Chapter 3

Wage Concentration in Spain: A Spatial Analysis

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Additional information is available at the end of the chapter

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Abstract

In this article, the degree of concentration of wages in Spain at the provincial and regional levels is estimated using the latest available micro-data corresponding to the Structure of Earnings Survey 2010 (N = 216.769). From the analysis of the statistics obtained, it is possible to know in detail the spatial distribution of national wage inequality, to identify those areas where inequality is greatest, and to estimate the possible existence of spatial dependence and structure. The analysis focuses not only on the study of global inequality, but delves into the question by extending the analysis from a gender perspective.

Keywords: inequality, Gini, gender, wages, spatial statistics, variogram

1. Introduction

It is not in dispute that there is growing concern for the increase in inequality in household disposable income in recent decades, both nationally and internationally [1]. In the case of Spain, the report of the International Monetary Fund [2] states that the Gini index [3] on disposable income has risen nearly 3% points, from 31.8 in 1980 to 34.7 in 2010, while in other advanced economies such as the United Kingdom or the United States, the increases were even 6.5 and 7.5% points, respectively, rising from 27.0 to 33.5 in the case of the United Kingdom and 30.1 in 1980 to a more worrying 38.6 in the United States in the same period. Considering the most up-to-date data, in the case of Latin America and the Caribbean zone in 2012, the net Gini average is 44.2 points out of 100, the latest data available for China stand the Gini inequality index at 47.3, reaching in India a value of 47.7 [4].

Wage inequality is found partly in the origins of this income inequality, since, in general, higher wages mean high disposable income and vice versa. From this point of view, the study of inequality in the distribution of wages among the population of a country is especially relevant.

However, besides the importance of dealing with the study of global income inequality in the country, from a sociological perspective and gender, it is equally important to develop indicators of equality between women and men, such as those carried out by some of different women's institutes [5, 6]. It is essential to know which degree of inequality in the distribution of wealth occurs among women themselves and among men themselves, as different groups. Also, in this area of study, the analysis of inequality between women and men, understood as gender inequality, also acquires special relevance. In the case that concerns us as wage concentration, between and within-group index concentration decomposition can be accomplished following the decomposition of Larraz [7].

But as we are dealing with spatially located data, because individuals (employees) work in a specific geographical area, the study of the spatial dependence should be taken into account. To analyze the evidence of existing spatial correlation, the study of this phenomenon should be accomplished from a spatial approach. It seems important to emphasize that the information provided by the spatial location of each observation through its spatial coordinates should not be underestimated. It will be important for spatial modeling, for example.

With this in mind, the aim of this study is to conduct an analysis of the degree of overall, female, male and gender wage concentration at regional and provincial levels (NUTS2 and NUTS3, respectively, [8]) in Spain, as an example that could be replicated in different countries. The study has two purposes: First, to point out the Spanish regions and provinces in which the concentration of wages is higher and more worrying, and, second, to determine the absence or existence of some degree of spatial dependence in the phenomenon. For the first part, this chapter analyzes the maps showing global inequality, inequality among women themselves, among men themselves and gender inequality at regional and provincial levels. To achieve the second objective, the analysis of the spatial dependence of the inequality and its structure has been carried out.

Thus, the chapter is structured as follows. After this introductory section, Section 2 describes the methodology used in the concentration index decomposition and the theory associated with spatial autocorrelation and its structure. Section 3 briefly describes the structure of earnings survey [9] developed by the Spanish National Statistics Institute, whose micro-data [10] have been used to calculate such concentration indices. Section 4 shows the maps, the spatial correlation tests, the estimation of experimental variograms, the fit of theoretical variograms and their analysis to finally conclude with Section 5.

2. Methodology

This section, first, makes reference to the methodology used in the decomposition of the concentration index in between- and within-group components. Subsequently, a brief sum-

mary is made of the study of spatial autocorrelation of global, gender, male and female inequality indexes, to conclude with the classic analysis of the structure of spatial dependence in geostatistics.

2.1. Measuring inequality

When addressing the quantitative study of the degree of concentration of an economic variable, the Gini index [3] continues to constitute, after nearly a century of existence, the most used inequality coefficient by official statistical agencies [9, 11] and in the scientific literature [12, 13]. In the case study of income or wages, the said concentration index is based on the relationship between the cumulative proportion of population, $p_i = i/n$, and income, $q_i = A_i/A_n$; where $A_i = \sum_{k=1}^{i} x_k$ and $\{x_i\}_{i=1}^{n}$ represent the individual earnings ordered from the smallest to the largest.

$$IG = \frac{\sum_{i=1}^{n-1}(p_i - q_i)}{\sum_{i=1}^{n-1} p_i}, \forall n \tag{1}$$

The values of this index range from zero, which corresponds to a level of total equal distribution, to one maximum economic concentration or total inequality in the distribution of the variable.

An equivalent expression that returns exactly the same result [7] is based on the definition of mean difference of Gini [14] and is given by the expression

$$IG = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right|}{2\bar{x}\cdot n(n-1)}, \ \forall n \tag{2}$$

being $\bar{x}$ the arithmetic mean of income.

Despite the validity of these definitions, it should be noted that expression (1) can only be applied if frequencies are unitary, so their use with survey data is limited, as the raising factor (or weight) involves repeating each entry a number of times, not an integer most of the time.

To overcome this limitation, when the available frequencies are not unitary, the calculation of the inequality Gini index should be made through the following expression:

$$IG = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left|x_i - x_j\right| n_i n_j}{2\bar{x} \cdot N(N-1)}, \quad \forall N \tag{3}$$

where N is the total number of individuals and n_i the number of them that has a salary of x_i currency units, which again are arranged in ascending order: (x_i; n_i) and $x_i \leq x_j$ if $i < j$.

When addressing this issue from a gender perspective, in this article, besides the concentration index among all individuals, indexes of male and female concentration are computed, understanding those calculated on all women and men separated. With them it is intended to understand what is happening with the inequalities among women themselves on the one hand and among men on the other hand. These indices will be important to know the reality and decide in which cases are relatively more urgent to take action, if that is the case.

Thus, the rate of female concentration is defined as

$$IG_{\text{Women}} = \frac{\sum_{i=1}^{n_W}\sum_{j=1}^{n_W}\left|x_{Wi} - x_{Wj}\right| n_{Wi} n_{Wj}}{2\bar{x}_W \cdot N_W (N_W - 1)} \tag{4}$$

where N_W is the total number of women and n_{Wi} is the number that has revenues of monetary x_{Wi} units, which again the x_{Wi} are arranged in ascending order: (x_{Wi}; n_{Wi}) and $x_{Wi} \leq x_{Wj}$ if $i < j$.

Similarly, the male concentration ratio is defined as

$$IG_{\text{Men}} = \frac{\sum_{i=1}^{n_M}\sum_{j=1}^{n_M}\left|x_{Mi} - x_{Mj}\right| n_{Mi} n_{Mj}}{2\bar{x}_M \cdot N_M (N_M - 1)} \tag{5}$$

where N_M is the total number of men and n_{Mi} the number that has revenues of monetary x_{Mi} units, which again the x_{Mi} are arranged in ascending order: (x_{Mi}; n_{Mi}) and $x_{Mi} \leq x_{Mj,}$ if $i < j$.

Also, the gender concentration index is defined, IG_{Gender} (6), as the one that calculates the wage gap exclusively between the wages of men compared to women, not including the differences between women and men, who have already been computed in the above indices (expressions 4 and 5). The index has been calculated after adapting the definitions 3 and 4 in [7] to groups of women and men as

$$IG_{\text{Gender}} = \frac{\Delta_{WM}}{\bar{x}_W + \bar{x}_M} \; being \; \Delta_{WM} = \frac{\sum_{i=1}^{n_W}\sum_{r=1}^{n_M}\left|x_{Wi} - x_{Mr}\right| n_{Wi} n_{Mr}}{N_W N_M} \tag{6}$$

Finally, to identify the contribution of inequality between men and women (gross between: IG_{gb}) and men and women together among themselves (within: IG_w), the degree of total inequality (IG) Larraz [7] decomposition can be used, which is given by:

$$IG = IG_w + IG_{gb} \tag{7}$$

where

$$IG_w = IG_{\text{Women}} \frac{N_W - 1}{N - 1} \cdot \frac{B_W}{B_n} + IG_{Men} \frac{N_M - 1}{N - 1} \cdot \frac{B_M}{B_n} \tag{8}$$

measures the contribution of inequity between the groups to total index and

$$IG_{gb} = IG_{\text{Gender}} \left(\frac{N_W}{N - 1} \cdot \frac{B_M}{B_n} + \frac{N_M}{N - 1} \cdot \frac{B_W}{B_n} \right) \tag{9}$$

measures the gross between contribution to total inequality, being $B_n = \sum_{i=1}^{n} x_i n_i$ the total wage bill; $B_W = \sum_{i=1}^{n_W} x_{Wi} n_{Wi}$ the total wage bill perceived by all women; and $B_M = \sum_{i=1}^{n_M} x_{Mi} n_{Mi}$ the total wage bill perceived by all men and making the subscripts *W* and *M* refer to the sample of women and men, respectively.

