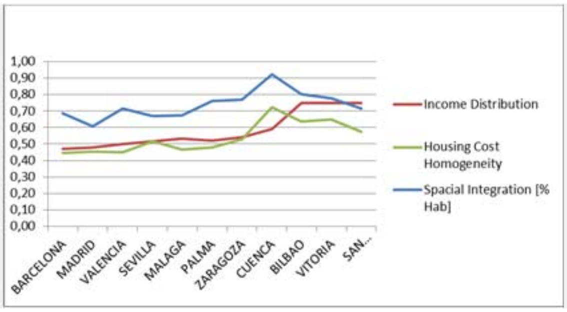


The review of Madrid city arranging its districts in increasing value of GDI, allows us to appreciate Spatial Segregation in different areas as the average GDI rises. Additionally, by normalizing GDI in relation to the average value and placing the value 0 in the poverty line we also see a striking resemblance [green dashed line] which is repeated in all cities for which GDI data is available and in Barcelona in relation to RFD.

Although ideally there should be available GDI data for each area, the resemblance between normalized GDI and AHC has enabled us working with the second if the first is not available.

It is important to note the obsolescence of some available data [e.g., Gini values for cities], which can provide somewhat different than actual correlations, emphasizing the importance that Public Administration takes care of the preparation and periodical publication of the necessary data.

And the second is the *high resemblance between the Gini coefficient applied to income* [Income Concentration] *and to the Cost of Housing* [Housing Cost Differentiation], and its correlation with the overall Spatial Segregation by Income in each city.



The high resemblance between HCH and overall cities' SII *leaves no doubt about the 'dependency' of these two dimensions. The again high resemblance between Income Concentration and HCH, shows the high coupling of the three variables.*

All these similarities allow us to state that *all the indicators proposed here allow to obtain consistent data to value [and intervene on] Space Segregation by Income.*

This does not imply that they intend to be definitive indicators. Knowledge is an open system; all the proposals that we make in this book can [and should] be improved in the future. For instance, some issues that can further researched in the future are:

- More accurately setting optimal/worst states thresholds for different indicators,
  - From the review of an extensive number of cities that includes cities from sufficiently different countries.
  - By differentiating between scales of urban analysis [the smaller the area assessed, the greater the permissible thresholds]
- Adapting the formulas of the indicators to obtain greater precision [e.g., adapting the partial indicators of the neguentropy indicator using Gaussian functions, ...]
- Designing tools to value cities by overlapping diffuse areas using GIS technologies and assessing the impact of distance between areas.

- Develop computer tools to individually extract houses' prices, allowing a more accurate calculation of cities' HCD.
- …

All this research can be greatly facilitated by public Administration by updating and making public more data on cities' concentration of income, which great importance makes difficult to understand its current absence from cities' publicly accessible statistical data.

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ANNEX I LIST OF ACRONYMS

AHC	Average Housing Cost [in €/m2]
GDI	Gross Disposable Income
CG	Corporate Governance
EI	Economic Inequality
HCH	Housing Cost Homogeneity [similarity]
HCV	Housing Cost Differentiation
H	Shannon's Entropy
HHI	Herfindahl Hirschman Index
IC	Income Concentration
MAUP	Modifiable Aerial Unit Problem
RFD	Family Available Income [Barcelona City Council indicator]
RTD	Residential Typologies Diversity
SEI	Socio Economic Inequality
SII	Spatial Integration of different Income citizens/inhabitants
SSI	Spatial Segregation of citizens/inhabitants by Income

ANNEX II ECONOMIC INEQUALITY AND THE SOCIOECONOMIC PARADIGM / STATE MODEL

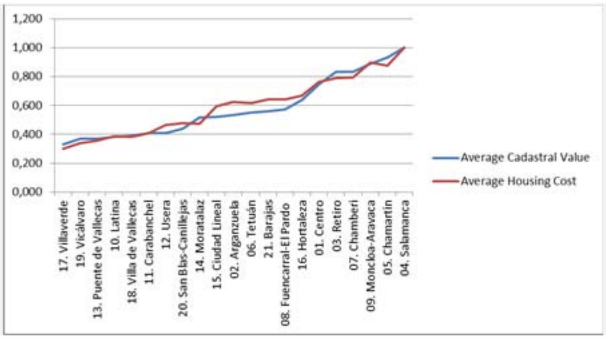
We have seen the high correlation between EI and SSI; higher EI usually involves higher SSI. *Achieving reduced EI values is prerequisite for achieving integrated cities*, making necessary a brief review of some important issues to achieve moderated EI states. We proceed from most specific to most global issues:

In the first place, it is necessary **modifying current paradigm which considers 'homes' as patrimonial assets instead of as fundamental citizens' right**. It is necessary to correct current process for the determination of houses' prices, which is left largely to be determined by Offer and Demand. The high impact housing has on society as whole, makes necessary considering it as one of the fundamental areas of State intervention:

- From an *individual perspective*, housing is necessary for life and should be a fundamental right of people.
- From a *collective perspective*, construction and management of housing is decisive for the *economic, social and environmental sustainability of the whole.*

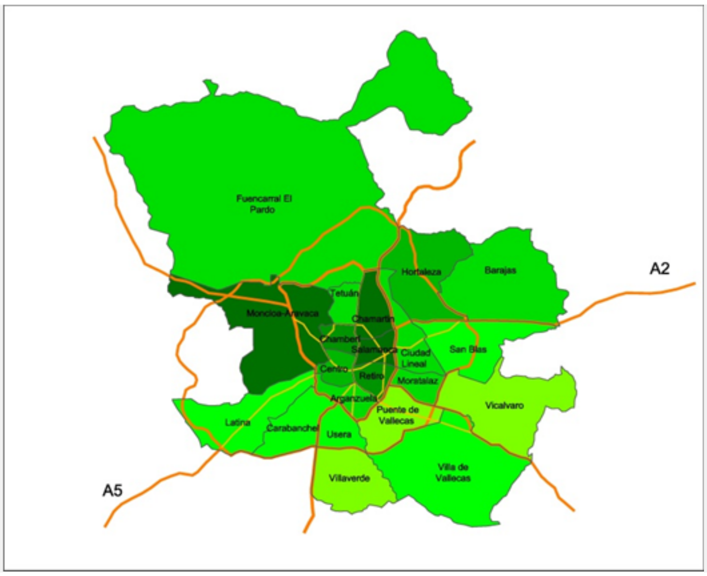
Noteworthy, both individual and economic perspectives lead to a matching optimum threshold. Expenditure of 25% income is considered as the threshold that separates accessibility from non-accessibility to housing, and review of data from the recent debt-crisis in the EU [Alvira, 2015a] shows housing represents approx. 25% of the citizens' income in the countries that best surpassed the crisis[63].

But in addition to its price determination, this consideration of homes as patrimonial asset is usually reflected in an inadequate design of taxes relating it. Submitting homes to taxes [IBI, Patrimonial Transmissions Taxes ...] in proportion to their market prices [instead of relating them to personal income] implies proportionally increasing the difficulty in access to housing generated by the free market, and housing price capacity to segregate inhabitants by income.



In Spain, many taxes on homes are calculated in proportion to their cadastral value*, which is in turn calculated seeking similarity to market values [RD Legislative 1/2004]. For example, if we revise the Average Cadastral Value of real estate [including 'homes'] owned by natural persons in Madrid [2014], we obtain an almost complete correlation [0.98] and very small deviation [0.027] with AHC [own calculation based on data from the city of Madrid and idealista.com, third quarter of 2014].*

[63] In Spain citizens' expenditure on housing was 33% of their income [1.3 times EU average]. This unjustified higher cost, challenges numerous articles of the Spanish Constitution. By limiting individual accessibility to housing, it challenges Art 47 which proclaims the Right to Housing. It also encourages the unsustainable growth of the construction sector, which is a low productivity sector [OECD, 2017], and reduces the economic resilience of the whole, challenging Art 128: Public function of wealth "All the wealth of the country in its different forms and whatever its ownership is subordinate to the general interest". Additionally, by increasing returns on capital over labor, it fosters the intergenerational transmission of social position [Piketty & Saez, 2004& 2006]. Personal effort and talent no longer matter so much for defining what place each one occupies in society as well as inherited wealth; the position of each person in society is largely determined by his birth conditions and tends to remain unchanged, challenging the equality principle explicit/embodied in numerous articles of the Constitution [e.g., Art 1; Art. 9...]



