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The Role of Neighborhood in the Analysis of Spatial Economic Inequality

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Abstract Spatial inequality measures should take into account the geographical position of the data of reference if the focus is on the spatial aspects of territorial inequality. However, these traditional spatial inequality measures like the Theil index do not distinguish among different locational situations. On the other hand, when analyzing the spatial decomposition of inequality, it is usual to express global inequality as a weighted sum of inequality values calculated for population subgroups (within component) plus the contribution arising out of differences among subgroup means (between component). Nevertheless, it is unclear whether the reported within and between contributions have been driven primarily by specific factors related to the spatial level of research or by neighborhood factors. The present paper has two main objectives. The first consists into propose a simple way to measure the role of the geographical position in economic inequality. The second aim is to provide an approach to decompose global inequality into its within-country and between-country components assessing which part of these components could be related to neighborhood factors. The proposals are illustrated for the case of European countries. Inequality within each of the countries and inequality between countries can be filtered of neighborhood components, showing inequality components related to specific (local) factors. For a considered spatial level, this exploratory approach can highlight the relevance of future place-based policies versus policies able to support and promote regional neighborhoods.

Keywords Inequality decomposition · Between–within decomposition · Interregional inequality

JEL Classification C43 · C10 · R1 · R12

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1 Introduction

For a long time, income inequality has been a core issue in Economics (see, among others, Kuznets 1955; Bourguignon 1979). In recent years, the study of income inequality has received increasing interest (Mussini 2015), both theoretically and empirically (Chakravarty 2001; Shorrocks and Wan 2005; Aguiar and Bils 2015). Measuring economic inequality is important (See, for example, World Bank 2016) and the patterns of regional inequalities should draw the attention of both researchers and policy-makers (Di Berardino et al. 2016). However, any causal analysis to explain economic inequality would require the usage of adequate measures of inequality.

Regional inequality refers to inequality among territories. A limitation of the conventional set of inequality indices is related to their effectiveness in reflecting the locational scope of regional inequality. When measuring global inequality for a regional system (or a group of countries), the conventional spatial inequality measures work under the hypotheses that all areas within a region have the same income and/or that the geographical positions of the areas do not affect these spatial inequality measures. In other words, traditional spatial inequality measures like the Theil index do not distinguish among different locational situations within countries. Under these conditions, the estimation of the relation between inequality and its explaining factors may be biased if part of the dependent variable is generated by neighborhood factors (Moser and Schnetzer 2017). This paper is an attempt to estimate the part of economic inequality that is generated by the spatial pattern of the data within a regional system (or a group of countries) through a simple measure of inequality. For any location in which regions are distributed within a country, the Theil index remains constant (it does not change). That is, neighborhoods were clearly not explicitly considered in the standard formulations of inequality measures. The Theil index is completely insensitive to where regions are located within a country, and it does not measure how geographical or spatial contexts affect regional inequality. The study of spatial variation in regional inequalities outcomes has a long tradition; some examples about this are provided by Novotný (2007), who analyzes 46 countries using a decomposition of inequality by spatially defined subgroups. This author provides a comparison of the relative importance of the spatial dimension of inequality with respect to the national level. The classification of the 46 countries according to the relative importance of the spatial dimension of inequality has shown that the spatial dimension of inequality in countries should be clearly included in the multi-facet aspects of inequality. A defining characteristic of many of these studies is that the concept of space takes a center place in the notion of neighborhood. The underlying idea is that regional neighborhoods should provide a critical level of general support services. Examples include (see Modrego and Berdegué 2015) improved physical and technological infrastructures, public health and education, social organizations, etc.…

On the other hand, while Chongvilaivan and Kim (2016) highlight the existence of a strand of literature using group mean incomes (within country information) to study regional inequality, between-groups comparisons have centered the focus of other studies (Seshanna and Decornez 2003). Although these existing studies produce relatively consistent findings, the empirical literature as focused on how economic inequality is decomposed by subgroups, providing the contributions arising from changes within subgroups and from changes between subgroups. Thus, in quantifying inequality across countries, most measures follow an approach where absolute income inequality is decomposed into its within-country and between-country components (Goda and Torres García 2017). Even though the influence of neighboring regions on inequality is recognized and empirically considered,[1] it is not possible to find contributions that estimate the proportion of between or within inequality that is due to neighboring factors. Economic processes do not stop in international borders or regional borders, and the between–within decomposition should reflect the existence of income inequalities explained by the spatial spillovers from neighboring areas. This paper attempts to add a new dimension to the empirical literature, moving from the usual decomposition of inequality in between and within components to a new one where it is measured the amount of between inequality and within inequality that could be explained by factors related to neighboring areas.

Our work is also motivated by the seeming conflict between the place-based approach to policy making and the absence of inequality measures that isolate the contributions to inequality derived from the existence of neighborhood factors. As stated by Quadrado et al. (2001), regions are composed by a number of subsystems (economic, social, political and infrastructural subsystems). Since the allocation of regional inequality is based on these region's subsystems, the regional allocation of economic inequality is likely to change along with the spatial location of regional characteristics. This connects with the idea of place-based policies (geographically targeted policies).[2] Effectively, place-based policies (Barca 2009) require the detection of contiguous regions within whose boundaries a set of factors are operating and generating local conditions conducive to similar inequalities contributions.[3] It is necessary to inform about the influence of neighborhood on regional inequality to harness the potential of place-based policies to combat regional inequality. The neighborhood can shape regional economic performances and limit or enhance their economic inequality. This means understanding how neighborhood is participating on regional inequality measures. The appraisal of whether policies for economic inequality should focus on site-specific (local) or neighborhood levels is complicated by the fact that existing measures of economic inequality are designed to evaluate inequality but they fail to address the influence of geographical location on inequality. Focusing on the neighborhood dimension, this paper develops a measure of economic inequality which, as it is argued, can be described as a measure that could draw a profile of economic inequality which would inform of the extent of inequality among the neighborhood of the areas of reference.

This article contributes to the existing literature in at least three aspects. First, to the best of our knowledge, this is the first attempt in proposing a simple way to capture the part of the conventional Theil index that it is generated by the geographical location of the data. Second, this article provides a way to decompose global inequality into its within-country and between-country components assessing which part of these components could be related to neighborhood factors. Last, but not least important, this article examines the relevance of the aforementioned neighborhood components in the European context, presenting results that shed light on policy options related to place-based policies that help

[1] For example, for countries with no survey information, Bourguignon and Morrison (2002) use the concept of "regional proximity" to forecast the within country distributions of income, assigning the within country distributions of neighboring countries.

[2] Neighborhood policies are proposed from the European Union to help poor regions.

[3] Following Partridge et al. (2015), place-based policies have two basic characteristics: local policies are always "place-based" and place-based policies result in mobile local investment such that the local population will benefit from the policy only while in the region.

mitigate income inequality. The empirical analysis is based on data on European NUTS3 regions[4] for 28 European countries in the period 2007–2014.

Determining the correct policy toward economic inequality requires not only identifying the between–within components, but also knowing where improvements would require neighborhood initiatives that spillover the borders of the areas of reference. Our empirical illustration indicates that neighborhood factors contribute the most extensively to income inequality in Europe (on average, for the period 2007–2014, 80.16%), while specific factors account, on average, 19.83%. The conventional decomposition yields the result that the between-group component constitutes the greatest part of income inequality (from 2007 to 2014, on average, 57.87%), while the within component contributes with 42.15%. From our proposal, it is possible to capture the amount of the reported within and between contributions that have been driven by specific factors related to the spatial level of research or by neighborhood factors. Our estimates are the first which show the importance of both neighborhood and specific factors on income inequality when dealing with between and within decomposition of inequality. Thus, on average for the period 2007–2014, the inequality due to the variability of income across different countries that have been driven by neighborhood factors is 55.17%, while the variability of income across different countries that have been driven by specific factors is 2.68%. On the other hand, income inequality due to the variability of income within each country was driven by neighborhood factors in 24.99%, being the relevance of specific factors operating within each country of 17.17%. Inequality as a pure location effect (a-spatial effect) represents 17.17% of the total regional European inequalities.

The main novelty of our contribution consists in assuming that regional location is used in part in the generation of its within-country and between-country components of global inequality. Through this starting strategy, we are able to take into account the existence of different inequality results depending on the regional location. The results of our proposal provide new insights on the role of location in global inequality. Regional European inequalities associated with neighborhood effects at NUTS3 level are very important. Rather than relying solely on place-based policies focused at the NUTS3 level, neighborhood policies should be an important tool for helping to tackle inequality.

The rest of the paper is organized as follows. Section 2 introduces the necessity of measuring inequality taking into account the spatial location of the regions under analysis. Besides, it is presented a new measure of regional inequality that tries to analyze which part of the conventional between–within components of total inequality could be due to neighborhood features. In Sect. 3, the proposal is illustrated for the case of 1298 European regions. Finally, some concluding remarks are given in Sect. 4.

2 An Approach to Assess the Influence of the Neighborhood Into the Economic Inequality

Regional economic inequalities in Gross Domestic Product (GDP) per capita could be explained as the result of different factors like differences in infrastructures, industry specialization, skills, social capital, ageing, innovation and geographic location (Camagni

[4] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the European Union; in the case of the NUTS3, the purpose is the socio-economic analyses of small regions for specific diagnoses.

2002; OECD 2003). Geographical location can explain income inequality; for example, an area could obtain benefit from the spillover effect generated by a neighboring growing area while peripheral areas could have an important competitive disadvantage. Different authors emphasize that spatial inequality measures should take into account the geographical position of the areas of reference (Guimarães et al. 2011; Milanovic 2015). From another perspective, other authors implicitly consider the connection between income distribution and neighborhood. For example, Sala-i-Martin (2006) estimates the quintile income shares for countries with no survey information by assigning the average quintile income shares of the neighboring region. According to Arbia (2001), spatial income inequality consists in two features that are related to both an a-spatial concept and a concept related to agglomeration. The a-spatial part is invariant to spatial permutations; that is, it is invariant to changes in the geographical location of the considered data. So, conventional measures of income inequality are constant under different locational situations (space does not matter when measuring this a-spatial part). The spatial part makes reference to the geographical pattern of data. The measure of this spatial part is neglected by conventional measures of income inequality. As noted by De Dominicis (2014), the influence of the spatial location on income inequality as a consequence of spatial spillovers is not contemplated in the literature (An exception is Márquez et al. 2016). However, conventional spatial inequality measures like the Theil index do not distinguish among different locational situations, and these conventional measures are not adequate tools for measuring the spatial part of income inequality. As a result, economic analyses at both the national and the sub-national levels may result in misleading policy recommendations to national and sub-national policy makers if measurements of income inequalities provide biased interpretations. In order to have meaningful results, policy makers should be clear about the relevance of geographical pattern of data on income inequality, and this would require the usage of adequate tools.