To end the methodology section devoted to the study of wage inequality, it should be noted that the concentration index used is not affected by changes in scale. This means, for example, the fact that *IG* shows less inequality (higher) in one province against another province would not respond to a relative position of lower (higher) wages in the first province with respect to the second province, if not at a lower relative reality of inequality itself. Also, remember that all defined indexes have their field of variation between 0 and 1, indicating a higher value of the index, increased inequality, and smaller, more equity.

2.2. Analysis of the spatial dependence

To study the possible presence of spatial dependence or correlation on observed variables, two alternative approaches can be implemented, according to data and observations pertaining to territorial units (areas) perfectly defined in space or considered as realizations of a random variable in space.

In the first case, in this article, the Moran's *I*-statistic has been used [15], capable of testing whether the hypothesis of the values obtained from sampling of a random variable are distributed totally random in space, or, on the contrary, there is a significant positive association of similar values between neighboring regions. In its construction, it is necessary to resort to the so-called physical contiguity matrix or spatial weight matrix in which the spatial relationship between each pair of locations is translated, to define the concept of proximity. In this case, it has resorted to the concept of physical contiguity first order used by Moran [16] and

Geary [17], where w_{ij} is unitary if i and j are physically adjacent regions (if provinces have a common border) and zero otherwise. Furthermore, suppose that the products $\left(x_i-\bar{x}\right)\left(x_j-\bar{x}\right)$ are calculated, with $\bar{x}$ as the arithmetic mean of the observations. Then, in the case of positive correlation, these products tend to be positive while in the case of alternation will tend to be negative. The statistics based on this principle was developed by Moran and is defined as follows:

$$I=\frac{n}{S_0}\frac{\sum_i\sum_j(X_i-\bar{X})(X_j-\bar{X})}{\sum_i(X_i-\bar{X})^2} \tag{10}$$

It is written in matrix equals

$$I=\frac{n}{S_0}\frac{(\mathbf{X}-\bar{\mathbf{X}})^t\mathbf{W}(\mathbf{X}-\bar{\mathbf{X}})}{(\mathbf{X}-\bar{\mathbf{X}})^t(\mathbf{X}-\bar{\mathbf{X}})} \tag{11}$$

being $\mathbf{X}-\bar{\mathbf{X}}=\begin{pmatrix}X_1-\bar{X}\\ \vdots\\ X_n-\bar{X}\end{pmatrix}$ the column vector of the deviations of the values of the performance in relation to its average. In terms of the statistical moments in the case of normality it is obtained as follows:

$$E_{Norm.}(I)=\frac{-1}{n-1}\text{ and }V_{Norm.}(I)=\frac{n^2S_1-nS_2+3S_0^2}{(n^2-1)S_0^2}-\frac{1}{(n-1)^2} \tag{12}$$

being $S_0=\sum_i\sum_j w_{ij'}$ $S_1=\frac{1}{2}\sum_i\sum_j\left(w_{ij}+w_{ji}\right)^2$ and $S_2=\sum_i\left(w_{i0}+w_{0i}\right)^2$ with $w_{i0}=\sum_j w_{ij'}$ $w_{0i}=\sum_j w_{ji'}$ $i\neq j$ and n the number of locations, while in the case of randomization are:

$$E_{Aleat.}(I)=\frac{-1}{n-1}\text{ and}$$

$$V_{\text{Aleat.}}(I)=\frac{n\left[\left(n^2-3n+3\right)S_1-nS_2+3S_0^2\right]-k\left[n(n-1)S_1-2nS_2+6S_0^2\right]}{(n-1)(n-2)(n-3)S_0^2}-\frac{1}{(n-1)^2} \tag{13}$$

where $k = m_4 \Big/ m_2^2$ is the kurtosis coefficient and being $m_r = \frac{1}{n}\sum_i (x_i - \bar{x})^r$.

Regarding the distribution of the statistic, Cliff and Ord [18] demonstrated that when the sample size is large enough, the Moran *I*-statistic follows a normal standardized asymptotic distribution:

$$\frac{I - E(I)}{\sqrt{V(I)}} \to N(0,1) \tag{14}$$

Thus, a non-significant value does not reject the null hypothesis of no spatial correlation, while a significant positive value, thereof, inform about the presence of a pattern of positive spatial autocorrelation, i.e., the presence of similar concentration values of the variable *X* between neighboring regions.

In turn, the representation of Moran's scatterplot is shown in this article. This representation is a visualization technique of spatial effects, providing another useful tool in the analysis of the degree of spatial dependence of a variable. This graph shows in abscissa the values of the x_i variable (normalized or not) and in ordinate the resulting spatial average delay (standardized or not) of variable values in other neighboring locations, i.e., those weighted with a value other than zero in the contiguity matrix. Through this cloud of points is achieved by comparing the value of the variable in a location with variable values in neighboring locations (those considered by the contiguity matrix).

On the other hand, from a statistical perspective, the variogram is the essential tool to analyze the dependence of the observed regionalization ([19, 20], among others). Under the framework of intrinsically stationary random functions, the variogram is defined as

$$\gamma(\mathbf{h}) = \frac{1}{2} V\left[X(\mathbf{s}+\mathbf{h}) - X(\mathbf{s})\right] \tag{15}$$

and shows the evolution of the similarity between the values of the phenomenon under study *X* and observed locations **s** and **s** + **h**, *X*(**s**) and *X*(**s** + **h**) separated by physical distance **h**. Specifically, a constant variogram for all **h** shows no spatial dependence of the phenomenon, while a variogram that presents a non-zero slope near the origin of the coordinates is indicative of the existence of some degree of spatial dependence. In this study, it was decided to allocate the concentration index of each province to the spatial coordinates of the capital, where the most of the population is concentrated in general terms.

Although the classical estimator $\gamma(\mathbf{h})$, which is given by the expression (16) [21], is commonly used

$$\gamma^*(\mathbf{h}) = \frac{1}{2N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} \left(X(\mathbf{s}_i + \mathbf{h}) - X(\mathbf{s}_i) \right)^2 \tag{16}$$

(being, in our case, $X(\mathbf{s}_i)$ the value corresponding to inequality index in the province whose provincial capital has coordinates $\mathbf{s}_i$ and $N(\mathbf{h})$ the number of pairs of provinces whose capitals are separated by a vector $\mathbf{h}$), this chapter has chosen to use the estimator by Cressie and Hawkins [22], given by equation (17), due to its larger robustness (see [23] for different options).

$$\gamma^*_{CH}(\mathbf{h}) = \frac{1}{2}\left[0.457 + \frac{0.494}{N(\mathbf{h})} \right]^{-1} \left[\frac{1}{N(\mathbf{h})} \sum_{i=1}^{N(\mathbf{h})} \left| X(\mathbf{s}_i + \mathbf{h}) - X(\mathbf{s}_i) \right|^{1/2} \right]^4 \tag{17}$$

3. Data from the structure of earnings survey

To carry out the study of wage inequality, we used the latest available information: micro-data on the distribution of wages, included in the Structure of Earnings Survey 2010 [9], with a 4-year basis. Through its micro-data, you can have, besides sex, individual wages and the province (NUTS3) in which they perform their job, data that will allow us to carry out the proposed study. This information is gathered from the quotation centers selected in the sample,

Figure 1. Map of Spain at the provincial level [8]. Source: own elaboration.

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excluding enterprises in agriculture and fishing, public administration employees not covered by social security, domestic staff and extraterritorial body workers.

The study has taken into account, on the one hand, the variable "gross annual earnings per worker", including payments in goods, to study the different degrees of concentration existing in annual gross wages. The analysis of inequality in the distribution of this variable allows us to analyze the possible consequences to the fact that women have lower gross annual salary on average than men. On the other hand, to isolate the effect on annual salaries increased by the presence of women in part-time jobs (a lower annual average wage), the study was also conducted on the variable "hourly earnings per worker".