Spatial representation of normalized cadastral values *almost matches that of the AHC. This approach confers a segregating nature to many taxes [IBI, Heritage and Transmissions of Housing ...] that use these values as a basis, increasing the difficulty of the inhabitants with lower income to reside in some areas of the city. For example, IBI [RD Legislative 2/2004] in the most expensive areas of Madrid can be triple that in the areas where the AHC is smaller.*
Reducing SSI requires that taxes that affect homes are calculated in relation to people's income, not to homes hypothetical market prices.

Second, it is necessary to modify the **paradigm in relation to the Concentration of Income.** Its importance is fundamental for defining both the quality of life of almost the entire population [and cities' SSI]; the efficiency of society as a whole, and the cost of sustaining the State. *This makes incomprehensible his absence from usual political debate.*

Societies operate optimally in Income Concentration values around 0.22-0.25[64], while above 0.30 social problems and society's inefficiency exponentially increase[65]. Knowing the Income Concentration different political programs intend to generate, is fundamental issue for society/citizens.

Politicians usually report how their programs will affect GDP and employment, avoiding to explicit how they will affect the Concentration of Income, suggesting that if these two first variables increase, Economic Inequality decreases. However, reality has repeatedly shown the relation GDP-Employment-Concentration Income is not unequivocal; it depends on the model of State and Growth. Demanding politicians a quantitative prediction of Income Concentration[66], forces them to incorporate the goal of reduced Economic Inequality as an important aspect of their political model [few citizens may vote a politician advocating high IC], and enables citizens subsequently assessing politicians' management while in government.

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[64] This is the value shown by the EU countries that have better withstood the 2008-2010 crisis [Alvira, 2015a]. Importantly, countries adopting free-market paradigms show Income Concentration values around 0.40-0.50.

[65] When inequality is high social problems increase and thus the economic cost of sustaining the State, An example of Social Problem highly inked to inequality is Domestic Violence [usually linked to gender violence]. DV is linked to poverty [it is approximately 5 times higher in households with lower incomes than households with higher incomes], and its probability is almost fourfold [from 2.7 to 9.5%] when the household inhabitants perceive they are in a difficult economic situation [Renzetti, 2009]. For other examples of link between inequality and Social Problems [Mental Health; Prison admission rates; Obesity,...] see Wilkinson & Pickett [2010]. These authors emphasize that high EI raises diseases proportionally at all levels of income, not only in the lower ones. An easy way to reduce many of the problems that concern us today is reducing EI. Noteworthy, Income concentration in Spain has grown steadily in recent years [34.7 in 2014 compared to 31.9 in 2006, Eurostat data, 2016], so reducing it is a priority.

[66] Estimating Income Concentration value in a future time moment does not imply more mathematical difficulty than estimating the variation of GDP or employment that different policies will produce [e.g., in Alvira, 2015a and 2016a, assessment of urban policies has been made estimating both the increase in employment and the modification of the Gini Coefficient].

In addition, it is nowadays emphasized that the reduction of Economic Inequality must be addressed both a posteriori [through progressive fiscal policies and subsequent redistribution, and social protection], and a priori through adequate labor market regulation and companies governance, which takes us to the third issue.

Third, **it is necessary to change the paradigm in terms of Corporate Governance [GC]**. Economic Inequality is largely generated by companies: different employees' salaries and types of contracts; taxes payment strategies… There is unanimous agreement that the growth of EI in the last 40 years and the economic crisis of 2008 have been largely caused by inadequate or even undue business practices [EC, 2011].

Some criteria of good Corporate Governance are [EC, 2010 and 2011; Stiglitz, 2015b, Oxfam, 2016]:

- Not avoiding paying taxes through *creative accounting*.
- Not exerting pressure on governments to obtain favorable legislation [at the expense of the rest of society]
- Limiting economic differentiation among workers:
    - Limiting workers' wages differentiation and excessively high salaries of top managers.
    - Establishing same salary for same task and same educational level[67].
- Limiting the percentage of temporary contracts[68].
- Provide continuing education to employees.
- Increase transparency of companies operational data [environmental, social, fiscal and corporate governance][69]

Inadequate CG implies high costs for society, including large EI, so it is necessary to avoid it through States' actions, combining compulsory legislation with measures that encourage proper CG voluntary by companies, granting greater accessibility to public contracting and some tax reductions on products and services [EC, 2011][70].

