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Spatial Inequality: A Multidimensional Perspective

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5.1 Introduction

Spatial inequality has received considerable attention from both scholars and politicians in the last two decades. It particularly coincides with the technological advance of developing countries like China, Russia, India, and Brazil, territories with geographical peculiarities characterized by high growth rates. Spatial and more specific regional inequalities may help to provide a completely different view of economic disparities and general social welfare indicators.

At least some of these questions remain unanswered or have received remarkably little systematic documentation in the literature. We should first understand the exact meaning of spatial inequality. To what extent spatial dimension should be relevant compared to the traditional inequality measurement? Why is it important in terms of policy response? How can geographical aspects influence the related measures of well-being?

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This chapter aims at studying such determinants, while proposing a conceptual perspective of theoretical and empirical contributions on spatial inequality and welfare in a jointly unified framework.

Spatial inequality is indeed a dimension of the overall disparity, but it contains additional multidimensional view. The idea of capturing the impact of the heterogeneous income distribution is typical of the standard literature of inequality measurement. Such aspects can be even more impressive by taking into account a spatial dimension as it helps to define the correct profile of inequality with unusual policy prescriptions.

The growing interest surrounding this issue has to do with the fact that spatial inequality involves different evaluations across geographical or administrative units, and such feature can be one component of overall income inequality across individuals. This topic may implicitly identify how much a rise in spatial inequality within a given country, other things being equal, does influence the overall national disparities. Suppose to get an accurate measure of the share of income inequality originated within a community of individuals located in a particular country or capture the average differences across societies. Moreover, gauging spatial difference may, for instance, be of interest in case of externalities in the geographical allocation of sources. Deriving the contributions of income sources implies, for example, to understand which spatial factor contributes to determining inequality in a local area. Such an effect can be even influenced by the internal migration flow that may shrink or enlarge the spatial gaps in terms of salary, opportunity, or general economic advantage profile. A clear answer to these points is far from being clear.

Our analysis, therefore, encloses different fields of the literature. The impact of measurement issue involves the use of some indices and their related properties able to disentangle the effect of inequality within and between territories (Shorrocks and Wan 2005). Second, the role of geographical characteristics is a source of spatial variation which emphasizes the necessity of georeferencing and digitizing maps, atlases, and census records, particularly in the historical perspective.

In the last decade, the discussion about measurement issues, besides theoretical implications, was useful to understand a proper combination of redistributive policies. We consider such aspects by looking at the inequality of opportunity literature. The idea is that not all elements that

contribute to an unfair income distribution are illegitimate. The society needs to distinguish between characteristics rendering the inequality practically unfair and attributes through which inequality should be considered legitimate.

The spatial dimension should regulate the distributive procedures by which territories come to acquire especially advantageous positions in terms of income and other related variables. The topic is broader, and there are attempts to address the issue about what extent of inequality across the individuals and their different territories in the society can be captured using a correct index. Measuring the spatial income profiles is also required to discover whether the gap between the top rung of society and the bottom rung should be large or small taking into account their possible influences on economic performance in all areas. Therefore, we investigate some forms of decomposition inspired by Foster and Shneyerov (2000). They introduce the "path-independent" decomposable class of inequality indices, which is extremely useful to compute a correct measure of the overall inequality while taking into account the within and the between component that the spatial dimension necessarily requires. This combination even involves an evaluation of the geographical size in a multidimensional channel of growth and more in general economic performance. For instance, Michalopoulos et al. (2018) provide a recent analysis showing the effect of measuring inequality by looking at the geographical border and economic performances. They discover that a process of income redistribution that ensures income transfers in return for safe passage was advantageous to develop trade connections.

 We finally examine the problem of public policies influencing economic geography through infrastructure or transfers to generate an equal spatial distribution of economic activities. The question would be: What is the impact of spatial analysis on equity grounds? Can regional policies be justified on this ground? This effect can be taken into account by the presence of externalities or spillovers with spatial industrial concentration, which induces lower costs of innovation. Hence, a trade-off exists between spatial equity in an industrial location and aggregate growth. This is the typical trade-off between efficiency and equity at regional level. Interestingly, Martin (1999) showed that concentrated economic geography is preferable due to the cost of innovation. However, the presence of trade-

off is motivated by the role of the immobile workers in the impoverished region because, further away from the leading production site, they have to pay higher transaction costs. Potential public policy that influences the investment reducing the cost of innovation can obtain a more significant growth rate and even more spatial distribution of both income and economic activities. We show the conditions under which this result is possible capturing a new channel due to the typical competition and agglomeration effects that arises in the market.

The rest of the chapter is organized as follows. Section 5.2 provides a general overview of the spatial inequality based on different contributions in the literature. In Sect. 5.3, we instead propose a novel aspect of the measurement of spatial inequality of opportunity. Section 5.4 instead offers normative prescriptions showing the pros and cons of specific public interventions. Concluding remarks follow in Sect. 5.5.

5.2   Understanding the Concept of Spatial Inequality

The formal definition of spatial inequality attains to the measure of resources, services, or general outcomes that are specific of an area or location under investigation. It implicitly suggests an interdisciplinary role between economics and geography (see Krugman (1991)). Even better, it requires the use of tools that typically belongs to geographic analysis with the use of georeferenced data. The idea put forth in the recent literature of spatial inequality is to understand the role played by communities, neighborhoods, rural areas, and regions in the dispersion of a specific outcome distribution. For instance, some parts of a country can be considered highly developed with a more significant range of resources and general services compared to other areas.