(a)

10	10	1	1
10	10	1	1
1	1	1	1
1	1	1	1

(b)

10	1	1	1
10	1	1	1
10	1	1	1
10	1	1	1

(c)

1	1	1	1
1	10	1	10
1	1	1	1
1	10	1	10

(d)

10	1	1	10
1	1	1	1
1	1	1	1
10	1	1	10

(e)

1	1	1	1
1	10	10	1
1	10	10	1
1	1	1	1

Fig. 1 Hypothetical study areas partitioned into 4 macro-regions (every macro-region is composed of 4 regions). A total GVA of 52€ is located in every hypothetical study area, but its distribution is very different in the five cases

2.1 The Problem

To illustrate the aforementioned idea, Fig. 1 shows five hypothetical study areas (Fig. 1a–e). Every study area is partitioned into 4 macro-regions (for example, countries) and every macro-region is itself composed by 4 regions. A total Gross Value Added (GVA) ascending to 52 euros (€) is located in each hypothetical study area, also it is assumed that 1 person is living in each region. In the example, the distribution of the total GVA is very different in the five cases but the distribution of total population is the same. It is expected that the influences on income inequality from the regions with 10€ is much higher in terms of spatial spillover in case 1(a) than in case 1(e). In other words, the spatial configuration in case 1(a) is encouraging income inequality more than in the rest of cases; the reason is that the spatial location of the data in the regions for Fig. 1a does not favor the generation of influences in the rest of regions. Therefore, from an intuitive perspective, these five situations could be ordered in descending order (from the highest to the lowest) in terms of the expected influence from case 1(a) to 1(e). The level of geographical influence is much higher in case 1(a) than in case 1(e).

Nevertheless, although these figures report very different situations, the Theil (1967) index is the same for the five cases.[5] Assuming a system composing by "*r*" macro-regions (for example, countries) and by "*p*" disjoints subnational geographical units (for example, NUTS3 regions) nested into countries, the Theil index can be expressed as[6]:

$$T_t = \sum_r \sum_p \left\{ \left(\frac{Y_{trp}}{Y_t} \right) ln \left[\frac{(Y_{trp}/Y_t)}{(N_{trp}/N_t)} \right] \right\} \tag{1}$$

where Y_{trp} denotes the Gross Value Added in year "*t*" in country "*r*" in NUTS "*p*", and N_{trp} is total population in year "*t*" in country "*r*" in NUTS "*p*".

[5] Although there have been a number of studies that measure regional income inequalities using the coefficient of variation (as the weighted coefficient of variation, Williamson 1965), the Gini index and the generalized entropy inequality measures, the Theil index is most often undertaken to decompose economic inequality according to a partition of the aggregate population into a set of geographical regions (Shorrocks and Wan 2005). The Theil index belongs to the family of generalized entropy inequality measures. The generalized entropy inequality measures satisfy the criteria that should be required to a good measure of economic inequality (see, for example, Haughton and Khandker 2009): mean independence, population size independence, symmetry, Pigou–Dalton transfer sensitivity, statistical testability and decomposability. The coefficient of variation does not satisfy the property of mean independence, since this inequality index changes if all regional values vary in the same proportion. In the context of additive decomposability, the generalized entropy class of inequality indexes is a good alternative since total inequality can be written as the sum of between-group and within-group inequalities and their economic interpretation is therefore straightforward. In this sense, it is well known that in general the Gini index for a regional economic system is not equal to the sum of the Gini coefficients of its regional subgroups (Deutsch and Silber 1999). On the other hand, among the generalized entropy inequality measures, some of them are more sensitive to changes in the lower tail of the distribution, while others are more sensitive to changes that affect the upper tail (Cowell 2011). When analyzing the differences in GVA per capita among regions, the units of observations are regions; i.e., each region is considered an individual. This would imply to give the same weight to all the regions, being the Theil index the special case of the generalized entropy inequality measures that assigns a same weight to all the regions. In summary, the Theil index was chosen by the aforementioned advantages (decomposability by regional subgroups and assignation of the same weight to all the regions).

[6] Equation (1) follows the Akita's first stage formulation (Akita 2003) that it is also similar to the Theil equation proposed by Anand (1983, p. 328). In our case the subscripts "r" (countries) is equivalent to Akita's "i" (regions), and our subscript "p" (NUTS3) is similar to Akita's "j" (provinces).

Table 1 Conventional Theil, Neighborhood Theil and Specific Theil. Results derived from Fig. 1a–e

	Fig. 1(a)	Fig. 1(b)	Fig. 1(c)	Fig. 1(d)	Fig. 1(e)
Theil	0.5926	0.5926	0.5926	0.5926	0.5926
Neigborhood Theil	0.2934	0.215	0.1198	0.0645	0.0016
Specific Theil	0.2992	0.3776	0.4728	0.528	0.591
% Neighborhood	49.51%	36.28%	20.22%	10.88%	0.27%
% Specific	50.49%	63.72%	79.78%	89.10%	99.73%

% represents the share of every component on the Theil

The Theil index[7] is calculated in Table 1 for the five cases in Fig. 1. The values of the five indices remain unchanged (taking the value of 0.592 in all the cases). This is explained by the fact that the standard Theil index measures the concentration, but it does not take into account the spatial location of the sub-regions. Accordingly, it is necessary an adequate approach to measure concentration by distinguishing different spatial regional patterns.

Starting from this problem, to investigate the spatial effects in the conventional inequality index literature, this paper extends and generalizes the authors' previous work (Márquez et al. 2016). These authors modify a Specific Theil index and the factor decomposition of the Theil inequality index presented by Goerlich-Gisbert (2001), allowing to assess which part of regional income inequalities could be due to neighborhood features.[8] Their proposal is based on the concept of pure neighboring count. This approach implies that the results calculated by inequality indexes only consider information in the neighboring units (without considering information from the regional reference unit).

Inspired by these authors, we develop a simple approach to deal with the regional inequalities generated by the spatial location of the regions. The measurement of spatial inequality should be sensitive to the relative position of the regions in Fig. 1. This paper differs from the contributions of Márquez et al. (2016) in several aspects. First, while they proposed a decomposition of a Specific Theil index, our paper is focused on the conventional Theil index. In this sense, the present paper is focused on the conventional Theil index providing an easy and useful tool. After to calculate the Neighborhood Theil based on the concept of pure neighboring count, the spatial pattern of the regional inequality is reflected (the Neighborhood Theil is sensitive to the spatial position of the regions). Besides, the conventional Theil index can be compared to the Neighborhood Theil showing the a-neighborhood component of the Theil index. This correction can be applied to evaluate the contextual processes (neighborhood effects) that account for how neighborhoods bring about changes in regional inequality. This approach has the advantage of being simple and very intuitive. Moreover, this has unrivalled advantages in case one is interested on what are the challenges for developing place-based policies. Further, this approach can

[7] We used the Theil index to measure regional inequality. The Theil index has been applied in the analysis of regional economic inequality (e.g. Chen and Wang 2015; Paredes et al. 2016). Higher values reflect greater regional inequality (Shorrocks and Wan 2005).

[8] The Goerlich-Gisbert index decomposes inequality into the unweighted sum of the inequality indices due to four factors; specifically, productivity per employed worker, employment rate, active population over working-age population rate, and working-age population over total population rate.

be used when a Theil index is estimated for the case of countries data (using the underlying average incomes), and this is the case for the majority of studies analyzing inequalities among countries. Second, the decomposition of the Theil index proposed in Márquez et al. (2016) is based on the contribution to total inequality of variation in mean incomes, while the present paper takes as a point of departure the decomposition of the Theil index incomes into between and within components (see Fishlow 1972).

2.2 A Proposal to Assess the Role of the Geographical Position in Economic Inequality

The proposal provides a simple approach that addresses the absence of contributions that present an inequality index to inform about differences among Fig. 1a–e, making explicit the spatial regional patterns (the location of the referenced macro-regions and regions).

Using a raw standardized spatial weight matrix W, a Neighborhood Theil index can be defined as:

$$Neighborhood\ Theil_t = NT_t = \sum_r \sum_p \left\{ \left(\frac{wY_{trp}}{\sum_r \sum_p wY_{trp}} \right) ln \left[\frac{\left(wY_{trp} / \sum_r \sum_p wY_{trp} \right)}{\left(wN_{trp} / \sum_r \sum_p wN_{trp} \right)} \right] \right\} \quad (2)$$

where wY_{trp} represents the spatial lag of Y_{trp} and wN_{trp} represents the spatial lag of N_{trp}.

This formula is based upon the concept of pure neighboring count (Márquez et al. 2016), where the socio-economic information from its neighboring regions is assigned to the region of reference (but ignoring the socio-economic information from the region of reference). The Neighborhood Theil index is defined over all the regions although considering in the calculus the contributions of both the GVA and the population of the neighboring regions. Hence, although the regions have the same weight calculating the index, their specific contribution is determined by the spatially smoothing from their corresponding neighboring regions. This measure would be a "region-specific" type of measure of spatial inequality (Bickenbach and Bode 2008) that only considers information from the neighboring regions when computing regional inequality, providing a measure of inequality among what we can define as "pure neighboring regions". Under these assumptions, the concept of neighborhood and its quantification is fundamental since it determines the spatial contexts (neighborhoods) that affect the inequality of the regions. Summarizing, the neighborhood decomposition proposed in Eq. (2) is a type of spatially smoothing version of the Akita's one-stage decomposition and in that manner it holds its regular properties as an inequality index. Additionally, Eq. (2) rests in the idea that measures of inequality and spatial auto-correlation are complementary. Following Arbia and Piras (2009) and Rey and Smith (2013), a system of regions with different levels of inequality can be associated to the same level of spatial autocorrelation. As other spatial measures, our proposed Neighborhood Theil is assuming that the underlying spatial process is isotropic and significant, in the sense that it is different to one derived by a completely random spatial process. Both conditions make possible that replacing the current GVA in NUTS "p" by its spatial average is adequate, because that number is a good proxy of the original variable, maintaining its standard properties as an inequality index.