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[67] For example, Iceland's Government has recently approved [March 2017] a law requiring companies to prove that wages for men and women are equal [New York Times, Access 2017/04/01].

[68] The average of EU countries which better withstood the recent debt crisis was [in 2006] 12.0% of temporary employment, while that of the worst performing countries was 20.5%. Spain had 33.4% of temporary employment in 2005 [Eurostat data].

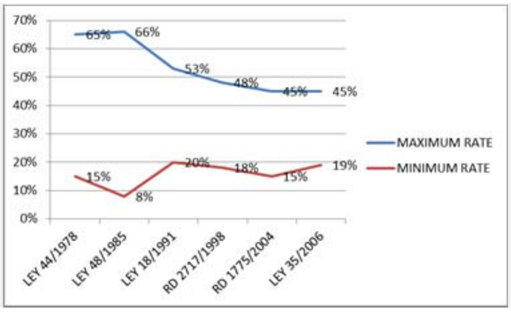
[69] Greater transparency in well-managed CSR increases the value of companies over incurred expenses [Ioannu & Serafeim, 2014: 21]. A growing number of countries already require companies to annually publish information on their impact on the environment and society, and their internal governance. In France, since 2002 reports must include 40 qualitative / quantitative indicators. Among them, some refer to "social information to employees", including "wage escalation" and "equality of men and women" [Kühn et al, 2013: 5]. Oxfam [2016] suggests that multinational corporations should be forced to make their country-specific performance data public as a way to prevent/detect tax avoidance. Bloomberg includes *executive compensation* as information companies must provide [Ionannu & Serafeim, 2014: 10]. Additionally, it would be in our opinion interesting to require companies to publish the Gini coefficient that results from their salary structure [including subcontractors, and salaries as well as bonus]. In terms of EI, a beneficial company for society would be one whose Gini was 0.22-0.28. A pernicious company for society would be one whose Gini was 0.40-0.50

[70] "Enterprises still face dilemmas when the most socially responsible course of action may not be the most financially beneficial, at least in the short term. The EU should leverage policies in the field of consumption, public procurement and investment to strengthen market incentives for CSR" [EC, 2011: 10]

Thus, it is concerning that many countries [among them Spain, see MESS, 2014] limit their strategies to 'recommendations' of voluntary compliance by companies, without setting targets in the short term. *The recent great negative impact of bad CG on society does not allow considering it a company's choice and highlights its priority for governments.*

We have highlighted several times how political decisions shape [for good or for bad] our societies, and this leads us to the next issue; **it is necessary to review our current paradigm of representative government and collective voting rules**.

Our societies increasing EI is the consequence of certain policies [Stiglitz, 2015b; Oxfam, 2016] that allow that large percentage of States' wealth is accumulated by small percentage of citizens. These policies which depart from the common good are enabled by the high accumulation of power by a few people.



Since 1978, successive Spanish governments have displaced the effort of sustaining the state from the rich to the poor*; by reducing the maximum tax [65% to 45%] and raising the minimum tax rate [15% to 19%] as well as raising indirect taxes. Current Economic Inequality in Spain is largely the consequence of political decisions. Complementarily, the reduction from 28 tranches in 1978 to the current 5 contradicts the principle most accepted by economists; the declining marginal utility provided by money.*

The relationship between Inequality and Concentration of Political Power has been repeatedly confirmed throughout history [Plato, 350 BCE; Aristotle, 344 BCE; Machiavelli, 1513; Harrington, 1656; Rousseau, 1762; Tocqueville, 1834; Dahrendorf, 1968; Sassken, 2005; UN-Habitat, 2010; Mfom, 2012; Oxfam, 2016; ...][71].