The analysis within areas represents the identification of various groups of individuals with similar economic conditions. Kanbur and Zhang (2005) investigate, for instance, the rising of inequality between the coastal areas and the inland regions in China. The Chinese government reacts to such increasing disparities by process of redistribution directed

to the western regions. This unequal distribution of sources is explained by a spatial pattern based on different aspects related, for instance, to race, culture, trade, connections, and so on. The problem is even more intense as they involve not only income disparities across regions, but even issues like discrimination among groups of citizens, for example rural farmers compared to urban residents or ethnic minorities or migrants or religious groups. This is the reason why the spatial dimension is abundantly treated in the literature of segregation (see Reardon and O'Sullivan (2004)). Moreover, differences in factor sources can even identify unequal disparities across groups that otherwise would be not possible to capture (Weil 2015). These factors may depend on how much the territories are rich in environmental, natural, architectural, and artistic characteristics. Several exercises can be developed to see whether or not differences in incomes across municipalities originate for different factors and which one is more important. Information about neighbors and the potential network, migration flows, quality of institutions, hospital services, roads, and railways may have enormous consequences for public policy interventions. The identification of the residence is not the only element useful to identify disparities among individuals (Kanbur and Venables 2005). The variation of the geographical location is crucial to separate the contribution of the spatial factors. Therefore, any additional information helping to identify the areas (districts, provinces, states) of individuals who live in disadvantaged conditions contributes to the measure of socioeconomic development across communities.

It is, however, fair to say that a severe drawback of this analysis is the requirement of information at the empirical level. It is challenging from an economic view to provide quantitative estimates in the absence of small-area data that characterize the local context to which individuals operate. Such scarcity of information is an element that we should take into account when we investigate any issue of spatial inequality looking at survey data. The result is somewhat weird. On one side, it can describe the kind of problems that may arise from the presence of heterogeneity at the local level and even put forth different policy prescriptions to reduce inequality. On the other side, we can hardly provide just a few economic contributions that have empirically shown the spatial dimen-

sion of inequality with georeferenced data (e.g., Michalopoulos et al. (2018)). The large part of contributions in this direction have studied particular issues like segregation, and they are mainly related to the field of geography (see Kanbur et al. (2006) and Östh et al. (2015, 2014)).

5.3   Spatial Inequality of Opportunity

An alternative option in the inequality perspective is the possibility to look at the inequality of opportunity (IOp, hereafter) issue (see Roemer (1998)). This branch of the literature suggests the precise distinction between factors through which individuals have no control, for example social or parental background, inherited wealth, genetic makeup, early childhood environment, and factors considered "total" responsibility of individuals, for example all measure of individual effort in a broad sense. People thus face unequal circumstances, but this inequality, due to unchosen factors, must be removed. Ex ante inequalities, and only those inequalities, should be eliminated or compensated for by public intervention. Justice requires the ideal of *leveling the playing field*. It implies that everyone's opportunities should be equal in an appropriate sense, and then, letting individual choices determine further outcomes.

5.3.1 The Basic Setting

Formally, this means that each individual outcome can be broadly explained by two characteristics. First, a vector of circumstances C which belongs to a finite set $\Omega = \left\{ C_1, \ldots, C_j, \ldots, C_m \right\}$, for each type j, where $j \in \{1, \ldots, m\}$.[1] Second, a scalar variable of effort $E \in \Theta$. Outcome is generated by a function $f : \Omega \times \Theta \to \Re_+$ as the joint result

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[1]It implies that individuals of each type t have identical circumstances in the vector C.

of individual decision E and social circumstances C:

$$y = f(C, E) \tag{5.1}$$

Note that efforts are endogenously determined and may thus partly depend on circumstances and other random characteristics denoted by η as,

$$E = g(C, \eta) \tag{5.2}$$

Therefore, the advantage model of Eq. (5.1) for each individual i is

$$y_i = f(\bar{C}, g(\bar{C}, \eta_i), v_i) \tag{5.3}$$

where v_i is a random-type component, while $\bar{C}$ identifies a vector of unique circumstances to which individual i belongs.

Interestingly, in the last decade, different papers have investigated the possibility to decompose and select the inequality originated from unequal circumstances (opportunity) to the one motivated by personal effort (responsibility) (see Pignataro (2012) for a general overview and Li Donni et al. (2014) for an application in the health context). However, only a few contributions have tried to look at a spatial methodology disentangling the impact of factors beyond the control of individuals.

5.3.2 Capturing the Spatial Pattern of Inequality

From our perspective, the focus would be to measure the effect of the spatial source of inequality due to the heterogeneity of residential locations. The idea indeed in this new frontier is to enclose the strict relationship that exists between the local community and the opportunities that IOp argument still does not consider. The variation among neighborhood areas can be defined as the main determinants of unfair inequality (circumstances outside the individual control) as made by de Barros et al. (2009). The literature developed in the last decade has considered some geographic aspects like birthplace or residence, unfortunately, limited to

urban/rural codes or administrative units (see Ferreira et al. (2010, 2011) and Peragine and Serlenga (2008)). The use of these regressors does not allow for the heterogeneity at the local level. Consequently, it cannot capture peer aspects that influence income or educational performances of individuals.

A specific spatial pattern is necessary to provide individuals' past, and present information on the residential environment and the potential interaction between individuals at neighborhood dimension. Any variables able to encompass the opportunity sets from ages, parents or neighbors' education, roads, or general distance may help to gauge this new profile of unfair inequality. What matters for a spatial approach to inequality is the use of individual residential coordinates to construct a neighborhood network for each individual. The purpose is to provide for each agent a series of information based on a k-nearest neighbors approach as in Östh et al. (2015). The methodology consists of creating areas of neighbors of varying size using the individual location and then calculating the proportion of different groups of residents in each neighborhood.