The latest survey, dated October 2010, gathers information for about 25,104 quotation centers and 216,769 employees of this, the grossing up factor (weight) is the number of workers in the population corresponding to that information. These workers develop their work in a particular province (NUTS3), which are in turn included in its region (NUTS2) (see **Figures 1** and **2**).

Figure 2. Map of Spain at regional level [8]. Source: own elaboration.

About the most important global statistics of the survey, following **Table 1**, it can be highlighted that though the total population of workers in Spain in 2010 is almost 12 million people, there are still more men (53.2%) than women (46.8%) working. But more important, women as a whole earn just the 40.5% of total annual payroll, while men as a whole earn the rest. Moreover, there is a great difference between the average wages per year of both genders: while men earn

25,479€ per year on average, women earn just 19,735€/year. Measuring this difference on wages per hour, it can be concluded that the gender pay gap is almost 14%.

	Individuals	Total annual payroll (%)	Average wage per year	Total payroll per hour (€/h)	Average wage per hour
Women	5,618,100 (46.8%)	40.5%	19,735.22€	42.7%	10.15€
Men	6,381,446 (53.2%)	59.5%	25,479.74€	57.3%	11.78€
Total	11,999,546		22,790.20€		11.06€
Gender pay gap[1]			22.55%		13.84%

Source: own elaboration from the Structure of Earnings Survey Micro-Data [9].
[1] 'Gender pay gap' indicator is defined by Eurostat as the difference between the average gross hourly earnings of men and women expressed as a percentage of the average gross hourly earnings of men.

Table 1. Descriptive statistics of wage distribution by gender in Spain.

Inequality indicators	
Gini index (on anual salaries)	32.72%
Female Gini index	33.53%
Male Gini index	30.91%
Gender Gini index	33.57%
Low pay rate (1)	13.42%
Proportion of women among total workers with low pay jobs	66.0%
D9/D5 (ninth decile (2) divided by the median (3) of wage per hour)	2.12
D5/D1 (the median divided by the first decile of wage per hour)	1.58
D9/D1 (ninth decile (2) divided by the first decile of wage per hour)	3.34

Source: Spanish Statistics Institute (2012) and own elaboration from the Structure of Earnings Survey micro-data [9].
(1) Proportion of workers whose wage per hour is below two-third of the median salary.
(2) Deciles are the values of the pay that, ordered from smallest to largest, divide the number of workers into 10 equal parts, such that within each are included 10% of them.
(3) Median is the value of the pay that divides the number of workers into two equal parts: the one who have a higher salary and the one who have a lower salary.

Table 2. Inequality indicators of wage distribution in Spain.

Having said that, as if these facts were not serious enough, **Table 2** reports the most important inequality indicators. It is worth noting that female inequality is higher than male one, which means that inequality among women themselves is higher than among men themselves. But it is also of concern that gender inequality, measured by expression (6), is even higher. Moreover, among workers with lower salaries, women account for 66% of them. It is also important to say that the 10% of workers with the highest salaries earn more than double that of median salary and more than three times the salary of the 10% of workers with lowest salary per hour. **Table 3** reports such percentiles.

	Total population	Female	Male
10th percentile	8,643.66	7,001.27	11,391.44
25th percentile	13,602.53	11,462.43	15,770.16
50th percentile	19,017.09	16,536.10	21,206.99
75th percentile	28,255.45	24,751.72	31,164.24
90th percentile	40,811.42	36,249.13	44,725.21

Source: Spanish Statistics Institute (2012).

Table 3. Percentiles by gender (€/year) in Spain.

4. Results

From the micro-data of the Structure of Earnings Survey [9], concentration indices have been calculated: overall, gender, male and female as it has been detailed in Section 2 at regional and provincial level in Spain. This is intended, first, to compare the situation of each region and province regarding the other as far as inequality of wages (annual and hourly) to each of the four concepts. To do this, remember that a higher index value corresponds to a more unequal distribution of variable, whereas a lower value corresponds to a more equitable distribution of the same. This information was reflected in the following maps (**Figures 3** to **6**), showing the detailed information in **Tables A1** and **A2** of the Annex.

The grey scale map has been made by compiling from the distribution decile values of the four indices (not of each separately, so they match the legend of the 4 maps on each figure) to be able to perform a comparison at a glance of the different degrees of inequality obtained. First it is commented at a regional level (NUTS2) to move later at the provincial level (NUTS3).

As aforementioned, it has also carried out the spatial analysis of the different degrees of concentration studied, to know whether a particular pattern of spatial autocorrelation should be considered in future studies.

Thus, in regard to the space study performed from gross annual salary (**Figure 3**)—remembering that it implies the fact that the average annual salary for women is less than the average for men due in part to increased female employment in part-time jobs—at first sight, in general, greater wage concentration of gender in Spain (**Figure 3b**) than global (**Figure 3a**) is observed, i.e., the distribution of wages among workers of different sex is more unequal if one considers all workers together. In addition, inequality among women (**Figure 3c**) is clearly higher than among men (**Figure 3d**) in all the regions (NUTS2).

Specifically, Madrid and Andalusia are positioned as the regions with highest overall wage inequality in Spain, followed by Murcia, Ceuta and Castilla Leon. At the other extreme, the Balearic Islands, Castilla-La Mancha and Navarra present a lower degree of wage concentration. In regard to gender inequality, Murcia, Andalusia, Madrid, Castilla Leon, Ceuta and Cataluña are the regions with highest degree of concentration, continuing Balearic Islands,

Navarra and Castilla-La Mancha as the most equalitarian regions in the distribution of wages between genders.

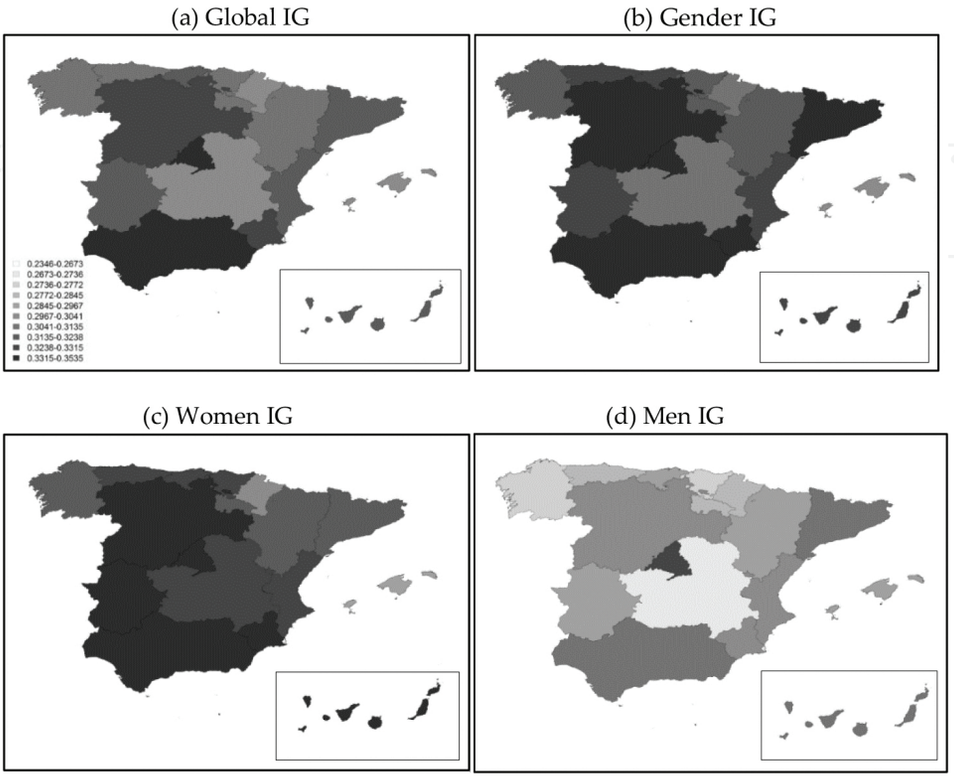

Figure 3. Map of Spain for the concentration index of the entire population (a), gender (b), the group of women (c) and the group of men (d) at regional scale (NUTS2), calculated from the annual gross salary received by each worker. Source: own elaboration.

If the study is carried out within the group of women, it is also of concern that the degree of internal concentration exceeds the generally assumed because of inequality between the distribution of annual wages between women themselves. Specifically, it is in the Midwest and southern Spain (Murcia, Extremadura, Andalusia, Melilla, Castilla Leon, Ceuta, the Canary Islands and Madrid) where this inequality is greater, while Baleares and Navarra regions stand out as having less difference in women's wages.