Leading our societies toward optimal states of reduced EI requires redesigning our systems to maximize the distribution of political power; i.e., to make them democratic. *Parliamentary representation and rule of law do not imply democratic government* and may well imply the opposite [Rousseau, 1762; Manin, 1998 ...]:

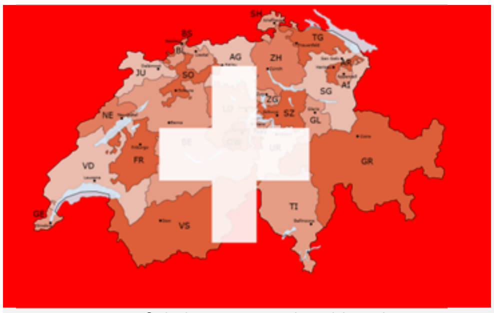
- *Not every parliamentary representation is democratic per se*[72]; many government models imply high concentration of power. And the coupling between Power and Inequality makes maximizing equal distribution of political power among citizens and territories / central government a prerequisite for reducing EI.
- *Not every law is democratic per se, nor should they be considered dogmas*. Laws are only changeable and perfectible tools whose democratic [or not] nature depends on

[71] It is significant that Aristotle after studying all political systems of Greek poleis, states democratic government provides greater social welfare and equality than any other type of government of the time. Additionally, it is important to emphasize that there is retroactivity between Inequality and system of government; Democracy benefits from [requires] reduced levels of inequality [Machiavelli, 1513; Rousseau, 1762; Tocqueville, 1836; Dahl, 2004...]. High unequal Socio Economic situations lead to political polarization and increased support for extremist parties [incorrectly designated as *populisms*], making democracy more difficult.

[72] The possibility that an elected representative may not act according to the will or values of those who elected him, was detected as soon as Crete [VIth century BCE]. The fact that short term of office/frequent elections was not enough to prevent it, was detected as early as the Spartan ephors [Aristotle, 344 BCE] and the tribunes of Rome [Cicero, 55 BCE]. For a review of the meaning of democracy see Ober, 2007. For the differences between Representative and Democratic Government, see Manin, 1998.

> their drafting and approval process, and their validity must be backed by them being able to bring societies closer to their optimal state[73].

Constitutional and legislative frameworks together with government actions, define the social environment, and most of our current models of parliamentary representation are designed to prevent/minimize citizens' intervention in the design of such framework. *A society where citizens lack the capacity to control governments' actions and the design of regulatory framework is not -by definition- democratic.*



Switzerland is an example that parliamentary representation, rule of law, market economy and stability are compatible with democratic government. *Its Constitution promotes the balance of political power between citizens and territories [cantons], both in its bicameral structure [and government formation] and in facultative referendums. In addition, it incorporates several types of Initiative and Referendum to enable citizens' control of the design of their constitutional and legislative framework and control on certain government actions.*

It is meaningful that Switzerland has been put as an example of a democratic state by the majority of political scientists since its first steps as a Federal State ca. 725 years ago [Machiavelli, 1513; Rousseau, 1750; Hattersley, 1930; Schumpeter, 1943 ...].

Additionally, there is high lack of knowledge about the right rules for making voted decisions. It is most striking that plurality rule is the most widely used rule nowadays, since outcome of elections can be easily manipulated, and even when it is not manipulated, the rule frequently chooses an option that is not preferred by most individuals [Borda, 1784; Wright, 2009…].

This often leads to voted decisions not arriving to democratic outcomes [Arrow, 1951], which can make them very unstable [Barberá & Jackson, 2004]. There is urgent need to move towards the generalization of voting rules that ensure the choice of the most preferred option and promote consensus/stable solutions, i.e. to generalize the use of Condorcet methods[74].

This issue becomes especially important in the design of Electoral Laws; the rules that are used nowadays do not ensure compliance with the Condorcet Criterion, and most often than not, lead to governments that are not the most preferred by the population [Colman & Poutney,

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[73] The idea that States are governed by laws rather than by men goes back to Plato and Aristotle. However, all political scientists have agreed that not every decree should be considered law. "We deny that laws are true laws unless they are enacted in the interest of the common weal of the whole state" [Plato, 349 AEC: 291]. Aristotle [344 AEC] states that depending on how laws are written they can promote a democratic or oligarchic society. Isadore of Seville [636] states laws should be drafted with the consent and participation of citizens. Machiavelli [1513] states that reviewing the government decisions' [e.g., their Laws] effect on reality is the way to determine whether they are for or against the common good. If the effect of a law on a society is negative, then it should be changed. The mantra that the law per se is democratic has been created at the end of the 20th century by political and economic elites, to give legitimacy to [often undemocratic] decrees.