The definition of the size of each neighbor's area is debatable. The literature on scalable egocentric blocks has adopted different techniques (see e.g., Chetty et al. (2015) and Reardon et al. (2008)), according to the different definition of neighborhoods. Galster (2001) argues that the neighborhood is a multidimensional phenomenon which has four actors: individuals or households, businesses, private property, and local institution. Part of this information is difficult to provide, and this attends to the problem of partial observability of circumstances treated later. The simplest possibility would be to identify the area as predetermined units and determine the spatial distribution across a set of fixed areal subdivisions such as census tracts or kernel-based density estimation. It is even possible to use the population density as a criterion to equalize the proportion of individual in sets with different size using bandwidths of kilometers. Alternatively, measuring the probability of meeting another person according to a spatial autocorrelation matrix in a set of people at the same distance level could be an interesting perspective. For instance, Östh (2014) proposes to find the k-nearest neighbor (using a variety

of k-values) of each individual by computing the share of individuals belonging to a user-specified subgroup for each k.[2]

Independently of the criteria adopted to dimension the areas of analysis, it is always possible to decompose the overall inequality by population subgroups (Chakravarty 1990) identifying each type (circumstance) as the local area of individuals with similar pattern of characteristics. On the one side, the within-group inequality would capture the fair distribution of outcomes, that is, the difference that emerges within each area depends on characteristics within the individual control. On the other side, the between-group inequality would gauge the disparities in terms of individual opportunities.

5.3.3 Spatial Decomposition by Population Subgroups

Based on Checchi and Peragine (2010), it is possible to define two different outcome distributions helpful to distinguish the spatial pattern of inequality.[3]

First, a *smooth* distribution Y_C is created by replacing each individual outcome y_i in Y with its area-specific mean μ_t. The value I identifies the particular inequality index chosen so that $I\{Y_C\}$ eliminates the inequality within areas capturing *directly* the between component reflecting the inequality of opportunity. Second, a *standardized* distribution Y_E is computed by replacing each individual outcome y_i in Y as follows:

$$y_i \rightarrow \frac{\mu}{\mu_j} y_i \tag{5.4}$$

where μ_j is the mean of the subgroup t while μ is the mean of the entire distribution. The distribution Y_E is important as it ensures removing the inequality originated between areas. It measures only the inequality

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[2]See Agovino et al. (2019) for the adoption of a Spatial Lag of X model for the determination of the spatial contiguity matrix.

[3]The model proposed here is a description of an *ex ante* approach where the within-inequality is measured for each opportunity set. The same analysis can be developed by looking at an *ex post* approach where the vector of circumstances enclosed individuals at the same degree of effort.

within similar locations and for this reason it can be interpreted as the inequality due to personal responsibility. The inequality of opportunity component in the standardized distribution can be obtained *residually* by the difference between $I\{Y\}$ and $I\{Y_E\}$. Calculating the IOp measure through these two distributions surely determine different results for different inequality indices. This is due to the dependence of the within component by the overall mean. Therefore, it is better to adopt a path-independent class of additive indice which is decomposable *by population subgroups.* This implies that it is always possible to derive a decomposition of the total inequality by distinguishing the within- and between-components (see Shorrocks (1984)). Indeed, the class of additive inequality indices reduces to a single inequality measure when the chosen reference income is the arithmetic mean, that is, the mean log deviation (MLD, hereafter), as demonstrated by Foster and Shneyerov (2000).[4]

$$MLD\{Y_C\} = MLD\{Y\} - MLD\{Y_E\} \tag{5.5}$$

the *direct* or *indirect* computation of the inequality at spatial level may perfectly coincides. Note that this is possible even in terms of public policy by looking at a measurement of equality of opportunity. Lasso de la Vega and Urrutia (2005) show the existence of path- independent class of multiplicative indices. In this class, when the arithmetic mean is the chosen reference income, the Atkinson coefficient A (Atkinson 1970) with $\epsilon = 1$[5] can be exploited due to its path-independent property and

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[4]The formal definition of the Mean Log Deviation is as follows:

$$MLD = \frac{1}{N} \sum_{i=1}^{N} \ln \frac{\mu}{y_i}$$

where N is the number of individuals, y_i is the income of the individual i, and μ is the mean of the distribution.

[5]The Atkinson index for $\epsilon = 1$ is:

$$A = \frac{\left[\prod_{i=1}^{N} y_i \right]^{\frac{1}{N}}}{\mu} \tag{5.6}$$

while the between components is:

the conclusion are similar to the one proposed in Eq. (5.5) such that:

$$A\{Y_C\} = \frac{A\{Y\}}{A\{Y_E\}} \tag{5.10}$$

where the multiplicative effect is generally used to capture the marginal change produced by the opportunity and the responsibility components. The decomposition of Eqs. (5.5) and (5.10) shows that it is possible to obtain a direct and indirect impact of spatial inequality of opportunity by looking directly or indirectly to the difference between neighborhood areas.