In the case of male inequality, Madrid is the region where the distribution is less equitable between them, followed by Ceuta, Cataluña and Andalusia, with Castilla-La Mancha, Galicia and the Basque Country more equalitarian.

By correcting the effect of the increased presence of women in part-time jobs on the annual profit by considering the variable of gain/time, we see, first, how wage differences are smoothed in all groups (**Figure 4**), while still maintaining the worrying situation of greater gender than overall concentration, lighter than in the previous case. In general, except in Castilla Leon and Extremadura, less concentration of female than male is now seen. Therefore, regardless of the number of hours worked per worker, data reflect a lower equity in the distribution of hourly wages among men than among women.

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Specifically, Madrid and Cataluña now appear as the most unequal regions (**Figure 4a**) together with Castilla Leon, La Rioja and Navarra being the most equitable. In the study of gender (**Figure 4b**), Madrid is the region with the highest degree of concentration between men and women, followed again by Castilla Leon and Cataluña, which are now joined by Asturias and Murcia. On the opposite side, again positioned are La Rioja and Navarra regions where also the distribution of wages between men and women is more equal.

In the case of female wage concentration (**Figure 4c**), making it through the hourly wage implies greater equity in regions such as Asturias, Basque Country, Navarra, La Rioja, Aragon, Valencia, Balearic Islands and Andalusia. At the other end, still stands Castilla Leon with an uneven distribution of the wage mass, in this case between women themselves.

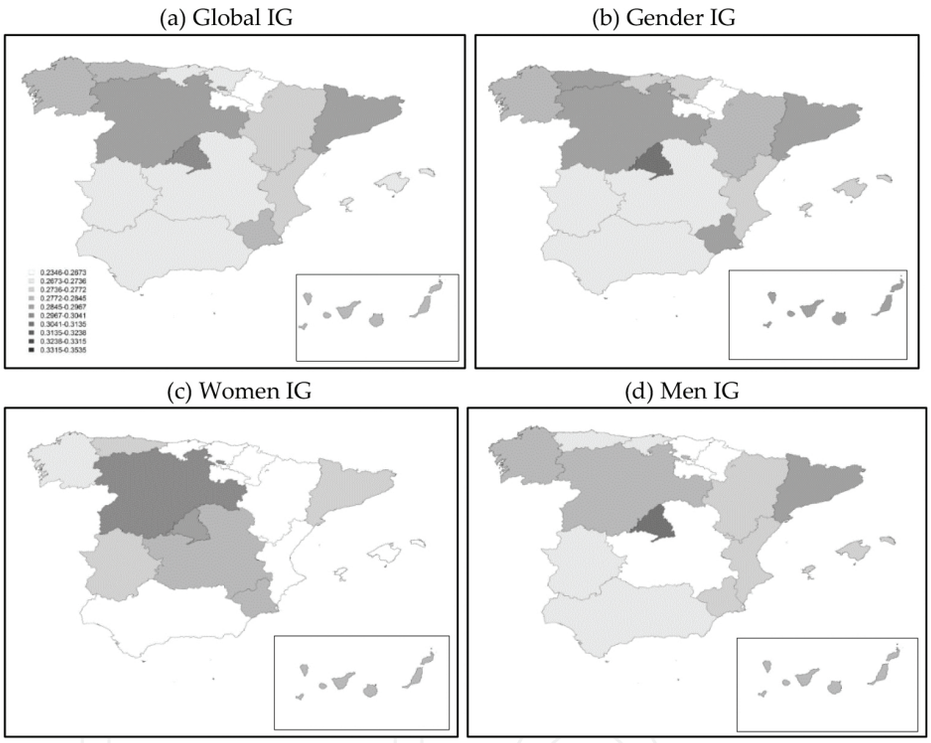

Figure 4. Map of Spain at a regional scale (NUTS2) for the concentration index of the entire population (a), gender (b), the group of women (c) and the group of men (d), calculated from the hourly wage earned by each worker. Source: own elaboration.

The study among men (**Figure 4d**), however, leads us to highlight the plight of Madrid on the distribution of male wages, followed by Cataluña, standing at the opposite ends of equity the regions of the Basque Country, Navarra, La Rioja and Castilla-la Mancha.

In **Figure 3**, a breakdown at the provincial level (NUTS 3), it is noted, first, that the range of values of the concentration indices are higher than the automatic scale. While the regional study on the minimum was 0.2346 and the maximum was 0.3535, in this case we find values between 0.2018 and 0.3868. This implies that the values that correspond to each color range of grays have changed substantially.

That been said, in the analysis of the overall annual wage concentration in the whole country at a provincial level (**Figure 5a**), three problematic areas are observed for their high levels of inequality compared to other provinces, which are western Andalusia and the area in the center and east of the peninsula. In the first stand Huelva, Seville and Cadiz as the provinces with the highest concentration indices. They are followed by Valladolid and Palencia as provinces with high levels of inequality in the distribution of annual wages, next is Madrid. Finally, the provinces of Murcia and Lleida have the highest income inequality in the east of the country, although any of the other three provinces of Cataluña also have high levels of inequality. On the other hand, among the provinces with greater equity in the distribution include Ciudad Real, Castellon, Albacete, Huesca and Alava.

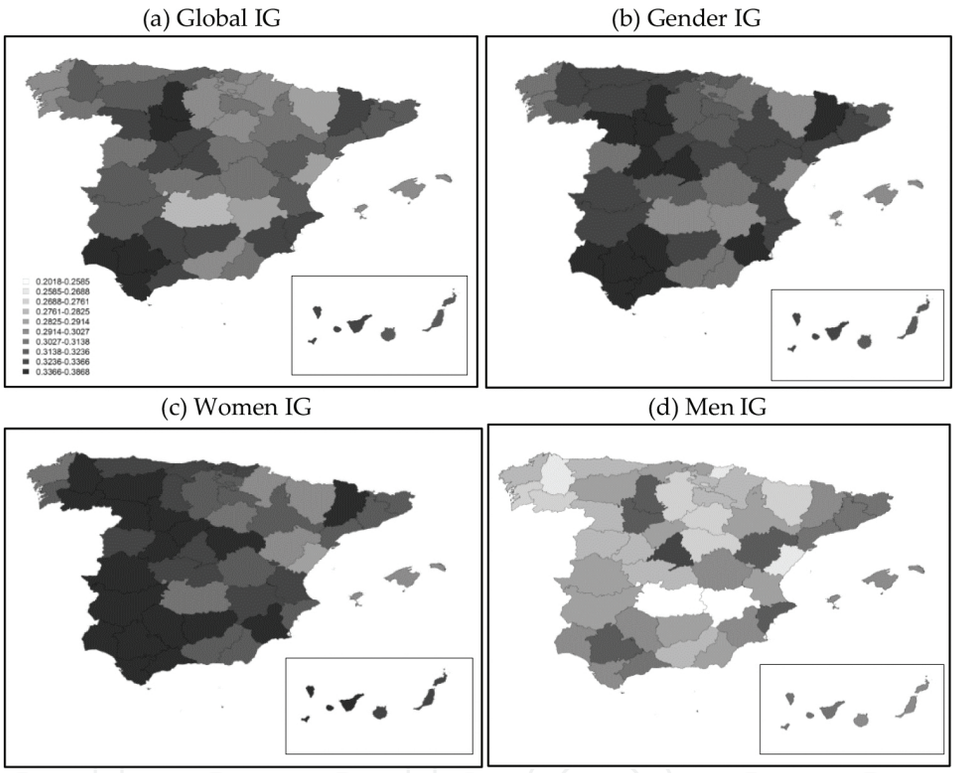

Figure 5. Map of Spain at a provincial level (NUTS3) for the concentration index of the entire population (a), gender (b), the group of women (c) and the group of men (d), calculated from the annual salary received by each worker. Source: own elaboration.

From the map of gender inequality (**Figure 5b**) we can conclude that, overall, these values are higher than the global inequality in each province, being the provinces with the highest levels of concentration gender the same as globally plus Zamora, Avila, Cordoba and Murcia. The areas of greater gender equity are found in Ciudad Real, Huesca, Castellón, Albacete and Baleares Islands.

In general, women's inequality is seen clearly higher than the male, having increased wage inequality among women in the western half of the country (including the two provinces of the Canary Islands) in the East with the exception of Murcia and Lleida, which also have high

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levels of concentration in the female rate (**Figure 5c**). Standing as provinces with the lowest female inequality are Castellon, Balearic, Navarra, Huesca, Teruel and Soria.