Table 1 provides the results of the application of the proposed Neighborhood Theil to the hypothetical study areas presented in Fig. 1a–e by using as W a binary first-order geographical contiguity. All five measures agree that inequality is highest in Fig. 1a (0.293), followed by 1b (0.215), 1c (0.119), 1d (0.006) and the lowest in 1e (0.001). These results indicate that inequalities among neighborhoods are not the same for the five figures. What these indices are measuring is inequality among pure neighboring regions, because each region is providing information from its neighboring regions (but ignoring its own information). Thus, the inequality measure captures inequality among pure neighboring regions, and a meaningful measure of the locational component of inequality is proposed. The degree of inequality among pure neighboring regions captures the relevance of spatial placement. These results make our measure a more intuitive (and useful) measure of inequality for regional policymakers than the Theil index if a significant measure of territorial inequality is desired.

Additionally, the quantification of the Neighborhood Theil let us to separate a-spatial components and spatial components by subtracting the neighborhood Theil from the conventional Theil. Thus, the part of the Theil index linked to specific factors emerges and the territorial scope can be identified with the spatial extent of the neighboring regions. The difference between the standard Theil and the Neighborhood Theil is the idiosyncratic term or Specific Theil. The Specific Theil represents the value of inequality that cannot be associated with neighborhood effects; it is a pure (specific) location effect occurring in the system.[9]

$$\textit{Specific Theil} = \textit{Theil} - \textit{Neighborhood Theil} \tag{3}$$

From Table 1, it is possible to say that location is an important factor when explaining inequality in Fig. 1a and b (49.51 and 36.28% of total income inequality, respectively, is related to neighborhood factors). On the other hand, Fig. 1c, d and e show 20.22, 10.88 and 0.27% of total income inequality that could be explained by neighborhood factors.

In Fig. 1a and b, the objective is to improve the neighborhoods, since the relevance of the neighborhood Theil indices are the symptoms of wider circumstances; the regional neighborhood is shaping regional behaviors. In contrast, the location of the regions in Fig. 1c, d and e are not generating important influences on the economic inequality; then, specific factors are operating. Regions in Fig. 1a and b should consider policies focused on macro-regions (neighborhoods at regional level). It is necessary to improve their neighborhoods through a neighborhood policy. The suggestion for regions in Fig. 1c, d and e would be to offer place-based policies to specific regions by emphasizing what some regions may lack in terms of, for example, investment in education or the provision of infrastructures.

2.3 A Proposal to Capture the Influence of the Neighborhood Into the Between–Within Components

The traditional Between (B)–Within (W) decomposition of the Theil index can be expressed as[10]:

[9] As indicated by a referee, the specific Theil is conditioned by the conceptualization and quantification of neighborhood that is used in Eq. (2). So, if the neighborhood Theil is defined in other way, a new specific Theil will be derived. This would require defining the appropriate concept of regional neighborhood (identifying the right neighborhood of analysis) by theorizing about the configuration of neighborhood that realistically shapes regional economic inequality.

[10] Following the equivalences shown in footnote 6, Eqs. (4) and (5) are similar to Akita's Eqs. (2) and (3) (Akita 2003, p. 58).

$$T_t = \mathrm{TW}_t + \mathrm{TB}_t = \sum_r \left(\frac{Y_{tr}}{Y_t}\right) T_{tr} + \sum_r \left(\frac{Y_{tr}}{Y_t}\right) ln \left[\frac{\left(Y_{tr}/Y_t\right)}{\left(N_{tr}/N_t\right)}\right] \tag{4}$$

where

$$T_{tr} = \sum_{p \in r} \left\{ \left(\frac{Y_{trp}}{Y_{tr}}\right) ln \left[\frac{\left(Y_{trp}/Y_{tr}\right)}{\left(N_{trp}/N_{tr}\right)}\right] \right\} \tag{5}$$

From the traditional decomposition, the between–within components are shown in Table 2 for every case from Fig. 1a–e. For Fig. 1a, total inequality is due to the variability of income between groups (macro-regions). For Fig. 1b, 55.47% of total inequality is explained by how income varies within each macro-region, while the remaining part (44.52%) is due to how incomes vary between macro-regions. For the cases of Fig. 1c, d and e, 100% of total inequality is explained by how incomes vary within groups.

Although the influence of neighboring regions on inequality is recognized and empirically considered, it is not possible to find contributions that estimate the proportion of between or within inequality that is due to neighboring factors. Authors like Milanovic (2013) use the term "locational" to call the between country inequality, since it depends on the differences of mean incomes between different countries (places). Nonetheless, it is clear that the conventional between country inequality is measuring spatial pattern of variables without consider the geographical location of the countries. So, it is unclear whether the reported within and between contributions have been driven primarily by specific factors related to the spatial level of research or by neighborhood factors. The present paper provides an approach to decompose global inequality into its within-country and between-country components assessing which part of these components could be related to neighborhood factors.

The inequality measured by the Neighborhood Theil index can be decomposed into "between" and "within" components. As this index is calculated considering information in the neighboring regions(without considering information from the region of reference), the decomposition can be used to assess if most inequality is due to disparities across macro-regions in terms of neighborhoods, or if inequality occurs because there is inequality within each macro-region (inequality varies because neighborhoods vary inside each macro-region). This way, starting from the Neighborhood Theil shown in Eq. (2), a neighborhood between–within decomposition at time "t" can be expressed as:

$$\begin{aligned} \mathrm{NT_t} = \mathrm{NTW_t} + \mathrm{NTB_t} &= \sum_{\mathrm{r}} \left(\frac{\sum_{\mathrm{p}\in\mathrm{r}} \mathrm{wY_{trp}}}{\sum_{\mathrm{r}} \sum_{\mathrm{p}} \mathrm{wY_{trp}}}\right) \mathrm{NT_{tr}} \\ &+ \sum_{\mathrm{r}} \left(\frac{\sum_{\mathrm{p}\in\mathrm{r}} \mathrm{wY_{trp}}}{\sum_{\mathrm{r}} \sum_{\mathrm{p}} \mathrm{wY_{trp}}}\right) \mathrm{ln} \left[\frac{\left(\sum_{\mathrm{p}\in\mathrm{r}} \mathrm{wY_{trp}} / \sum_{\mathrm{r}} \sum_{\mathrm{p}} \mathrm{wY_{trp}}\right)}{\left(\sum_{\mathrm{p}\in\mathrm{r}} \mathrm{wN_{trp}} / \sum_{r} \sum_{p} wN_{trp}\right)}\right] \end{aligned} \tag{6}$$

$$\mathrm{NT_{tr}} = \sum_{\mathrm{p}\in\mathrm{r}} \left(\frac{\mathrm{wY_{trp}}}{\sum_{\mathrm{p}\in\mathrm{r}} \mathrm{wY_{trp}}}\right) \mathrm{ln} \left[\frac{\left(\mathrm{wY_{trp}} / \sum_{\mathrm{p}\in\mathrm{r}} \mathrm{wY_{trp}}\right)}{\left(\mathrm{wN_{trp}} / \sum_{\mathrm{p}\in\mathrm{r}} \mathrm{wN_{trp}}\right)}\right] \tag{7}$$

Table 2 Traditional between–within decomposition. Results derived from Fig. 1a–e

	Fig. 1(a)	Fig. 1(b)	Fig. 1(c)	Fig. 1(d)	Fig. 1(e)
Theil	0.5926	0.5926	0.5926	0.5926	0.5926
Between	0.5926	0.2638	0	0	0
Within	0	0.3287	0.5926	0.5926	0.5926
% Between	100.00%	44.52%	0.00%	0.00%	0.00%
% Within	0.00%	55.47%	100.00%	100.00%	100.00%

% represents the share of every component of the Theil

where wY_{trp} represents the spatial lag of Y_{trp} and wN_{trp} represents the spatial lag of N_{trp}.

Table 3 Between–within decomposition of the Neighborhood Theil. Results derived from Fig. 1a–e

	Fig. 1(a)	Fig. 1(b)	Fig. 1(c)	Fig. 1(d)	Fig. 1(e)
Neighborhood Theil	0.2934	0.215	0.1198	0.0645	0.0016
Neighborhood Between	0.1885	0.2137	0.0096	0	0
Neighborhood Within	0.1049	0.0013	0.1101	0.0645	0.0016
% Neighborhood Between	64.25%	99.40%	8.01%	0.00%	0.00%
% Neighborhood Within	35.75%	0.60%	91.90%	100.00%	100.00%

% represents the share of every component on the Neighborhood Theil

Therefore, the spatial decomposition proposed in Eqs. (6) and (7) is a type of spatially smoothing version of the Akita's one-stage decomposition, and in that manner it holds its regular properties as an inequality index.

Thus, following the previous arguments, the neighborhood Theil inequality index is decomposed into between and within-neighborhoods inequality components for Fig. 1a–e (see Table 3).

Using expressions (1), (2), (4) and (6), the Specific Theil can be expressed as:

$$\begin{aligned} \mathit{Specific\ Theil} &= \mathit{Theil} - \mathit{Neighborhood\ Theil} \\ &= (\mathit{Within\ Theil} + \mathit{Between\ Theil}) - (\mathit{Neighborhood\ Within\ Theil} \\ &\quad + \mathit{Neighborhood\ Between\ Theil}) \\ &= (\mathit{Within\ Theil} - \mathit{Neighborhood\ Within\ Theil}) \\ &\quad + (\mathit{Between\ Theil} - \mathit{Neighborhood\ Between\ Theil}) \\ &= \mathit{Specific\ Within\ Theil} + \mathit{Specific\ Between\ Theil} \end{aligned} \tag{8}$$

Table 4 Between–within decomposition of the Specific Theil. Results derived from Figs. 1a–e

	Fig. 1(a)	Fig. 1(b)	Fig. 1(c)	Fig. 1(d)	Fig. 1(e)
Specific Theil	0.2992	0.3776	0.4728	0.528	0.591
Specific-Between	0.4041	0.0502	− 0.0096	0	0
Specific-Within	− 0.1049	0.3275	0.4824	0.528	0.591
% Specific-Between	135.06%	13.29%	− 2.03%	0.00%	0.00%
% Specific-Within	− 35.06%	86.73%	102.03%	100.00%	100.00%

% represents the share of every component on the Specific Theil

Table 5 Decomposition of the conventional Theil in Neighborhood-Between, Specific-Between, Neighborhood-Within and Specific-Within. Results derived from Figs. 1a–e

	Fig. 1(a)	Fig. 1(b)	Fig. 1(c)	Fig. 1(d)	Fig. 1(e)
Theil	0.592 (100%)	0.592 (100%)	0.592 (100%)	0.592 (100%)	0.592 (100%)
Neigh-Between	0.188 (31.81%)	0.213 (36.06%)	0.009 (1.62%)	0	0
Spec-Between	0.404 (68.19%)	0.050 (8.47%)	– 0.009 (– 1.62%)	0	0
%Neigh-Within	0.104 (17.70%)	0.001 (0.22%)	0.110 (18.58%)	0.064 (10.88%)	0.001 (0.27%)
%Spec-Within	– 0.104 (– 17.70%)	0.327 (55.26%)	0.482 (81.40%)	0.528 (89.10%)	0.591 (99.73%)

% represents the share of every component on the total inequality

Equation (8) means that Specific Theil is itself composed by an Idiosyncratic or Specific-Within Theil and also by an Idiosyncratic or Specific-Between term. Table 4 illustrates this decomposition for the five cases from Fig. 1.