Recently, Türk and Östh (2019) adopted a similar idea with interesting analysis on the spatial pattern. They used an egocentric neighborhood approach to capture the effect that local communities have on the opportunity sets of individuals. They look at educational and earning outcomes using Swedish longitudinal register data. In particular, they study the inequality and the school performance, respectively, in 2010 and 2011 following the individual of the 1985 cohort. They distinguish between *aspatial* and *spatial* information from the data. The formers are the typical

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$$A_B = \frac{\prod_{j=1}^{m} (\mu_j)^{p_j}}{\mu} \tag{5.7}$$

where $p_j = N_j/N$ is the population share. Hence, we define the Atkinson's equality index within subgroup j as follows:

$$A_j = \frac{\left[\prod_{i=1}^{N_j} y_{ji} \right]^{\frac{1}{N_j}}}{\mu_j} \tag{5.8}$$

and the inner product is equal to

$$A_W = \frac{A}{A_B} = \frac{\prod_{j=1}^{m} (A_j \mu_j)^{p_j}}{\mu} \frac{\mu}{\prod_{j=1}^{m} (\mu_j)^{p_j}} = \prod_{j=1}^{m} A_j^{p_j} \tag{5.9}$$

variable used in the literature as parental background, that is, education and employment status, marital status, household income, migration, and so on. The novel aspect of their analysis consists of using peculiar spatial information which perfectly fits in terms of opportunity egalitarianism, in particular the share of (1) similar-age peers in the neighborhood, (2) visible minorities, and (3) equivalence household scales, according to the *k*-level differentiation discussed above. Moreover, they use an exposure index of potential adverse environments which surround the neighborhood computed under a different measure of poverty or general disparities. They even allow for the computation of the commuting measure based on the observed distance from the workplace.

Interestingly, Ordinary Least Square (OLS) estimation should be avoided when observations are included in larger hierarchical geographical units. OLS regressions underestimate standard errors when residuals at nearby locations are not identically and independently distributed. The violation of the *iid* assumption is typical when spatial inequality is measured at municipalities or georeferenced areas. The preferred methodology (as the one chosen by Türk and Östh 2019) thus consists of multilevel models. The advantage is the possibility to manage the spatial autocorrelation inferences across neighborhoods. The authors show that inequality of opportunity counts for more than 50% in the case of educational distribution, while the percentage is lower for earnings. Moreover, they demonstrate that spatial characteristics are more important in the definition of disparities. The difference between opportunity sets is more considerable for neighborhoods with visible minorities, and this figures out as the primary cause of inequality of opportunity inducing potential conclusion for targeting policy interventions.

5.3.4 Spatial Decomposition by Income Sources

The measurement issue of spatial IOp can even be discussed by looking at an alternative decomposition, called *income sources*. The idea here is to capture the impact of inequality through the measure of specific spatial income items. The literature has historically developed different methods

to gauge total inequality concentrated in specific items. For instance, Shorrocks (1982) proposes one of the most interesting methodologies to face these types of decomposition. He demonstrates that an infinite number of decompositions is possible by income sources. This property is called the *natural* decomposition property, which is valid for all inequality indices. The traditional contributions on inequality measurement usually look at the Gini coefficient.[6]   Instead, we propose a decomposition of the Atkinson index (Atkinson 1970) for all $\epsilon \in [0, 1]$ exploiting the well-known Shapley procedure (Shapley 1953) under the equality of opportunity principle.[7] Compared to the setting proposed in Sect. 5.3.1, we instead focus on the spatial variation of sources obtaining the total inequality as the weighted average of each factor components. For the sake of simplicity, we propose a simple exercise with two spatial factors that help to understand the sequence of analysis immediately.

We now define a society with N individuals. For the income vector $Y = \{y_1, \ldots, y_i, .., y_N\}$ where $i \in \{1, \ldots, N\}$ and the partition of the population $\hat{N} = \{N_1, \ldots, N_j, \ldots, N_m\}$ where $j \in \{1, \ldots, m\}$. Note that in this new setting the label j does not identify the type of circumstances to which individuals belong, but instead identifies the sources of different income at spatial level. For example, we can distinguish between incomes above the individual's control as spatial endowments, lands, or even financial capitals, which are considered as circumstances, and labor household income, which is interpreted as responsibility factor. It's assumed that the total income Y is the sum of incomes from m-sources, that is,

$$Y = \sum_{j=1}^{m} y_{ij} \tag{5.11}$$

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[6]See Fei et al. (1980), Lerman and Yitzhaki (1985), and Silber (1989).
[7]See Pignataro (2010) for a decomposition à la Shapley by population subgroups.

Let μ_j be the mean income for the j-th source, which can be written as:

$$\mu_j = \sum_{i=1}^{N_j} \frac{y_{i,j}}{N}$$

while the average income for all sources can be defined as follows:

$$\mu = \sum_{j=1}^{m} \sum_{i=1}^{N_j} \frac{y_{ij}}{N}$$

We are supposed to have only two income sources for the income Y. Define land resources as K, which represents our income component out of the individual's control, and labor earning as L, which is referred to as responsibility variable. They are used for producing the entire income distribution Y such that,

$$Y = f(K, L) \tag{5.12}$$

We express the Atkinson inequality measure *à la* Atkinson (1970) as follows:

$$A = A(y) = 1 - \frac{\left(\sum_{i=1}^{N} \frac{1}{N} y_i^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}}{\mu} \tag{5.13}$$

We can easily derive the contribution of each income source to unit Y applying the Shapley procedure to the Atkinson index of Eq. (5.13). When all sources are distributed evenly among all N individuals, that is, $K_i = k$ and $L_i = l$ for all $i \in \{1, \dots, N\}$, income Y is equally distributed among individuals and $A = A(k, l) = 0$. This represents a

simple example of a potential distribution of income sources:

Individuals Incomesources	Ind.1	Ind.2	Ind.3
K	5	10	9
L	12	6	8

The average income of the distribution is equal to $\mu = 8.333333333$, while the average income for both capital and labor sources are, respectively, $\mu_K = 8$ $\mu_L = 8.666666667$. Applying the Shapley decomposition, we divide the sequence of decomposition in four steps:

5.3.4.1 Measuring the Spatial Variation of Both Income Sources

In the first step, we represent the general case $A(K \neq k; L \neq l)$, which refers to the case where both income sources differ from their own mean. We may therefore write the overall Atkinson index of inequality A as:

$$A(K \neq k; L \neq l) = 1 - \frac{\left(\sum_{i=1}^{N} \frac{1}{N} y_i^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\mu}$$

$$= 1 - \frac{\left[\frac{1}{6}\left(5^{\frac{1}{2}} + 10^{\frac{1}{2}} + 9^{\frac{1}{2}} + 12^{\frac{1}{2}} + 6^{\frac{1}{2}} + 8^{\frac{1}{2}}\right)\right]^2}{8}$$

$$= 1 - \frac{\left[\frac{1}{6}(2.23606 + 3.16227 + 3 + 3.46410 + 2.449489 + 2.82842)\right]^2}{8.33333}$$

$$= 1 - \frac{8.160867251}{8.33333} = 1 - 0.959304 = 0.0406$$

Following the decomposition of income sources, we can also express the Atkinson index taking into account the inequality derived for each

income source. It follows that:

$$A = 1 - \frac{\left(\sum_{i=1}^{N} \frac{1}{N} y_i^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\mu} = 1 - \frac{\left(\sum_{j=1}^{m} \sum_{i=1}^{N_j} \frac{1}{N_j} y_{ij}^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\mu}$$

$$= \sum_{j=1}^{m} \frac{\mu_j}{\mu} A_j = \sum_{j=1}^{m} q_j A_j \qquad (5.14)$$

where A_j is the inequality for the j-th source ,which is given by:

$$A_j = 1 - \frac{\left(\sum_{i=1}^{N_j} \frac{1}{N_j} y_{ij}^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\mu_j} \qquad (5.15)$$

applying expression (5.15) to both income source in our simulation, we can obtain:

$$A_K = 1 - \frac{\left(\frac{1}{3}(5^{\frac{1}{2}} + 10^{\frac{1}{2}} + 9^{\frac{1}{2}})\right)^2}{8}$$

$$= 1 - \frac{\left(\frac{1}{3}(2.23606 + 3.16227 + 3)\right)^2}{8} = 0.02039$$

$$A_L = 1 - \frac{\left(\frac{1}{3}(12^{\frac{1}{2}} + 6^{\frac{1}{2}} + 8^{\frac{1}{2}})\right)^2}{8.6666667}$$

$$= 1 - \frac{\left(\frac{1}{3}(3.46410 + 2.449489 + 2.82842)\right)^2}{8.6666667} = 0.02023$$

Therefore, the Atkinson index for this part of the distribution is:

$$A(K \neq k; L \neq l) = \sum_{j=1}^{m} \frac{\mu_j}{\mu} A_j = \frac{8\,(0.02039) + 8.66666\,(0.02023)}{8.33333}$$

$$= \frac{0.16312 + 0.175326666}{8.33333} = 0.0406$$

The following cases must be considered in the definition of the marginal contribution of both spatial determinants, respectively K and L.

5.3.4.2   Measuring the Spatial Variation on L-Source

In the second step, we represent the case in which $A(K = k; L \neq l)$. It refers to the inequality when capital income is equally distributed among individuals, while labor income differs from the average as:

$$A(K = k; L \neq l) = 1 - \frac{\left(\sum_{j=1}^{m} \sum_{i=1}^{N_j} \frac{1}{N_j} y_{ij}^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}}{\mu}$$

$$= 1 - \frac{\left[\frac{1}{3}(3.46410 + 2.449489 + 2.82842) \right]^2}{8.6666667} = 0.02023$$

5.3.4.3   Measuring the Spatial Variation on K-Source

Here, we define the situation in which labor income is equally distributed among individuals while this is not true in the case of capital income.

Therefore, the Atkinson index $A(K \neq k; L = l)$ can be expressed as:

$$A(K \neq k; L = l) = 1 - \frac{\left(\sum_{j=1}^{m}\sum_{i=1}^{N_j} \frac{1}{N_j} y_{ij}^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}}}{\mu}$$

$$= 1 - \frac{\left[\frac{1}{3}(2.23606 + 3.16227 + 3)\right]^2}{8} = 0.02039$$

5.3.4.4   Capturing No Spatial Variation of Both Sources

Finally, when all income sources are equally distributed among individuals, we can have that $A(K = k; L = l) = 0$.

5.3.4.5   Total Marginal Contributions

We compute the marginal contribution to inequality for both capital and labor incomes:

$$C(K) = \frac{1}{2}\{[A(K \neq k; L \neq l) - A(K = k; L \neq l)] \quad (5.16)$$

$$+ [A(K \neq k; L = l) - A(K = k; L = l)]\}$$

$$= \frac{1}{2}\{[0.0406 - 0.02023] + 0.02039\}$$

$$= 0.02038$$

$$C(L) = \frac{1}{2}\{[A(K \neq k; L \neq l) - A(K \neq k; L = l)] \quad (5.17)$$

$$+ [A(K = k; L \neq l) - A(K = k; L = l)]\}$$

$$= \frac{1}{2}\{[0.0406 - 0.02039] + 0.02023\}$$

$$= 0.02022$$

The overall Atkinson index A is equal to 0.0406, according to Eq. (5.13). We demonstrate that the sum of the contributions of both land resources and labor earnings, respectively Eqs. (5.16) and (5.17), is equal to:

$$A = C(K) + C(L)=0.02038 + 0.02022 = 0.0406$$

In this case, the spatial egalitarian interpretation suggests that actors, for example natural resources K, beyond the individual control identify the unfair distribution due to different opportunities, while factors, for example the level of labor earnings L, indicate the inequality which must be considered fair as originated within the communities' control. Therefore,

$$\textbf{opportunityinequality} : C(K) = 0.02038$$

$$\textbf{effortinequality} : C(L) = 0.02022$$

The decomposition and the consequent interpretation are compatible with more sources and alternative inequality indices.