As shown in **Figure 5d**, the degree of concentration in the wages of men seems much more encouraging in general, existing provinces such as Ciudad Real and Albacete with high levels of equity; however Madrid is still of concern, which has the highest degree of male inequality in the country, followed by Sevilla, Alicante, Palencia, Teruel and Valladolid.

Figure 6 shows, as happened at regional level, obviously that the hourly wage distribution is more equal at the provincial level that the distribution of annual salary, since the use of the variable earning per hour involves no consideration of part-time sessions, both male than female.

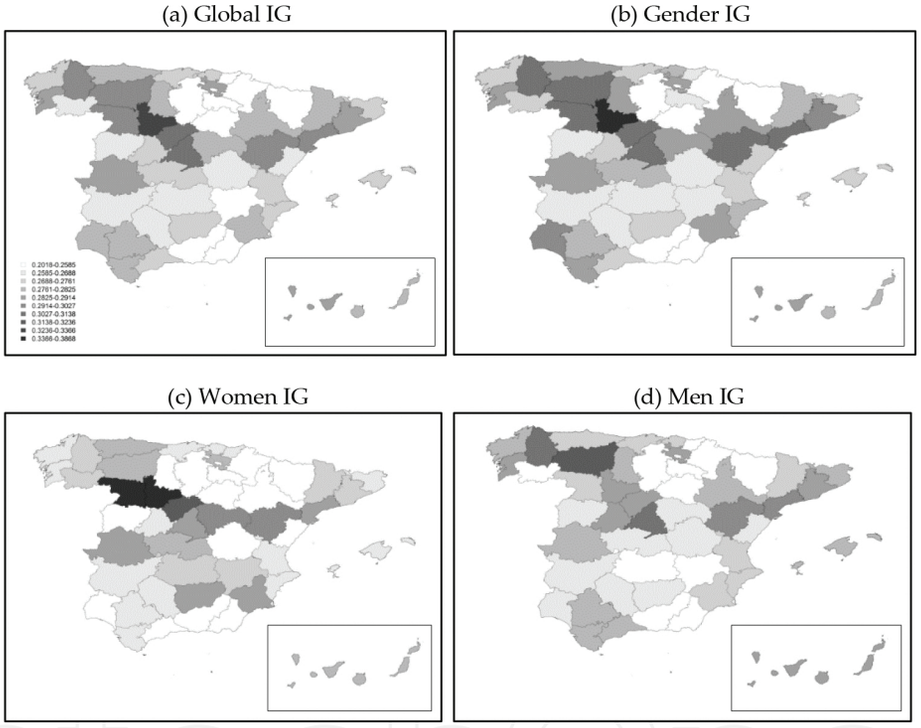

Figure 6. Map of Spain at a provincial level (NUTS3) for the concentration index of the entire population (a), gender (b), the group of women (c) and the group of men (d), calculated from the hourly wage earned by each worker. Source: own elaboration.

In regard to global inequality measured in terms of hourly wages, **Figure 6a** shows two areas in the peninsula clearly with more equitable distributions, such as in the north, the provinces of Soria, Burgos, Navarra, Huesca, La Rioja and Gipuzkoa and, in the southeast, Almería, Granada and Albacete. On the other hand, the greatest inequality is observed in Valladolid, followed by Ceuta, and around by Segovia, Madrid, Leon and Lugo.

Also in the case of the study of hourly earnings, all provinces have greater gender inequality (**Figure 6b**) than overall, although we are talking of figures about a tenth on average. Therefore, although the map shows an image similar to that of global inequality, it is worthy to highlight

it for its high concentration the province of Valladolid, followed behind by the provinces of Lugo, Zamora, Ceuta, Segovia, Tarragona, Madrid and Teruel.

	Global IG	**Women IG**	**Men IG**	**Gender IG**
p-Valor annual salary	0.00023***	0.00019***	0.00122***	0.00270***
p-Valor per hour salary	0.01319**	0.16276	0.00789***	0.01069**

Note: *** They refer to the statistical significance of the 1% and ** to 5%.
Source: own elaboration.

Table 4. Test of significance of Moran's *I*-statistic: *p*-values of Moran's *I*-statistic for overall concentration indices, female, male and gender indices.

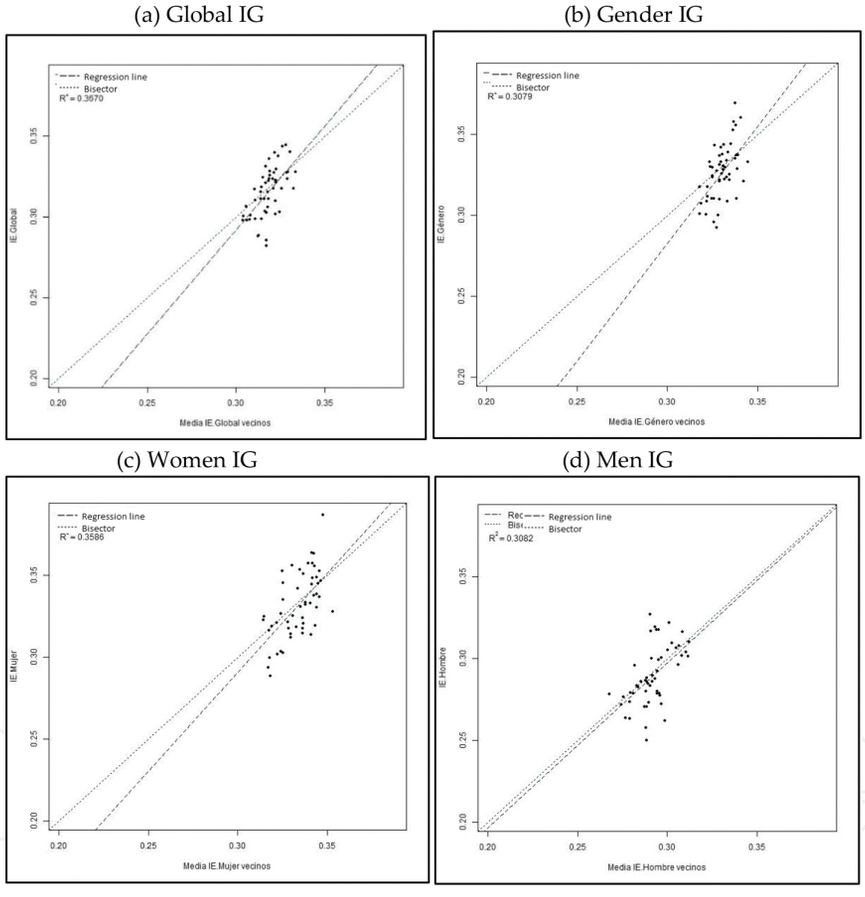

Figure 7. Moran's Scatterplot corresponding to the degree of concentration of the entire population (a), gender (b), the group of women (c) and the group of men (d), calculated from the annual salary perceived by each worker. Source: own elaboration.

Finally, female inequality, shown in **Figure 6c**, shows a clear strip of greater inequality in the center, highlighting Valladolid and Zamora as those provinces with the highest rate of female concentration, followed by Segovia, Ceuta, Melilla and Teruel. Especially equitable for women is the distribution of hourly wages in the North (interior), some provinces in central and

southern Spain. Male inequality (**Figure 6d**) has not yet clear spatial/geographic patterns, highlighting Leon, Lugo, Madrid, Ceuta and Tarragona as provinces with less equity and, at the other end, Soria, Guipuzkoa, and Burgos and Huesca as provinces with more equity in the wage distribution.

Once analyzed the maps of global inequality, gender, male and female in Spain, next a spatial autocorrelation analysis of the phenomenon is performed. First the contrast of lack of spatial correlation to positive existence of spatial correlation is performed, through statistical Moran's *I* (**Table 4**). This statistic is significantly positive in all cases when the variable annual gross salary calculates the indices. In the case of earnings per hour, only in the event of the women's concentration index, the statistic is not statistically significant, in which case one could not reject the hypothesis of no spatial correlation.