Finally, the total inequality in the system can be expressed as:

$$\begin{aligned} Theil &= Neighborhood\,Theil + Specific\ Theil \\ &= Neighborhood\,Between\,Theil + Specific\,Between\,Theil \\ &\quad + Neighborhood\,Within\,Theil + Specific\,Within\,Theil \end{aligned} \tag{9}$$

Table 5 shows the decomposition of the conventional Theil index for the five cases in Fig. 1; the share that each component represents on the conventional Theil index is shown.

The traditional between–within decomposition shown in Table 2 is enriched using the framework exposed in expression (8). The results for Fig. 1 are shown in Table 5. The new approach provides a way to decompose global inequality into its within-country and between-country components assessing which part of these components could be related to specific regional factors or to neighborhood regional factors. This way, for Fig. 1a, all members of the same group (macro-region) have the same income, while income differs between groups (the between component accounts for 100% or total inequality). This implies that the variability of income within group is now zero. Nevertheless, the greatest part of this between inequality is explained by Specific-Between inequality (68.19%), while the remaining part is due to factors related to the neighborhood between component (31.81%). Conversely, in the cases of Fig. 1c, d and e, total inequality is due to the variability of income within groups (the traditional within components represents 100% of total inequality); but our new findings highlight Specific-Within inequality as the main inequality component (with respective percentages of 81.40, 89.10 and 99.73%). As a conclusion, the relevance of factors operating and generating regional conditions within regional boundaries would be the key elements conducive to reduce regional inequalities.

In Fig. 1b, income inequality across neighborhood levels constitutes about 44.52% of total income inequality; the traditional within dimension explains 55.47%. The findings highlight within inequality as the main inequality factor. However, it is unclear whether this reported decomposition has been driven primarily by neighborhood inequalities within or between countries. From Table 4, the contribution of income inequality by the neighborhood within Theil appears to be negligible (0.22%): neighborhood is not participating on the within regional inequality as a relevant element. The Specific-Within inequality element captures explains the variability of income within each group (55.26% of total inequality). On the other hand, the Neighborhood-Between inequality is capturing 36.06% of total inequality, while the variability of income across different groups attributable to specific factors represents 8.47% of the total inequality.

3 The Role of the Geographical Position in Economic Inequality and the Influence of the Neighborhood Into the Between–Within Components: Illustration for European Regions

In this section, the approach proposed in Sect. 2 is illustrated. The main purpose is the analysis of regional economic inequality in the European Union.[11] In investigating the inequality in these countries it is tried to understand how regional inequalities evolve and to what extent the observed patterns are conditioned by specific (local) or neighborhood factors. In spite of the relevance of the topic, the literature that exists on EU regional inequality is scarce (Fredriksen 2012), and little attention has been paid to income inequality within Europe.

3.1 Data and Results

The Cambridge Econometrics' European Regional Database (ERD) is used to analyze the regional economic inequality of 28 European countries across the period from 2007 to 2014. The choice of both the country sample and the time period is dictated by the period over which most of the 28 European countries are member states of the EU.[12] Gross Value Added (GVA) and population were taken from the ERD, which in turn takes as primary source of data the Eurostat's REGIO database supplemented with data obtained from AMECO (a dataset provided by the European Commission's Directorate General Economic and Financial Affairs -DG EcFin-). The data set used in the analysis is a balanced annual panel with 1298 NUTS3 regions in 27 EU member states (and Noruega) for the period 2007–2014 (see Fig. 2) As stated by a referee, the results and the policy implications are conditioned by the choice of the NUTS3 level as unit of reference. In effect, the modifiable areal unit problem (MAUP) is a classic problem in statistical analysis of geographical data (Openshaw 1984). In our case, the MAUP problem could occur if the data at NUTS3 level were aggregated to a different level (for example, at NUTS2 level). Indeed, regional aggregation would imply a smoothing effect because regional inequalities would tend to be averaged out (inequality among units would be reduced through aggregation) and,

[11] Following the arguments provided by Blank (2011), and adapting these arguments to the regional field, there are different effects that should stimulate the analysis of regional economic inequality. First, increases in regional economic inequality may indicate declines in regional economic income, and so, decreasing regional well-being in lagged regions. Second, regional economic inequality may intensify socio-economic regional differences, reducing regional economic mobility. Third, regional economic inequality could have negative effects on aggregate economic growth over time. Finally, regional economic inequality may have adverse consequences on non-economic outcomes, like political processes, social welfare or public policy concerns.

[12] As the European Union reached its current size of 28 member countries with the accession of Croatia on 1 July 2013, our analysis does not consider Croatia. Thus, the country sample is composed of 27 countries that are members of the EU from 2007. Additionally, Noruega was considered in the analysis because this country is member of the Schengen border-free area.

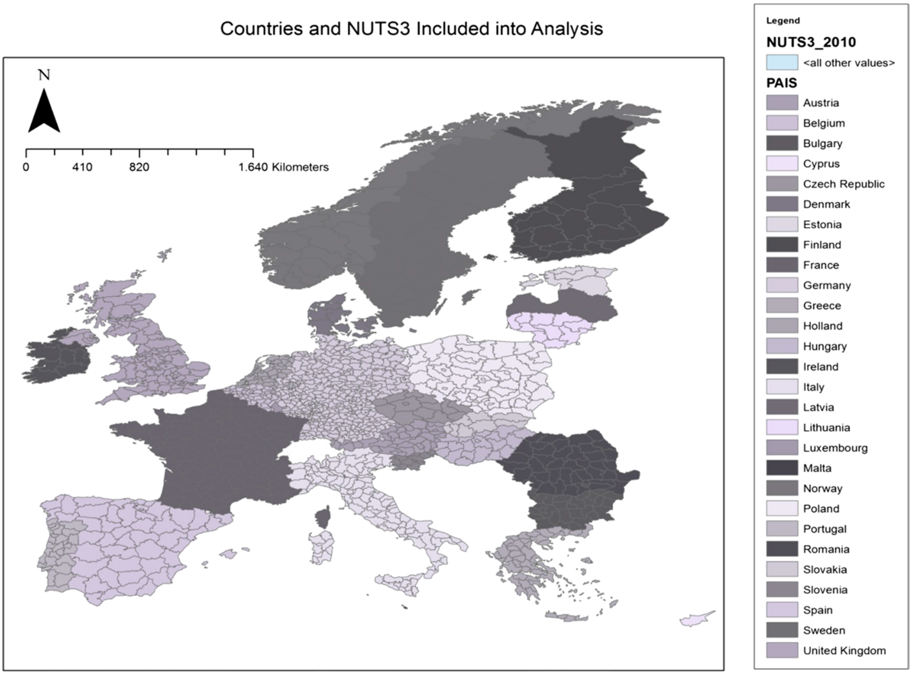


Fig. 2 Countries and European NUTS3 regions under analysis. *Source*: Own elaboration with ARGIS 10.1

consequently, the regional inequality index would decrease (Spiezia 2003). Additionally, the regional inequality index could be affected because, due to the way of construction of the indices of inequality, they tend to underestimate regional inequalities when the sizes of the regions increase (Deltas 2003). From another perspective, the measure of regional inequality could be affected by the grouping effect; that is, how the formation of larger areal units can change the result of the measure of inequality through the choice of the regions that integrate the aggregated area. Hence, as regional inequality measures are sensitive to the number of regions, to their relative size and to the internal formation of the aggregated area, the right areal unit of analysis should be determined by theoretical reasons. I our case, to minimize the MAUP problem derived from the usage of grouped data, data at the lowest level of aggregation were used, i.e. NUTS3 regions. However, the analysis is focused on NUTS3 regions as reference regions because, in order to measure regional inequalities, the NUTS3 aggregation is a grouping system more homogenous that the NUTS2 and this desaggregation can operate as a mitigation factor for the MAUP problem. Besides, the NUTS3 neighborhood may be a more relevant socioeconomic environment than the NUTS2 neighborhood, where the impact of the socioeconomic NUTS2 neighborhood could be wider.

The advantage of using 28 EU data for this period is that considerable care has been taken to ensure that all the countries are integrated within a border-free area during the period of analysis and that the data are consistent both across space and over time. Furthermore, the effect of the global economic crisis of 2008 can be studied since the sample period let us analyze the post-crisis period.