5.3.5 Partial Circumstances and Causality

Before discussing the appropriate frame of policy prescriptions, it is useful to linger over some empirical concerns addressed in the literature of equality of opportunity. They should be corrected (or at least evaluated) to obtain a correct measure of income and welfare disparities.

We here point out the role of partial observability of circumstances and the causality of the estimate. The former is characterized by the difficulties to design data able to enclose all relevant circumstances concerning specific outcomes. Indeed, the possibility to include all opportunity traits is extremely difficult due to data limitations. We can easily imagine several unobservables which matter according to the real inequality of opportunity. The spatial dimension, therefore, enriches the framework due to the potential correlation among relevant characteristics attaining to the personal interaction of individuals. Although the interpretation of

Fleurbaey (2008) about a lower-bound estimation remains, the richness of information implies that the resulting IOp would be larger than the typical one without the accuracy of the spatial aspects. Moreover, as far as additional information at a local level contributes to describing the potential variation across individuals within and between types, then the identification of multiple circumstances ensures a larger accuracy in the estimation. This influences both parametric and nonparametric procedures used in the IOP estimation and the consequent use of the predicted values in the decomposition of inequality, as shown in the previous subsection.

Second, the argument about causality issue beyond the mere statistical association of the variables is instead in place, and the problem of identification can be even more severe than the traditional analysis. In particular, it is relatively challenging to accept that the spatial error does not feature any spatial autocorrelation. There are different approaches in this case that mainly involve the use of a set of instruments including, for instance, time lags and spatiotemporal lags of the related regressors and the more in general of the other covariates. A definite answer, however, cannot be provided as the complexities of the linkages between spatial characteristics indeed reduce the likelihood of identifying the impact of IOp accurately. It is a general problem of IOp literature and even more so when the spatial correlation matrix of neighborhood enriches the practical design of estimation. As long as we do not know whether and how likely unobserved variables or autocorrelations are determined, it may be difficult to separate the net effect of the spatial regressors due to their possible correlations. Further, the simultaneous determination of the networks at the local level should always lead to a discussion on the issue of endogeneity built on the idea of controlling for observable factors.

5.4   Policy Prescriptions on the Spatial Dimension

Spatial inequality generally implies the concentration of general affairs and business in a specific region compared to the others. Such economic activities seem to be essential characteristics of the development of a

country and can be justified by efficiency reasons. Okun (1975) was the first to introduce the concept of the *leaky bucket,* such that "The money must be carried from the rich to the poor in a leaky bucket…. Some of it will disappear in transit, so the poor will not receive all the money that is taken from the rich." This argument was promoted in the historical debate by all those against any forms of redistribution.

Indeed, evaluating redistributive policies is always under the scrutiny of policymakers to take care of the necessity of the population. Any representative government of both developing and developed countries usually tries to counteract the unequal trend of the income profile based on equity ground. The problem of uneven patterns of local development involves all countries, even the one with a long tradition of no policy interventions and requires the analysis of the typical trade-off between equity and efficiency. It is, therefore, essential to analyze the potential effect of policies at the spatial level, for example regional one, and their political consequences. Spatial policies distort the landscape of economic activities since they may influence the location decisions of firms across regions.[8] The general idea is that a process of redistribution toward the poor areas should be profitable for the entire country (Jaffe et al. 1993). The causes of spatial disparities are generally related to the extent of capital mobility and labor agglomeration.

A higher level of inequality is observed in places with the presence of immobile agents with lower incentives to economic activity. The public intervention through pure redistribution and fiscal incentives directed to the territories induces firms to relocate in the poor areas. They can be in the form of progressive taxation or subsidies, helping or not to increase the efficiency of the economy. The results are not so obvious. Further, the introduction of economies of scale and transaction costs may help to justify at least in part that the concentration of activities in certain regions characterized better access to the large markets or more natural opportunity to innovate.[9] This partial concentration can create some

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[8]Note that in this perspective even housing policies that influence the commuting of agents should be considered for the spatial effects of agents.

[9]The notion of the *neoclassical theory* of income disparities and trade suggests that a low level of productivity of a poorer region does not necessarily impede to gain from trade due to the

advantages at the national level looking at both inequality and welfare for the poorer regions.

The purpose of this section is, therefore, to understand better the dynamics of spatial inequality with an overview of different policies that can be locally implemented.

5.4.1 Externalities, Mobility, and Inequality

In the real world, much of the conclusion on the equity-efficiency ground depends on the role of externalities. In particular, technological externalities are the most cited elements to justify public intervention from a spatial viewpoint. The reason is that externalities influence physical space, increasing the productivity of areas due to the proximity effect. The vicinity of firms in an agglomerate reduces the transportation cost, and in particular it influences the value of innovation, facilitating the realization of a new production process, for example Silicon Valley. However, Matsuyama and Takahashi (1998) show that the high level of mobility may sometimes reduce the welfare of agents, causing the rise of inequality. Motivations are guided by the continuous agglomeration of people in urban areas which, above a certain threshold, increase the competition effect in the labor market, lowering their salaries. In turn, this has an impact on the poor regions, for example their production of goods declines due to the lack of specialized agents. Larger mobility of agents and their consequent concentration in certain regions are not welfare improving when congestion externalities prevail on the innovation process. The overall result can be harmful in a general equilibrium setting.