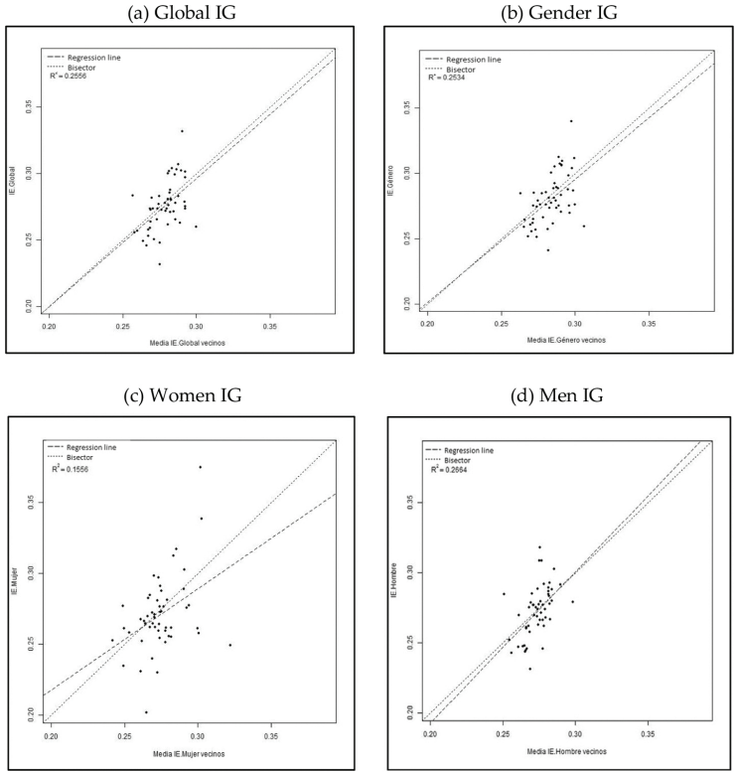

Figure 8. Moran's Scatterplot corresponding to the degree of concentration of the entire population (a), gender (b), the group of women (c) and the group of men (d), calculated from salary when perceived by each worker. Source: own elaboration.

These results can be checked visually in **Figures 7** and **8**, showing the Moran's scatterplot of the concentration indices calculated from the variable annual gross profit and earnings per hour, respectively. **Figure 7** shows how neighboring provinces with high concentration values also and vice versa surrounds provinces with high concentration values. However, in the female concentration index computed from the wage by time, as shown in **Figure 8c**, the point cloud shows the absence of spatial correlation, indicated by the low ratio between the concentrations of the provinces and those of their neighbors.

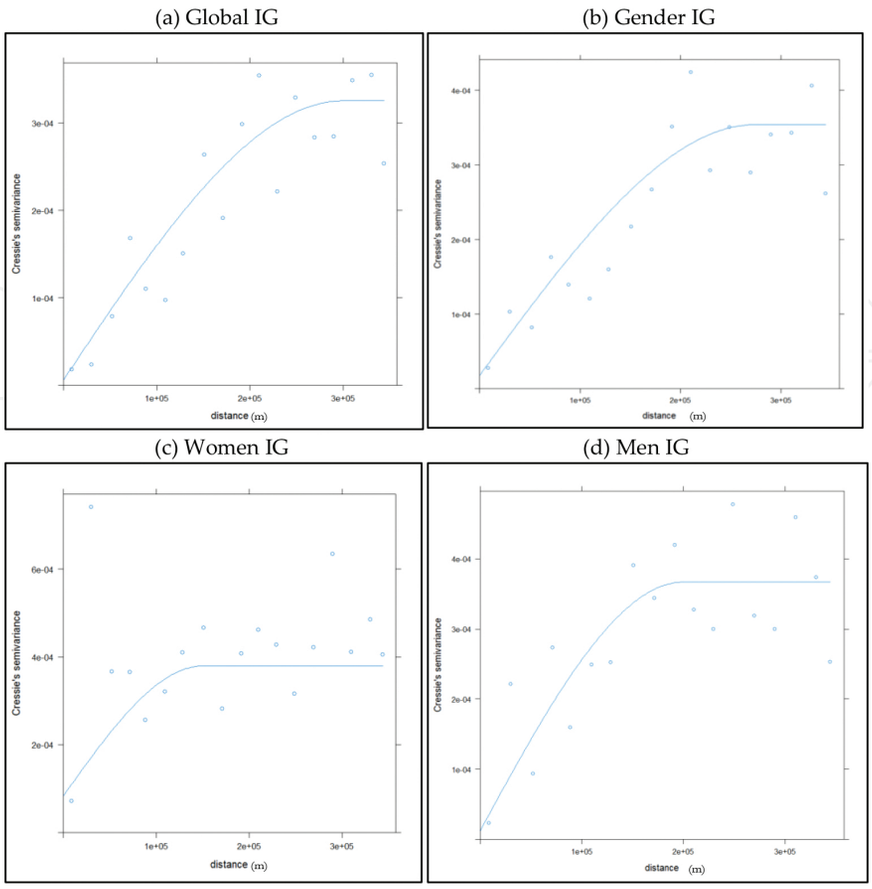

Figure 9. Structural analysis of spatial dependence: Experimental and theoretical variograms adjusted for the concentration index of the entire population (a), gender (b), the group of women (c) and the group of men (d), calculated from gross annual salary received by each worker. Source: own elaboration.

	Global IG		**Gender IG**	
Model	Sill	Range	Sill	Range
Nugget effect	0.0000061	0	0.0000175	0
Spherical	0.0003189	300.011 km	0.0003364	275.015 km
	Women IG		**Men IG**	
Model	Sill	Range	Sill	Range
Nugget effect	0.0000833	0	0.0000120	0
Spherical	0.0002962	149.976 km	0.0003547	200.003 km

Source: own elaboration.

Table 5. Nested variogram theoretical models, with their sills and ranges used for fitting theoretical variograms of global inequality, gender, male and female calculated from the variable annual gross salary.

Theoretical models	Parameters for global IG	
Model	Sill	Range
Nugget effect	0.0000038	0
Spherical	0.0002718	299.995 km

Source: own elaboration.

Table 6. Theoretical models of the nested variograms, with their sills and ranges used for the adjustment of the directional variograms of global inequality

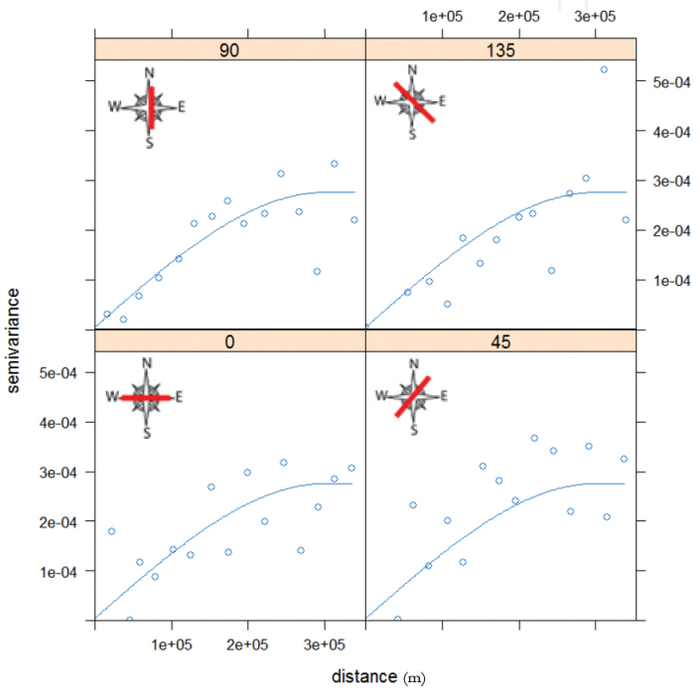

Figure 10. Global IG directional variograms calculated from the annual salary. Source: own elaboration.

The aforementioned significances are confirmed with the alternative approach of variograms represented in **Figure 9**, given that to the lower the *p*-value, the greater the structure of spatial dependence of the phenomenon and less discontinuity at the origin (see **Table 5**). It can be seen how the experimental variograms of each of the four events are adjusted from a linear combination of a nugget effect and a spherical model. However, adjustment parameters (sill and range) are different.

Large discrepancies are observed between them, and while the overall concentration index has a range around 300 km (which is, more or less, the distance from the center of the Iberian Peninsula to the coast), the gender goes down to 275 km, with the male and female of 200 km and 150 km, respectively. Recalling that the lower the range, the smaller the distance where the spatial correlation fades away, in the case of female concentration index, the positive spatial correlation disappears already at short distances. However, the other three cases (the global, male and gender concentration indices) show important spatial correlation structures.