[74] The limited extension of this publication prevents further development of an issue that requires more than one book [for more information, see Alvira, 2015b]. In random samples Plurality Rule may not choose the most preferred option as often as in 60% of the occasions [actual percentage depends on the number of eligible choices and how these are selected]. A voting rule that gives consistent and non-manipulable results in almost 100% of cases is Beatpath Schulze [Schulze, 2011]. Alternatively, the author proposed in 2016b the MnLL rule, an improved version of Simpson Kramer Minimax, which gives coincident results with BS except in exceptionally improbable cases.

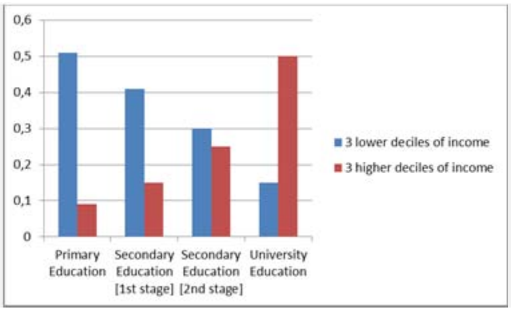
1978; Van Deemen, 1993; Kurrild-Klitgaard, 2008] and to parliaments whose preferences' structure does not match that of society [Alvira, 2016b][75].

Finally, **it is necessary that the regulatory framework promotes –inter and intra- generational social mobility**. Social mobility refers to the degree to which the position that each person will occupy in society is –more or less- determined by its birth status. It therefore refers to one of most fundamental issues of the Western socioeconomic paradigm; to the *equality [or not] of opportunity among of societies' members.*

Although still few, existing studies assessing factual data confirm so far that the greater the Socio Economic Inequality is, the lower Social Mobility is [Blanden et al., 2005; Wilkinson & Pickett, 2010; Dabla-Norris et Al, 2015]; i.e. the less the equality of opportunity between people is. As SEI increases, the place each one occupies in society throughout his life comes determined to a greater extent by his birth condition/family background.

Again this equality/inequality of opportunities is determined largely by the legislative / constitutional framework; creating a society with a high equality of rights and opportunities, requires designing an appropriate framework. *It is not enough that all citizens are equal before the law; in addition the law must be adequate.* Taxation; Education… many laws can be designed so they promote low EI and high equality of opportunity or vice versa.

An example is the access conditions to higher education in Spain, which impose economic fees unrelated to each person actual income, hindering access to people with lower family income. Given the high correlation between studies and future income [Mfom, 2012…], this makes more likely the income difference in each generation repeats the one that existed in the previous generation; i.e. it immobilizes the social structure by limiting equality of opportunity.



In the period 2009-2015 data from Madrid city show a clear link between educational level and income *[the bars in blue indicate the probability of belonging to the three deciles with less income -i.e., of being poor- and the red bars the likelihood of having high income]. These data allow us to state that without universal access to higher education, intergenerational transmission of poverty is more likely than not likely. Under current Spanish Education regulation, not all Madrilenians are born with the same opportunities / rights***,** *challenging Art 1 of the Universal Declaration.*

Achieving equality of opportunity would require, in terms of education, re-writing Article 27 of the Spanish Constitution [and Art 14 of European Social Chart] to establish the constitutional right of all citizens to access all levels of education, including higher education[76].

[75] In Alvira [2016b] Spain general elections of 2016 are modeled using different voting rules. It is shown that current parliament [built according to current Electoral Law] does not represent citizens' preferences' structure [Pearson=0.04] and a simple Condorcet consistent rule is proposed for election of representative chambers that provides high similarities between the preferences of the camera and those of citizens [Pearson=0.76].

[76] An example where legislation ensures equal access to education is Norway, where the State provides free education and guarantees low interest credit to any citizen. These credits are returned upon completion of studies [70% of the loan] or 100% if they are dropped out [i.e., to reward effort, 30% of the credit is condoned to the people who complete the studies]. It is significant that

of the 8 countries studied by Wilkinson & Pickett [2010], Norway presents the highest social mobility and reduced income concentration.