Part of the literature has studied the construction of infrastructure building, for example highways or railroads, as a possible solution to the unequal spatial distribution. Such policies decrease potential transaction costs in the country and, consequently, may induce manufacturing firms to relocate in more productive regions due to the innovation externalities. Therefore, a policy prescription devoted to the development of infras-

comparative advantage. It depends naturally on the decreasing/increasing return to scale of trade integration or potential liberalization of capital movements.

tructures may lead to a paradoxical result. The reduction of transaction cost should be accompanied by a fiscal incentive (not merely a subsidy for a unit of production) to induce firms investing in the poor regions. In this case, it is possible to exploit economies of scale due to the most extensive rise in trade and competition in the country. According to the geographical allocation of resources, this kind of combined interventions would improve welfare for all consumers (see Martin and Rogers (1995) for a theoretical analysis on this issue).

The spatial equity problem can be even observed within regions, not only across regions. In particular, empirical evidence shows that the higher the level of inequality among workers and capital owners, the larger is the problem of spatial variation that must be solved (see Piketty (2014)). Therefore, public policies aimed at correcting spatial disparities should take into account the role of capital owners. Even in this case, the results are not so simple. On the one side, significant mobility of individuals due to policy interventions drives up the profits of capitalists in the more impoverished regions due to the relocations of the largest companies in the richer ones. However, workers and consumers in those areas may lose part of their salaries as the market power increases in the hands of few sellers (see Scotchmer and Thisse (1992)). On the other side, the concentration process due to larger mobility across regions will also decrease inequality in the most prosperous areas. As the competition among firms increases, profits of such companies will fall, and this induces higher welfare for consumers at lower prices.[10] Spatial inequality definitively reduces in those areas.

Still, note that since the profits of capitalists increase in the more deprived areas, the spatial inequality even grows more when firms choose their location freely. More in general, whenever the transaction cost reduces (for any reasons), and more extensive mobility is ensured, then spatial inequality within areas may increase. This can be a significant

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[10]Usually, more impoverished regions with a lower level of initial resources have higher returns on capital attracting money from abroad (think about the integrated European areas). Policy interventions toward the more deprived areas are more difficult to justify in a neoclassical perspective in case the competition effect is stronger without economies of scale.

argument in favor of a pure redistribution through progressive taxation at the local level with the purpose to converge the socioeconomic condition of the communities. The conclusion on this point should be that any policies that reduce the incentive to a relocation process may increase income disparities within and between regions. However, a rise of agents' mobility must always be supported by a pure redistribution within areas (particularly the poor ones) as the market power of companies increases.

5.4.2 Welfare Evaluation

The debate about the rise of inequality and the consequent trade-off between efficiency and equity reasons does not take into account the evaluation of individuals' welfare.

It is well known that the extent of technology spillovers increase the growth rate of a country. The net result in welfare terms intertwines both poor and rich regions at the same time. A large concentration in the wealthy regions rises the general welfare in the society because of more efficiency of production due to the agglomeration effect. Instead, individual welfares reduce in the more deprived area due to a large amount of spending on transaction costs on imports from the more prosperous regions. On this point, Martin and Ottaviano (1999) answer that more spatial concentration can be detrimental or beneficial to the welfare conditions of individuals. The prevalence of a positive or negative effect depends on the level of transaction costs across communities.

In case of limited transaction costs, indeed the positive agglomeration impact dominates. Welfare increases as the imports of products and services from the rich to the impoverished region play a marginal role. Geographical interconnections, therefore, become more efficient and more conducive to the growth of the country. Therefore, any policy interventions that can address the issue of infrastructure can be beneficial to the population. The public prescription will be effective if and only if it reduces the transportation costs of agents, products, and services influencing the mobility in general.

The net effect is even more vigorous, according to the initial endowment of the regions. The impact of growth produces as a consequence higher competition among firms, which in turn reduce their profits in the more prosperous areas. Poor areas have, by definition, a lower level of resources to exploit, which implies a more moderate reduction in the profits of companies there. However, the competition effect is even more beneficial for individuals due to lower prices and relatively low transportation costs.

We have seen in the previous paragraph some policies whose primary objective was to reduce cost and increase mobility among individuals. We have observed how policies like a pure redistribution toward the poorer or subsidies that induce companies to move to the more disadvantaged location do not always determine a reduction of inequality. Now we confirm that similar results are not so evident even for welfare evaluation. Whenever the technological spillovers are more effective with lower transaction costs, it is always better to concentrate the investments in the more productive regions due to the agglomeration effect. This helps in reducing spatial inequality and contributes to the increase of welfare in the poorer areas.

Conclusions suggest that the existence of localized spillovers and a different distribution of resources among regions are essential characteristics in the selection of the spatial policy program to implement.