	Global IG		**Gender IG**	
Model	Sill	Range	Sill	Range
Nugget effect	0.0002142	0	0.0001816	0
Spherical	0.0001240	99.982 km	0.0001886	99.978 km
	Women IG		**Men IG**	
Model	Sill	Range	Sill	Range
Nugget effect	0.0004623	0	0.0001941	0
Spherical	–	–	0.0001777	100.004 km

Source: own elaboration.

Table 7. Theoretical models of the nested variograms, with their sills and ranges used for fitting theoretical variograms of global inequality, gender, male and female calculated from the variable hourly wage.

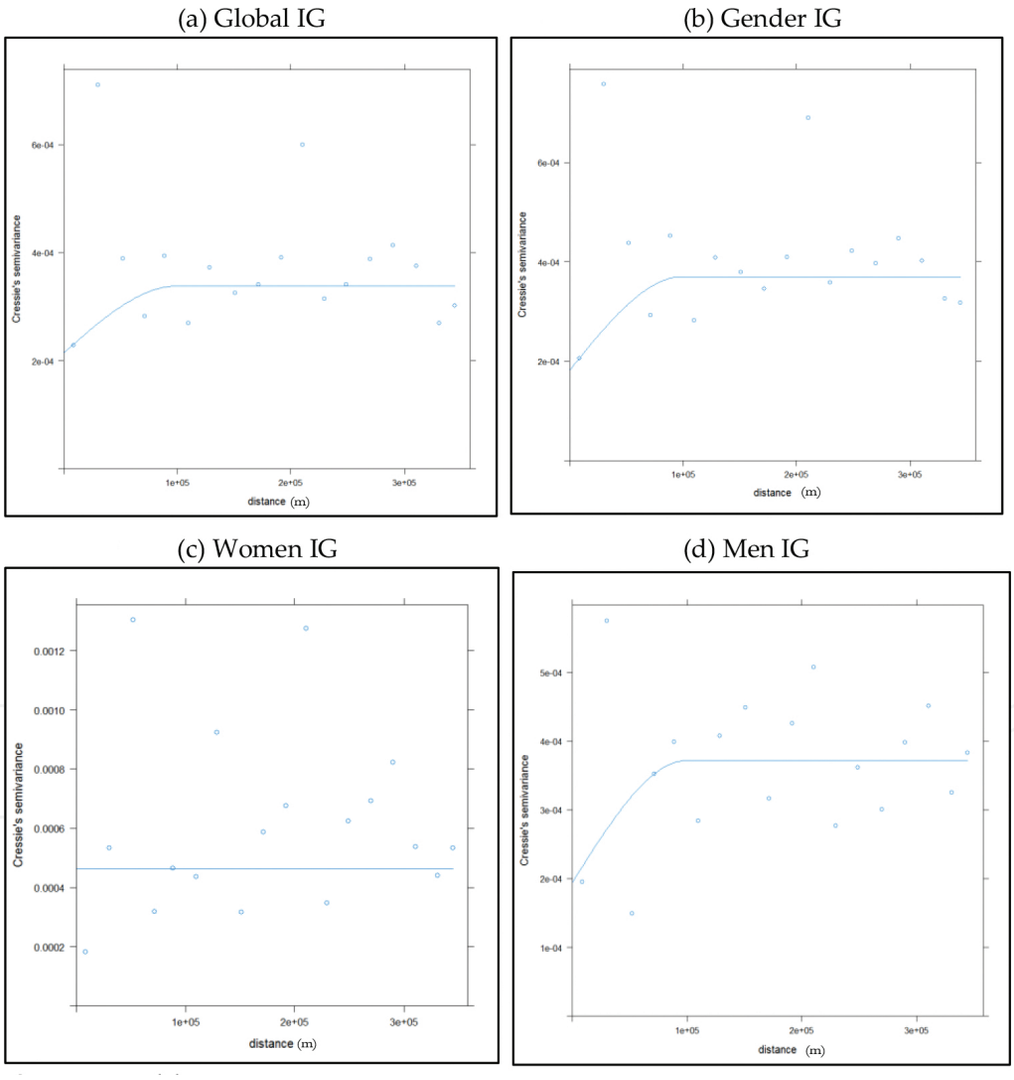

Figure 11. Experimental and theoretical variograms fitted for the concentration index of the entire population (a), gender (b), the group of women (c) and the group of men (d), calculated from hourly wage earned by each worker. Source: own elaboration.

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In the case of the global concentration index, directional variograms have also been calculated, to see which one of the main directions presents the greater correlation (**Table 6**). **Figure 10** shows how the fit of the north–south direction experimental variogram is substantially better than in the other three main directions of space.

If we perform the same variogram analysis of the concentration indices calculated from the variable "earnings per hour", in cases of global, gender and male inequality a lower spatial correlation structure is observed than in the case of annual wage, as the ranges are very small (100 km) and the nugget effects are very large in relation to the total variability of the respective processes (**Table 7** and **Figure 11**). In the case of the concentration index among women, the high variability of the process is reflected in the adjustment through a model of pure nugget effect, indicating the absence of spatial correlation (**Figure 11c**).

Consequently, a clear structure of spatial correlation is observed, following a spherical model, in all inequality indices calculated from "annual gross earnings" but very little in the case of global, male and gender indices based on the "gain per hour" and even non-existent in the case of female concentration.

5. Conclusions

In this chapter, the spatial structure of wage inequality in Spain has been analyzed. The study contributes to the literature on wage concentration and gender equality analysis of the various degrees of concentration of regional and provincial areas in Spain. The research was carried out from the last micro-data of the Structure of Earnings Survey conducted by the Spanish Statistical Institute in 2010, both for the whole population and the group of women together, men together and including both genders. This is intended to give pause for the thought on the importance of the information provided by the spatial coordinates of the data and of the growing wage concentration in the hands of a part of society, from a gender perspective.

From this study we conclude, first, that the rate of wage concentration in the group of women are always higher than in the group of men, implying greater inequality in the distribution of wages among female workers than among the men of each region or Spanish province. In addition, in general, a greater gender wage inequality is observed, than global one, worrying fact, which hinders the equality between women and men.

In addition, as expected, a higher degree of concentration in the study of the annual gross profit is observed, than in gross profit per hour, because part-time jobs result in a lower annual salary, thereby increasing the concentration of wage levels.

From a regional perspective, at the top of the table, one corresponding to higher concentration values are Murcia, Madrid, Andalusia, Castilla Leon, Ceuta and Cataluña, joined by Extremadura and Canary Islands in the case of high levels of female inequality. At the bottom of the table, regions such as Balearic Islands, Navarra, Castilla-La Mancha, Aragón and Galicia are highlighted as regions with the lowest rates of wage concentration.

Moreover, this chapter focuses on the study of the spatial analysis of wage concentration indices. We appreciate the presence of positive spatial autocorrelation in the case of the indices calculated by the variable annual gross earnings and earnings per hour, being unable to reject space randomization in the case of female inequality from the earnings per hour.

Finally, through the analysis of the structure of spatial dependence of the phenomenon, greater spatial correlation structure is concluded in the indices calculated on the annual profits, which have ranges of up to 300 km and small nuggets effects, while those calculated on earnings per hour see its ranges reduced to 100 km and present indicative nugget effect of lower spatial correlation at smaller distances. Even, the female concentration measured in hourly earnings must have been modeled through a pure nugget effect, showing the absence of spatial correlation. Such patterns of spatial autocorrelation present in wage inequality should be considered in future studies.