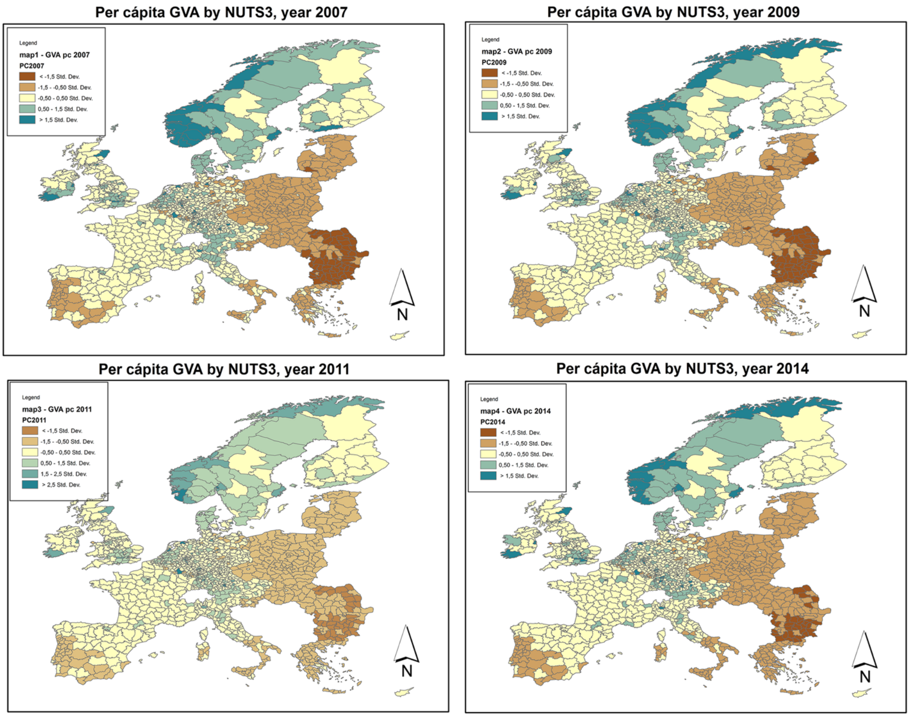


Fig. 3 Spatial distribution of European regional GVA per capita: standard deviation maps. *Source*: Own elaboration with ARGIS 10.1

Figure 3 presents the standard deviation maps of per capita GVA (GVA) from the ERD in different years (2007, 2009, 2012 and 2014). These maps show a strong geographic pattern in the European regional data about output per worker, being this general pattern constant along the time. As overview, the maps suggest the general presence of spatial heterogeneity in the form of two spatial groups of regions with high and low income: the high-income group situated in Europe's economic core area, and the low-income cluster including some of the least developed regions of Europe (located in Europe's periphery).

Let W $GVApc_i$ be the spatial lag for variable GVApc in region *i,* where W represents the first-order spatial lag operator. For each European region, the spatial lags of the GVApc variable are built as $\sum_{j=1}^{N} w_{ij}\, GVApc_i$ with elements w_{ij} reflecting the neighborhood structure between regions and the strength of the relationships across them. The restrictions $w_{ij} \geq 0$, $w_{ij} = 0$ and $\sum_{j=1}^{N} w_{ij} = 1$ are satisfied. Although for expositional reasons we will continue being referring only to W, two different spatial matrices are considered; one is based on first-order geographical contiguity and the other on nearest neighbors of European NUTS3 regions.

Thus, a spatial contiguity matrix W^q with dimensions *n x n* is defined, where n is the number of Europeans regions. From this matrix, its typical entry in row i and colum j (w_{ij}^{q}) is defined as:

$$w_{ij}^{q} = \begin{cases} 1 & \text{if } i \text{ and } j \text{ share a common border} \\ 0 & \text{if } i \text{ and } j \text{ do not share a common border or } i = j \end{cases}$$

Table 6 Global spatial autocorrelation for the European regional GVA per capita income: Moran's I

Year	W matrices			
	W^{qs} (Queen order 1)		W(5 nearest neighbors)	
	I's Moran	*p* value	I's Moran	*p* value
2007	0.5146	0.0001***	0.5415	0.0001***
2008	0.5134	0.0001***	0.5398	0.0001***
2009	0.5101	0.0001***	0.5350	0.0001***
2010	0.4928	0.0001***	0.5191	0.0001***
2011	0.4939	0.0001***	0.5130	0.0001***
2012	0.4842	0.0001***	0.5147	0.0001***
2013	0.4832	0.0001***	0.5143	0.0001***
2014	0.4810	0.0001***	0.5122	0.0001***

***Denotes *p* value < 0.001

Dividing each row of W^q by the respective row sum, a row-standardized contiguity matrix is obtained (W^{qs}).

In the same way, a second measure of neighborhood is defined by using a k-nearest neighbors matrix. Specifically, for region i, all distances of i to all other regions are ranked, and declare the k nearest regions to be a neighbor of i. Let us denote the distance of the k-nearest neighbor to region i as $d_i^{(k)}$. Repeating this for all regions, this information can be collected in a matrix W^k with dimensions $n \times n$, where n is the number of regions. From this matrix, its typical entry in row i and colum j (w_{ij}) is defined as:

$$w_{ij}^{k} = \begin{cases} 1 & \text{if the distance between } i \text{ and } j \text{ is } \leq \mathrm{MAX}\,(d_i^{5 closest\ neighbors}) \\ 0 & \text{otherwise} \end{cases}$$

Again, dividing each row of W^k by the respective row sum yields to W which is a row-standardized matrix.

Table 6 shows the values of the Moran's I statistics for the two row standardized weights matrices (W^{qs} and W, where k = 5). For all the cases along the period it is rejected the null hypothesis revealing the existence of a strong positive and statistically significant degree of spatial dependence in the distribution of European regional GVA per capita for all the years. At the same time, it is interesting to highlight that the positive spatial dependence is time changing. The results indicate the necessity to explore the contribution of this positive spatial dependence on the measurement of regional inequality. Following Arbia (2001), the Moran's I is a measure of the level of polarization, but it does not provide information about which part of the economic inequality could be associated with this significant geographical pattern in the economic inequality in the European regions.

To provide a better picture of the distribution of European regional economic inequality and its development during the period 2007–2014, the Theil index is reported in Table 7 (and also in Fig. 4). The Theil index shows that European regional economic inequality decreased from 2007 to 2009; on the contrary, it increased between 2010 and 2012, downing from 0.173 in year 2012 to 0.169 in 2014. Figure 4 shows that with the onset of the global economic crisis of 2008, the downward trend in income inequality continued until 2009. However, the trend was reversed during the period 2010–2012, when inequality was on the highest level. Finally, since 2013, inequality is decreasing again in the EU. The Theil index indicates the amount of dispersion of income distribution across European regions

Table 7 Conventional Theil, Neighborhood Theil and Specific Theil for European regions at NUTS3 level

Years	2007	2008	2009	2010	2011	2012	2013	2014
Theil	0.1736	0.1714	0.1689	0.1724	0.172	0.1732	0.1721	0.1696
Neighborhood Theil	0.1409	0.139	0.1359	0.1383	0.1374	0.1382	0.1371	0.134
Specific Theil	0.0327	0.0324	0.0329	0.0341	0.0347	0.035	0.035	0.0356
% Neighborhood	81.16%	81.10%	80.46%	80.22%	79.88%	79.79%	79.66%	79.01%
% Specific	18.84%	18.90%	19.48%	19.78%	20.17%	20.21%	20.34%	20.99%

% represents the share of every component on the total inequality

without taking into account the spatial location of the regions. To measure the role of the geographical position in regional economic inequality, the Neighborhood Theil was calculated by using the 5-nearest neighbors matrix previously defined[13] (see Table 7 and Fig. 4).

Finally, the Specific Theil is shown in Table 7 and Fig. 4.

The breakdown of the Theil index into neighborhood and specific components helps to highlight that neighborhood factors contribute the most extensively to regional income inequality in Europe (on average, for the period 2007–2014, 80.16%), while specific factors account, on average, 19.83%. Figure 4 provides a representation of the relative contributions of the neighborhood inequalities and the specific inequalities to the total European regional income inequality. During the period, although neighborhood inequality contributes four times more to the total inequality than specific inequality, it is important to emphasize the decrease (increase) of the relative importance of the neighborhood (specific) component. Thus, the European regional inequalities at NUTS 3 level have been mainly driven by neighborhood regional factors; though specific regional factors at this level would provide a base for addressing inequality.

With regard to the traditional between–within decomposition of the European regional income inequality (see Table 8 and Fig. 5), our results show that European regional inequality was mainly driven by between-country inequality (from 2007 to 2014, on average, 57.87%), while the within component contributes with 42.15%. Nevertheless, the importance of these two components for explaining European regional income inequality was not constant over the time period. The dominance of the between-country component is decreasing, while within-country inequality is increasing its relevance.

Considering the global trends in between income inequality, our results show that the trend in between country inequality is declining over time, while the trend in within inequality is increasing.[14] This finding is consistent with Doran and Jordan (2013) for the case of 14 members of the European Union (prior the enlargement of the EU in 2004 excluding Luxemburg). Nevertheless, these authors attribute the majority of total inequality to

[13] With respect to the spatial weights matrix, in our application, we experiment with a binary first-order geographical contiguity matrix, being the results similar to the results obtained with the 5-nearest neighbors matrix. Nevertheless, due to the presence of some regions that do not present geographical connection with other regions, the 5-nearest neighbors matrix was used in order to capture the contextual process that could account for how regional neighborhoods affect regional inequality.

[14] Similar results were presented by Doran and Jordan (2016) for the case of the composition of income inequality among United States counties from 1969 to 2009; these authors find that income inequality has increased, with Between-State inequality decreasing and within-State inequality increasing.

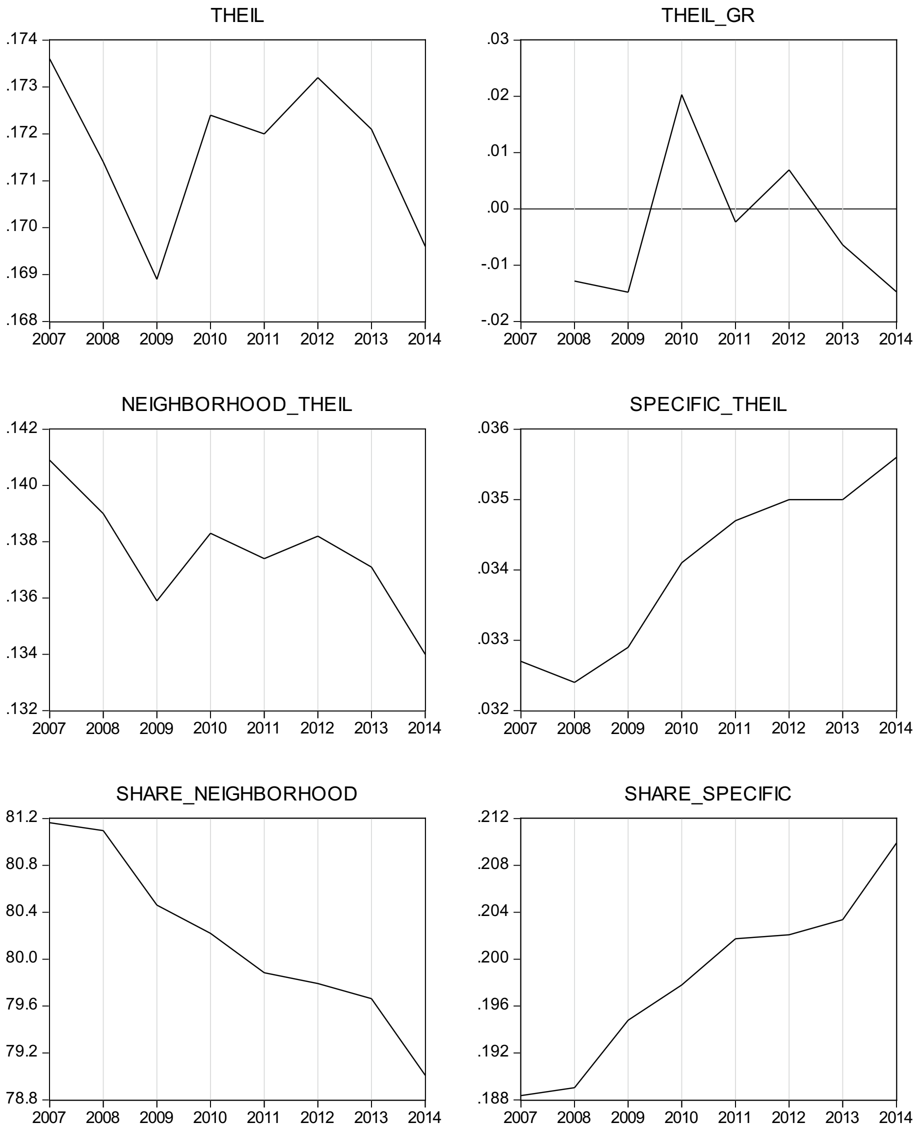


Fig. 4 Conventional Theil, Neighborhood Theil and Specific Theil for European regions at NUTS3 level. Shares of Neighborhood Theil and Specific Theil over the Theil. *Note* THEIL_GR denotes percentage change in the Theil over time. *Source*: Own elaboration

within-country inequality, while in the case of the EU27, the majority of total inequality is attributable to between-country inequality.

European regional inequality has declined but at the cost of an increase in within-country inequality. Total inequality is driving by a decrease in inequality between countries affecting the evolution of European regional income inequality.

Table 8 Traditional between–within decomposition of the Theil for European regions at NUTS3 level

Years	2007	2008	2009	2010	2011	2012	2013	2014
Theil	0.1736	0.1714	0.1689	0.1724	0.172	0.1732	0.1721	0.1696
Between Theil	0.1051	0.1009	0.0988	0.0992	0.0985	0.0985	0.0973	0.0958
Within Theil	0.0685	0.0704	0.07	0.0732	0.0735	0.0747	0.0748	0.0737
% Between Theil	60.54%	58.87%	58.50%	57.54%	57.27%	56.87%	56.54%	56.49%
% Specific Theil	39.46%	41.07%	41.44%	42.46%	42.73%	43.13%	43.46%	43.46%

% represents the share of every component on the total inequality

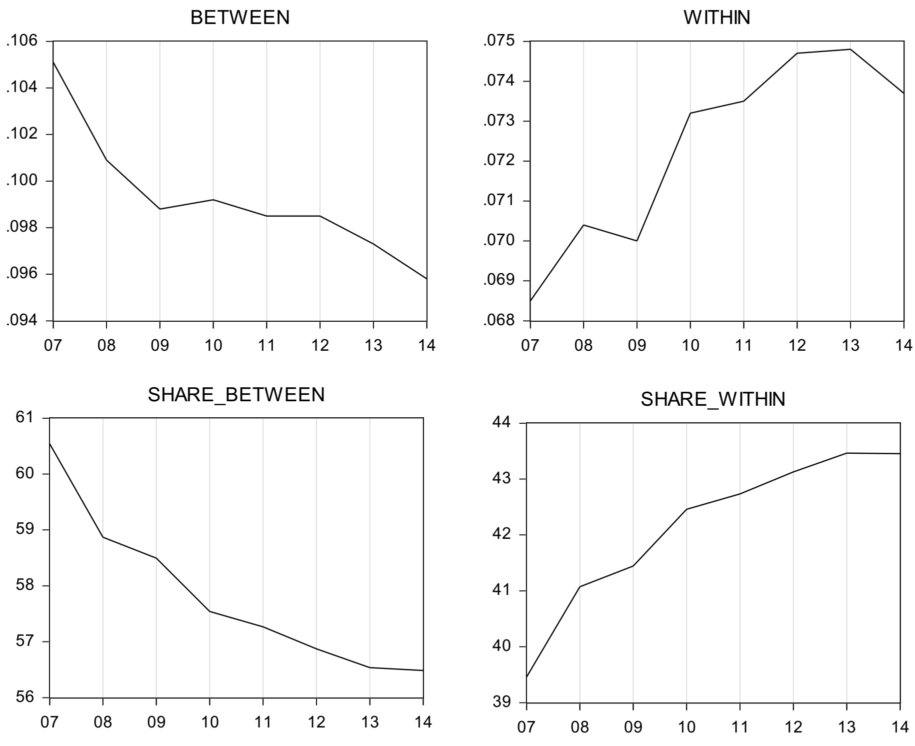


Fig. 5 Between and within components of the Theil index. Shares for both components on total Theil. *Source*: Own elaboration

The traditional between–within decomposition neglects which part of these components could be related to specific regional factors or to neighborhood regional factors. The approach exposed in expression (8) is used to decompose global inequality into its within-country and between-country components assessing which part of these components is explained by specific or neighborhood regional factors. The results of this decomposition of the Theil index for the European regional data are shown in Table 9. The corresponding shares are presented in Table 10.

Table 9 Decomposition of the Theil index capturing the influence of both neighborhood and specific factors into the between–within components for European regions at NUTS3 level

Years	2007	2008	2009	2010	2011	2012	2013	2014
Theil	0.1736	0.1714	0.1689	0.1724	0.172	0.1732	0.1721	0.1696
Neighborhood Between Theil	0.1002	0.0962	0.0941	0.0946	0.0938	0.0942	0.0931	0.0914
Specific-Between Theil	0.0049	0.0047	0.0048	0.0046	0.0047	0.0044	0.0043	0.0044
Neighborhood-Within Theil	0.0407	0.0427	0.0419	0.0437	0.0435	0.044	0.044	0.0426
Specific-Within Theil	0.0278	0.0277	0.0282	0.0295	0.03	0.0307	0.0307	0.0312

Table 10 Shares of Neighborhood-Between, Specific-Between, Neighborhood-Within and Specific-Within over global income inequality for European regions at NUTS3 level

Years	2007	2008	2009	2010	2011	2012	2013	2014
Theil	100	100	100	100	100	100	100	100
% Neighborhood-Between Theil	57.72	56.13	55.71	54.87	54.53	54.39	54.10	53.89
% Specific-Between Theil	2.82	2.74	2.84	2.67	2.73	2.54	2.50	2.59
% Neighborhood-Within Theil	23.44	24.91	24.81	25.35	25.29	25.40	25.57	25.12
% Specific-Within Theil	16.01	16.16	16.70	17.11	17.44	17.73	17.84	18.40

% represents the share of every component on the total inequality

Our new findings highlight neighborhood-between inequality as the main inequality component. On average for the period 2007–2014, the inequality due to the variability of income across different countries that have been driven by neighborhood factors is 55.17%, while the contribution of income inequality by the Specific-Between Theil appears to be negligible (2.68%). Specific factors are not participating in the between-countries European regional inequality as relevant elements, being the neighborhood-between inequality the element that captures the variability of income between countries.

On the other hand, on average for the period 2007–2014, neighborhood within inequality is capturing 24.99% of total income inequality, while the relevance of specific factors operating within each country represents 17.17% (Specific-Within component). As a conclusion, the European regional income inequality that could be assigned as a pure location effect (that is, as a a-spatial effect) represents 17.17% of the total regional European inequalities.

To avoid distortions for graphing the trend in every component of European regional economic inequality over time, two perspectives are provided. So, Figs. 6 and 7 display the evolution of the four components obtained as percentages over the total European regional income inequality. While both the neighborhood-between and the Specific-Between components tends to decrease importance, the neighborhood-within and the Specific-Within components are gaining relevance.

From another perspective, Figs. 8, 9, 10 and 11 show the contribution to every component by country and year.

The highest mean inequality values among the contributions to the Neighborhood-Between component are found for the case of United Kingdom, Germany and France (see Fig. 8). This is the most important component, where Poland, Spain and Romania have got the lowest (and negative) contributions.