Annex

	Annual wage				**Per hour wage**			
Province	**IG**	**IG_{Woman}**	**IG_{Man}**	**IG_{Gender}**	**IG**	**IG_{Woman}**	**IG_{Man}**	**IG_{Gender}**
Araba/Álava	0.2977	0.3162	0.2766	0.3074	0.2833	0.2768	0.2846	0.2845
Albacete	0.2881	0.3252	0.2576	0.3005	0.2575	0.2695	0.2478	0.2608
Alicante/Alacant	0.3243	0.3177	0.3194	0.3300	0.2735	0.2647	0.2751	0.2761
Almería	0.3033	0.3145	0.2847	0.3102	0.2457	0.2306	0.2459	0.2516
Ávila	0.3273	0.3637	0.2788	0.3435	0.2752	0.2609	0.2866	0.2752
Badajoz	0.3175	0.3485	0.2860	0.3250	0.2652	0.2686	0.2612	0.2662
Balears (Illes)	0.2979	0.2937	0.2956	0.3010	0.2735	0.2673	0.2769	0.2742
Barcelona	0.3213	0.3213	0.3062	0.3305	0.2874	0.2728	0.2894	0.2922
Burgos	0.3025	0.3141	0.2731	0.3222	0.2480	0.2298	0.2437	0.2572
Cáceres	0.3152	0.3509	0.2857	0.3242	0.2830	0.2874	0.2787	0.2844
Cádiz	0.3400	0.3572	0.3015	0.3602	0.2776	0.2592	0.2800	0.2833
Castellón/Castelló	0.2856	0.2884	0.2618	0.2998	0.2654	0.2514	0.2668	0.2704
Ciudad Real	0.2821	0.3135	0.2501	0.2923	0.2591	0.2710	0.2473	0.2619
Córdoba	0.3293	0.3633	0.2992	0.3387	0.2638	0.2644	0.2619	0.2648
Coruña (A)	0.3007	0.3119	0.2780	0.3087	0.2736	0.2618	0.2791	0.2760
Cuenca	0.3060	0.3183	0.2923	0.3096	0.2616	0.2555	0.2662	0.2616
Girona	0.3176	0.3203	0.3094	0.3219	0.2718	0.2593	0.2770	0.2733
Granada	0.3017	0.3191	0.2786	0.3085	0.2506	0.2397	0.2578	0.2511
Guadalajara	0.3110	0.3524	0.2723	0.3282	0.2803	0.2971	0.2619	0.2886
Gipuzkoa	0.3005	0.3248	0.2634	0.3173	0.2569	0.2610	0.2427	0.2646
Huelva	0.3445	0.3481	0.2962	0.3692	0.2809	0.2541	0.2679	0.3002
Huesca	0.2885	0.3017	0.2707	0.2955	0.2531	0.2582	0.2443	0.2569

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	Annual wage				Per hour wage			
Province	**IG**	**IG_{Woman}**	**IG_{Man}**	**IG_{Gender}**	**IG**	**IG_{Woman}**	**IG_{Man}**	**IG_{Gender}**
Jaén	0.3236	0.3571	0.2857	0.3366	0.2725	0.2847	0.2601	0.2751
León	0.3225	0.3447	0.2881	0.3352	0.3023	0.2773	0.3178	0.3039
Lleida	0.3284	0.3452	0.3004	0.3377	0.2761	0.2724	0.2740	0.2789
Rioja (La)	0.3066	0.3228	0.2792	0.3177	0.2556	0.2527	0.2523	0.2588
Lugo	0.3171	0.3418	0.2636	0.3329	0.3017	0.2729	0.3087	0.3122
Madrid	0.3357	0.3333	0.3270	0.3419	0.3031	0.2888	0.3085	0.3059
Málaga	0.3275	0.3383	0.3078	0.3370	0.2714	0.2549	0.2777	0.2737
Murcia	0.3311	0.3535	0.3000	0.3431	0.2814	0.2825	0.2750	0.2849
Navarra	0.2982	0.2997	0.2785	0.3117	0.2490	0.2346	0.2468	0.2557
Ourense	0.3112	0.3526	0.2737	0.3216	0.2628	0.2757	0.2455	0.2696
Asturias	0.3109	0.3238	0.2823	0.3255	0.2804	0.2766	0.2688	0.2894
Palencia	0.3378	0.3321	0.3177	0.3557	0.2787	0.2576	0.2773	0.2866
Palmas (Las)	0.3173	0.3305	0.3012	0.3209	0.2807	0.2766	0.2832	0.2811
Pontevedra	0.2989	0.3173	0.2716	0.3103	0.2829	0.2615	0.2880	0.2875
Salamanca	0.3031	0.3277	0.2797	0.3101	0.2596	0.2490	0.2663	0.2592
Santa Cruz de Tenerife	0.3278	0.3367	0.3104	0.3329	0.2856	0.2806	0.2847	0.2884
Cantabria	0.3153	0.3306	0.2863	0.3293	0.2708	0.2614	0.2695	0.2754
Segovia	0.3257	0.3561	0.2875	0.3336	0.3037	0.3172	0.2851	0.3074
Sevilla	0.3437	0.3556	0.3218	0.3575	0.2778	0.2642	0.2796	0.2810
Soria	0.2986	0.3033	0.2707	0.3209	0.2314	0.2018	0.2310	0.2408
Tarragona	0.3221	0.3186	0.3053	0.3331	0.2993	0.2912	0.2929	0.3065
Teruel	0.3210	0.3024	0.3177	0.3311	0.3001	0.2981	0.2919	0.3053
Toledo	0.3098	0.3331	0.2772	0.3234	0.2736	0.2810	0.2627	0.2775
Valencia/València	0.3182	0.3350	0.2898	0.3294	0.2725	0.2620	0.2740	0.2760
Valladolid	0.3396	0.3467	0.3165	0.3527	0.3316	0.3746	0.2883	0.3399
Bizkaia	0.3101	0.3264	0.2832	0.3234	0.2736	0.2662	0.2697	0.2790
Zamora	0.3236	0.3868	0.2798	0.3442	0.3012	0.3386	0.2714	0.3117
Zaragoza	0.3113	0.3211	0.2832	0.3274	0.2769	0.2523	0.2769	0.2856
Ceuta	0.3279	0.3377	0.3161	0.3371	0.3069	0.3124	0.3025	0.3094
Melilla	0.3235	0.3446	0.3039	0.3285	0.2970	0.3027	0.2915	0.2982
Spain	**0.3272**	**0.3353**	**0.3091**	**0.3357**	**0.2879**	**0.2779**	**0.2895**	**0.2910**

Source: own elaboration.

Table A1. Provincial concentration indices on the whole population (IG), on the group of women (IG_{Women}), men (IG_{Men}) and gender (IG_{Gender}) concentration index. All have been calculated from the variable annual gross earnings and earnings per hour.

	Annual wage				Per hour wage			
Autonomic community	**IE**	**IE_{Woman}**	**IE_{Man}**	**IE_{Gender}**	**IE**	**IE_{Woman}**	**IE_{Man}**	**IE_{Gender}**
Andalucía	0.3315	0.3483	0.3060	0.3430	0.2708	0.2732	0.2596	0.2735
Aragón	0.3092	0.3160	0.2861	0.3224	0.2762	0.2753	0.2588	0.2834
Asturias	0.3109	0.3238	0.2823	0.3255	0.2804	0.2688	0.2766	0.2894
Baleares	0.2979	0.2937	0.2956	0.3010	0.2735	0.2769	0.2673	0.2742
Canarias	0.3229	0.3348	0.3058	0.3271	0.2839	0.2842	0.2805	0.2853
Cantabria	0.3153	0.3306	0.2863	0.3293	0.2708	0.2695	0.2614	0.2754
Castilla-La Mancha	0.3009	0.3292	0.2708	0.3120	0.2691	0.2599	0.2775	0.2720
Castilla y Leó	0.3246	0.3418	0.2976	0.3375	0.2927	0.2842	0.2969	0.2966
Catalunya	0.3233	0.3236	0.3087	0.3321	0.2883	0.2902	0.2746	0.2928
Comunidad Valenciana	0.3173	0.3244	0.2980	0.3268	0.2739	0.2757	0.2633	0.2771
Extremadura	0.3170	0.3499	0.2863	0.3250	0.2716	0.2678	0.2750	0.2725
Galicia	0.3043	0.3230	0.2757	0.3139	0.2804	0.2834	0.2677	0.2841
La Rioja	0.3066	0.3228	0.2792	0.3177	0.2556	0.2523	0.2527	0.2588
Madrid	0.3357	0.3333	0.3270	0.3419	0.3031	0.3085	0.2888	0.3059
Navarra	0.2982	0.2997	0.2785	0.3117	0.249	0.2468	0.2346	0.2557
Euskadi	0.3053	0.3245	0.2768	0.3187	0.2706	0.2654	0.2669	0.2755
Murcia	0.3311	0.3535	0.3000	0.3431	0.2814	0.275	0.2825	0.2849
Ceuta	0.3279	0.3377	0.3161	0.3371	0.3069	0.3025	0.3124	0.3094
Melilla	0.3235	0.3446	0.3039	0.3285	0.297	0.2915	0.3027	0.2982
Spain	**0.3272**	**0.3353**	**0.3091**	**0.3357**	**0.2879**	**0.2779**	**0.2895**	**0.2910**

Source: own elaboration.

Table A2. Indices of regional concentration on the whole population (IG), on the group of women (IG_{Women}), men (IG_{Men}) and gender (IG_{Gender}) concentration index. All have been calculated from the variable annual gross earnings per hour.

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