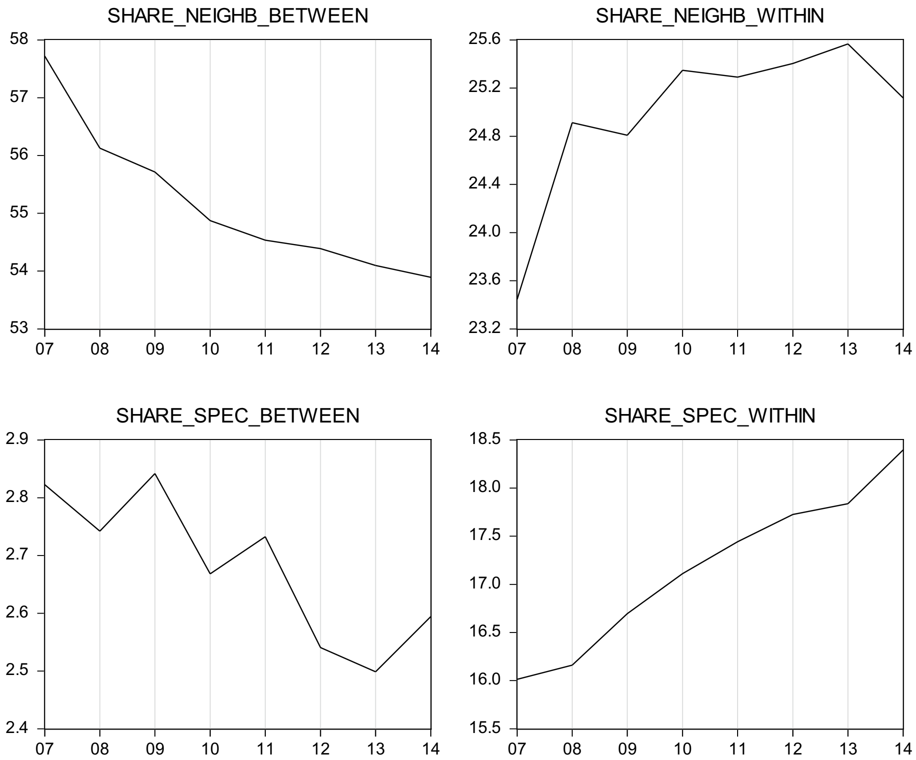
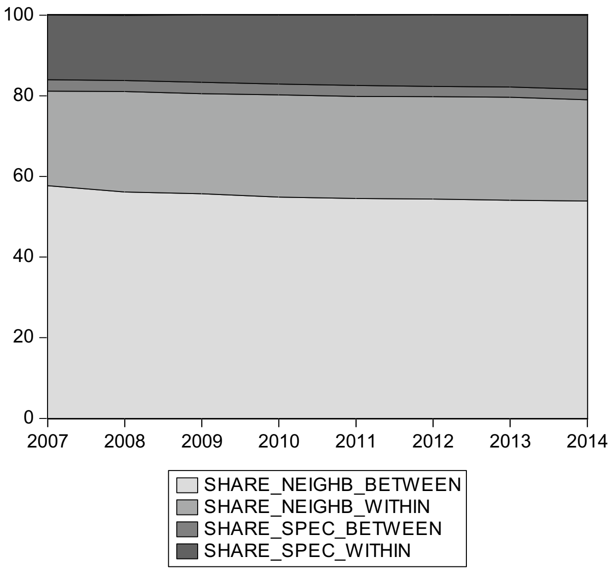


Fig. 6 Evolution of the shares of Neighborhood-Between, Specific-Between, Neighborhood-Within and Specific-Within components over global income inequality for European regions at NUTS3 level. *Source*: Own elaboration

Fig. 7 Decomposition of global income inequality for European regions at NUTS3 level: Shares of Neighborhood-Between, Specific-Between, Neighborhood-Within and Specific-Within components. *Source*: Own elaboration



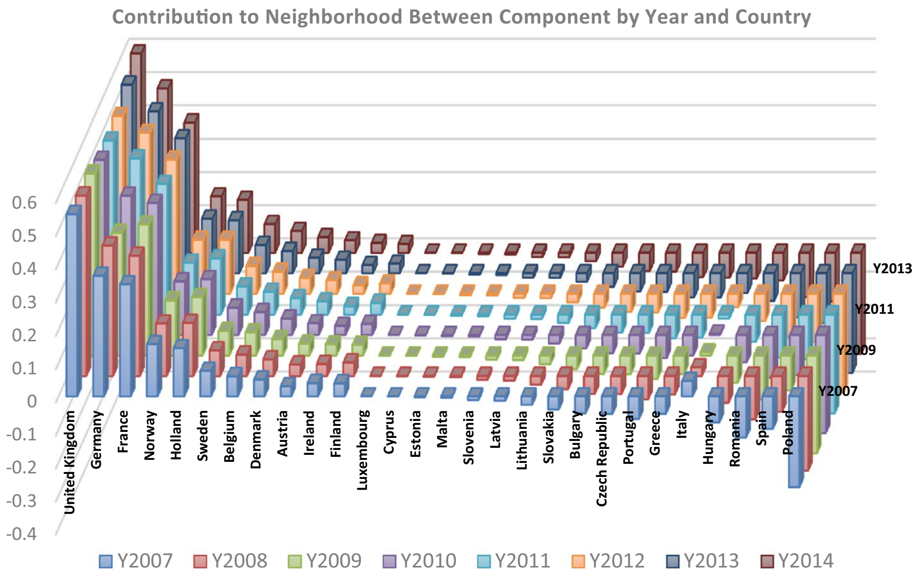


Fig. 8 Contribution to Neighborhood-Between component by years and countries. *Source*: Own elaboration

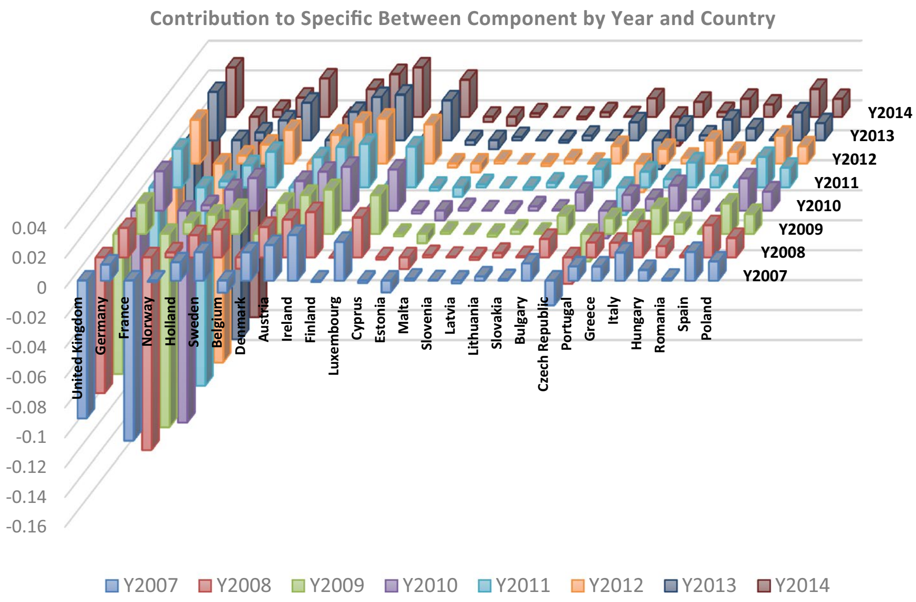


Fig. 9 Contribution to Specific-Between component by years and countries. *Source*: Own elaboration

The second component in importance is the Neighborhood-Within component (see Fig. 10), there all the contributions are positive, and some countries show quite large values of contributions; among others: Slovakia, Bulgary and Czech Republic, signaling a higher

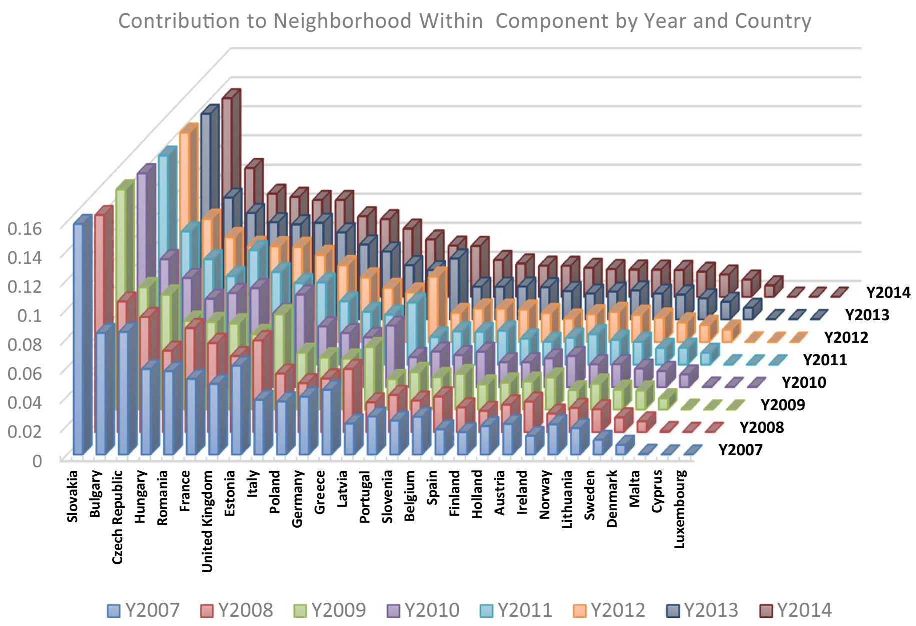


Fig. 10 Contribution to Neighborhood-Within component by years and countries. *Source*: Own elaboration

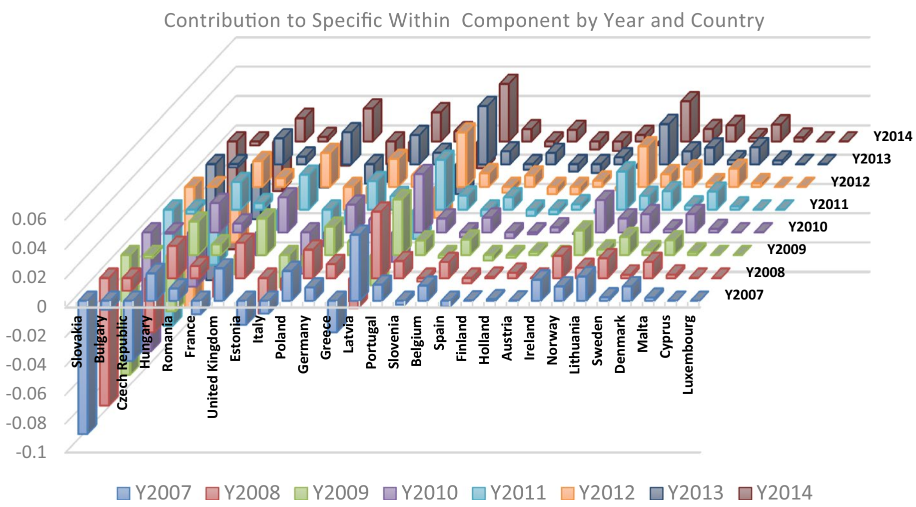


Fig. 11 Contribution to Specific-Within component by years and countries. *Source*: Own elaboration

level of internal inequality between its NUTS3 units. On the contrary, countries without internal NUTS3 units, as Luxembourg or Cyprus, contribute with zero to this within measure. In the case of Denmark, Sweden, Lithuania and Norway, they contribute with the lowest values among those countries with several internal NUTS3 units.

In the case of Specific-Within component (see Fig. 11), it shows a large variation across countries, but the countries that lead the highest values are: Latvia, United Kingdom and Ireland. In contrast, the lowest contributions are: Slovakia, Czech Republic and Greece.

Finally, although the level of the contributions is low, the temporal patterns of the Specific-Between component (see Fig. 9) show that the countries with highest contributions are: Ireland, Austria and Luxembourg. On the other hand, the lowest contributions in this component are: Czech Republic, United Kingdom and France.

3.2 Policy Implications

Different authors have emphasized the challenge for investigation into the patterns of economic inequality, demanding a systematic empirical evidence to provide responses about trends in spatial inequality (Pike et al. 2017). Our proposed framework seeks to present a means of analyzing regional economic inequality, especially from the perspective of economic inequality policy and the spatial level at which such policy should be administered. This is important, since our approach indicates the spatial level by which different types of regional economic policies can achieve improvements in the regional economic inequality.

From the exploratory analysis provided in Sect. 3.1, a reflection on a proper design of inequality policies could be done. In particular, the message that our results convey makes reference to the most appropriate design that inequality policies should follow. As neighborhood inequality dominates the European regional economic inequality, a focus only on each regions' specificities could be ignoring other important neighborhood factors. On the other hand, policies designed on each regions' specificities, building NUTS3-based initiatives without coordination at the NUTS3 level, could induce percentage changes in the European regional income inequality of about 17% (since our results have shown that the relevance of specific factors operating within each country represents, on average, 17.17%; Specific-Within component). If neighborhood planning policies are considered, our results reflect the importance of neighborhood since, on average for the period 2007–2014, neighborhood within inequality is capturing 24.99% of total income inequality. This could be informing about the needs of minimum regional requirements at neighborhood level (requirements relatives to factors as accessibility, access to services and facilities, etc.).

In Fig. 12 a conditional plot is offered to illustrate the novelty of the proposed framework, there countries are ordered in a tridimensional space; in an imaginary X axes (horizontal plane) the Average Country Contribution to the Within Theil measure during 2007–2014 period is displayed. In an Y imaginary axes (vertical plane) the Average Country Contribution to the Between Theil measure during 2007–2014 period is also displayed. A third imaginary Z axes is displayed by colors, representing quantiles group distribution for that period of the Average Specific-Within Component by country. Combining those variables, nine maps are generated and displayed in an array by 3×3 rows and columns. The bottom-left position (cell 3,1) represents countries (Spain) with low contributions both in terms of Within and Between inequalities. On the other hand, the top-right position (cell 1,3) represents countries (UK, France and Germany) with high contributions both in terms of Within and Between inequalities.

At least two additional cases are worth mentioning. Top-left map (cell 1,1) represents countries (Sweden and Denmark) highly contributing to Between Inequality with low contributions to Within Inequality. Also the bottom-right map (cell 3,3) represents countries in oppose roles, highly contributing to Within Inequality with low contributions to Between Inequality (Poland, Slovakia, Hungary, Romania and Bulgary).

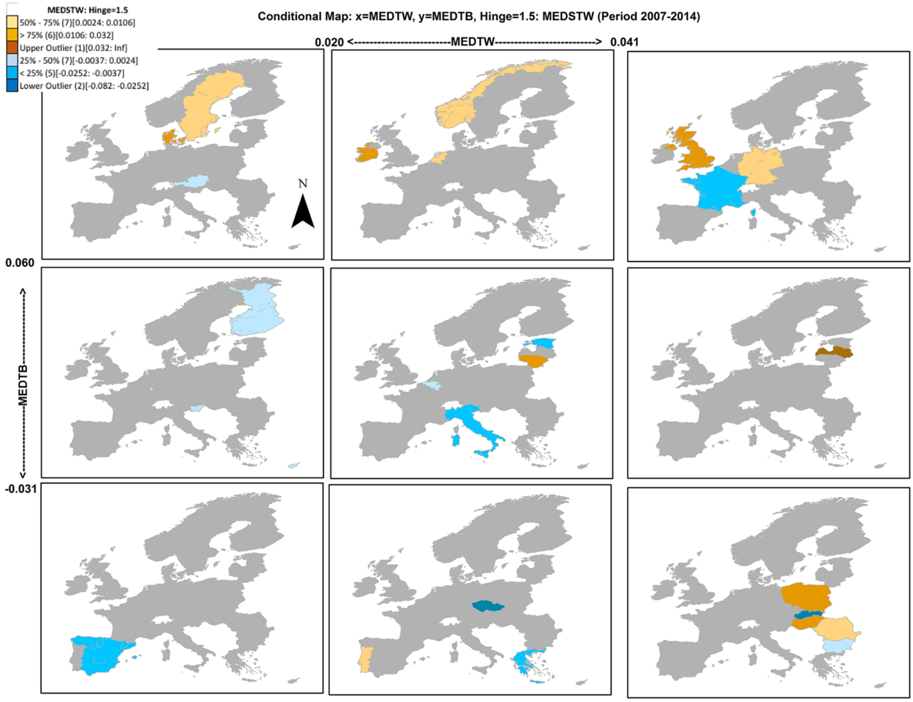


Fig. 12 Conditional Plot Within/Between Theil and Specific-Within Theil Component, Average for the period 2007–2014. *Source*: Own elaboration with GeoDa

When the Specific-Within component is taking into account a completely new picture emerges. There countries located in cell (1,3) are not behaving in a unique manner, there UK has a high degree of specific component, while France has the lowest degree of the specific component. It means that UK shows more suitable conditions to be object of place-based, while France not; Germany is similar to UK but with relative low intensity. Similarly cell (3,3) shows that Poland and Hungary have a high level in the specific component, but Slovakia and Bulgary not; meaning that for Poland and Hungary placed base policies could be more suitable compared with Slovakia and Bulgary, even when they apparently behave in the same fashion in terms of the traditional Within/Between decomposition.

What our results point out is that the winning strategy is neither to focus on place-based policies at NUTS3 level nor on regional neighborhood; policies designed on each regions' specificities complemented with policies able to support and promote regional neighborhoods would be the right policies. Therefore, although it is usual to consider that bottom-up activity focused on the enhancement of local systems can induce regional improvements (Huggins and Clifton 2011), this perspective should be complemented with coordinated policies, wherein regional neighborhoods act as the reference area to facilitate progresses in regional economic inequality. Our results highlight that policies that support neighborhood locations could be a useful policy tool to reduce inequality. This means understanding how better built initiatives could help to mitigate income inequality at both neighborhood and regional level. To exploit underutilized regional economic potential, it is necessary to detect where this underutilized potential is located (McCann and Ortega-Argilés 2016).

Further studies are needed to investigate the channels through which neighborhood affects European regional economic inequality. Following Glaeser and Gottlieb (2008), three major types of policies could be used: transportation policy, large-scale interventions for strengthening particular places (like urban renewal) and the provision of much greater resources to much smaller areas. In this context, our measurements of European regional income inequalities provide a new tool[15] for the analysis of the determinants of inequality.

4 Conclusions and Final Remarks

This paper proposes an approach to measure the role of the geographical position in regional economic inequality. The starting strategy consists in assuming that regional location is used in part in the generation of regional economic inequality. The approach can discern the existence of different regional inequality results depending on the regional location. Our decomposition tool shows the importance of both neighborhood and specific factors on income inequality. Besides, it is possible to capture the amount of the reported within and between contributions that have been driven by specific factors related to the spatial level of research or by neighborhood factors.

The above described approach is applied to analyze the regional economic inequality of a balanced annual panel with 1298 NUTS3 regions in 28 EU states for the period 2007–2014. The Theil Index shows that European regional economic inequality decreased from 2007 to 2009, increased between 2010 and 2012 and decreased from year 2012 to year 2014. As a meaningful contribution, our exploratory approach reflects the importance of regions and their neighborhoods in European regional inequality: the European regional neighborhoods are shaping regional behaviors. On average for the period 2007–2014, our results show that neighborhood factors account 80.16%, while specific factors represent, on average, 19.83%. Although neighborhood inequality contributes four times more to the total inequality than specific inequality, it is important to highlight that the neighborhood component is losing relative importance over the recent 8 years, while the relative importance of the specific component is increasing.

From another perspective, European regional inequality has declined but at the cost of an increased within-country inequality: total inequality is driving by a decrease in inequality between countries affecting the evolution of European regional income inequality. The between-country component constitutes the greatest part of European regional income inequality (on average for 2007–2014 period, 57.87%), while the within country component contributes on average with 42.15%. From our proposal, and as an important novelty, it is possible to capture the amount of the reported within and between contributions that have been driven by specific factors related to the spatial level of research or by neighborhood factors. Our estimates show that, on average, the European between country income inequality that have been driven by neighborhood factors is 55.17%, while Specific-Between country factors is 2.68%. In respect of European within country income inequality, neighborhood factors were driving about 24.99% of total European regional income inequality, being the relevance of specific factors operating within each country of 17.17%. The factors explaining the rise in within inequality are related to both specific characteristics

15 Additionally, as it was indicated by a referee, inferential exercises could be performed in line with both Rey and Smith (2013) and Novotny and Nosek (2012). Another future development would be to individuate some comparisons between the behavior of Moran's I and our spatial Theil index.

of the NUTS3 European regions and neighborhood factors. While both the neighborhood-between and the Specific-Between components tends to decrease in importance, the neighborhood-within and the Specific-Within components are gaining relevance.

As an important result, this paper provides empirical evidence about the relevance of the neighborhood components in the context of the European regional income inequality at NUTS3 level. Neighborhood factors have been driven European regional income inequalities at NUTS3 level. This information can shed light on policy options related to place-based policies that could help mitigate income inequality. From our results, both between and within European regional inequalities have been driven by neighborhood factors. Thus, place-based policies have to be designed in the context of more global policies (neighborhood policies) that harness the potential of place-based policies, increasing the potential of regional neighborhoods as the fundamental areas where inequality policies should be applied. Rather than relying solely on place-based policies, the EU should also promote and incentivize the coordination of place-based initiatives. It is necessary to build regional neighborhoods to support regional environments that can play important roles to combat European regional income inequality. In lagging European NUTS3 regions there may be neighborhood factors that condition regional economic processes. This would suggest that for regional policy to be most effective neighborhood policies must be addressed, since, at NUTS3 level, European regional income inequality as a a-spatial effect represents 17.17% of the total regional European inequalities.

In the analysis of factors causing European regional economic inequality, our approach is useful to provide the quantitative base to broadly differentiate between factors affecting each of the components of inequality. The availability of these quantifications will allow the design and the assessment of European regional income inequalities in the context of confirmatory studies analyzing the determinants of regional income inequalities. Finally, future studies should also examine the extension of this approach to other measures.

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