5.4.3 Welfare and Spatial Inequality Measurement

We now propose an evaluation of social welfare based on the literature of inequality measurement.[11] The idea is to understand the relationship between inequality and welfare in society from a policy view. Understanding the dynamics of such evolution should help to address better public interventions described above. It is possible to observe the concrete pattern of welfare/inequality in a different direction. Here we choose a typical utilitarian welfare function, according to Atkinson (1970) described in the previous section. The advantage of this approach is to capture the

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[11]See Pignataro (2009).

hypothetical level of income, called *equally distributed equivalent* income (*ede*, hereafter) y_e, that each individual should receive in order to keep the society to the same level of social welfare. Starting from an average utility function of N individuals in the society,

$$W = \frac{1}{N} \sum_{i=1}^{N} U_i(y_i) \tag{5.18}$$

where the function $U_i(y_i)$ refers to the utility function of each individual i. In particular, we can formally express the individual utility function based on the variation of inequality aversion ϵ such that,

$$U_i(y_i) = \frac{1}{1-\epsilon} y_i^{1-\epsilon} \quad if \ \epsilon > 0 \ \epsilon \neq 1 \tag{5.19}$$

$$U_i(y_i) = \log y_i \quad if \ \epsilon = 1$$

In global perspective, we can select the condition for a general welfare of the society by looking at a proper redistribution among individuals,

$$W(y_1, \ldots, y_i, \ldots, y_N) = W(y_e, \ldots, y_e, \ldots, y_e) \tag{5.20}$$

and this is possible by searching for the hypothetical *ede* income defined above, able to ensure the same level of welfare among individuals. Therefore, from Eq. (5.19), we get:

$$U(y_e) = \frac{1}{1-\epsilon} y_e^{1-\epsilon} \tag{5.21}$$

and the expression of the social welfare function in the extensive form is:

$$W = \frac{1}{N} \sum_{i=1}^{N} \frac{y_i^{1-\epsilon}}{1-\epsilon} \tag{5.22}$$

A consequence of this approach is that it can be easily derived a functional form of the *ede* income y_e from Eqs. (5.21) and (5.22) as follows:

$$y_e = \left[\frac{1}{N} \sum_{i=1}^{N} y_i^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \quad if \ \epsilon > 0 \ \epsilon \neq 1$$

$$y_e = \left[\prod_{i=1}^{N} y_i \right]^{\frac{1}{N}} \quad if \ \epsilon = 1$$

However, the connection between welfare and inequality is summarized by the general expression of Atkinson index of inequality A of the entire distribution Y:

$$A = 1 - \frac{y_e}{\mu} = 1 - \frac{\left[\frac{1}{N} \sum_{i=1}^{N} \frac{y_i^{1-\epsilon}}{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}}{\mu} \quad if \ \epsilon > 0 \ \epsilon \neq 1 \qquad (5.23)$$

$$A = 1 - \frac{y_e}{\mu} = 1 - \frac{\left[\prod_{i=1}^{N} y_i \right]^{\frac{1}{S}}}{\mu} \quad if \ \epsilon = 1 \qquad (5.24)$$

5.4.4 Capturing the Spatial Dimension of Welfare

The same analysis can be developed by measuring welfare and inequality across regions. The proposal is the decomposition of the Atkinson index by taking into account differences in the income profiles of individuals belonging to richer and poorer regions.

$$W = \frac{1}{N} \sum_{j=1}^{m} \sum_{i=1}^{N} U_{ij}(y_{ij}) \qquad (5.25)$$

The values of j and m precisely identify the subgroups as in Sect. 5.3.3. According to the population subgroup decomposition, we do not require any further restrictions on the functional form $U_{ij}(y_{ij})$. The procedure is similar to the one proposed by Atkinson (1970). This kind of utility function by population subgroups captures the income of individual i that belongs to group j. Hence, it follows that:

$$U_{ij}(y_p) = \frac{1}{1-\epsilon} y_{ij}^{1-\epsilon} \quad \text{if } \epsilon > 0 \ \ \epsilon \neq 1 \tag{5.26}$$

A similar result can be provided for the value of inequality aversion ϵ equal to 1. However, from Eqs. (5.25) and (5.26), the social welfare function assumed the following form:

$$W = \frac{1}{S} \sum_{j=1}^{m} \sum_{i=1}^{N} \frac{1}{1-\epsilon} y_{ij}^{1-\epsilon} \tag{5.27}$$

Let $(y_{e1}, \ldots, y_{ej}, \ldots, y_{em})$ define the *ede* income vector for subgroups $\{1, \ldots, j, \ldots, m\}$ such that:

$$\frac{1}{N} \sum_{j=1}^{m} \sum_{i=1}^{N} \frac{1}{1-\epsilon} y_{ij}^{1-\epsilon} = \frac{1}{N} \sum_{j=1}^{m} \sum_{i=1}^{N} \frac{1}{1-\epsilon} y_{ej}^{1-\epsilon} \tag{5.28}$$

Then, each *ede* income y_{ej} for subgroups $j \in \{1, \ldots, m\}$ is given by:

$$\sum_{i=1}^{N} \frac{1}{1-\epsilon} y_{ij}^{1-\epsilon} = N \frac{1}{1-\epsilon} y_{ej}^{1-\epsilon} \tag{5.29}$$

and implies that,

$$y_{ej} = \left[\frac{1}{N} \sum_{i=1}^{N} y_{ij}^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \tag{5.30}$$

From Eqs. (5.27) and (5.30), a direct expression enclosing the *ede* income of the overall income profile as a function of the *ede* incomes

in the subgroups is possible as:

$$\frac{1}{S} \sum_{j=1}^{m} \sum_{i=1}^{N} \frac{1}{1-\epsilon} y_{ij}^{1-\epsilon} = \frac{1}{m} \sum_{j=1}^{m} \sum_{i=1}^{N} \frac{1}{N} \frac{1}{1-\epsilon} y_{ij}^{1-\epsilon} \qquad (5.31)$$

$$= \frac{1}{m} \sum_{j=1}^{m} \frac{1}{1-\epsilon} \left(y_{e_j} \right)^{1-\epsilon} = \frac{y_e^{1-\epsilon}}{1-\epsilon}$$

and consequently it follows that,

$$y_e = \left[\frac{1}{m} \sum_{j=1}^{m} \sum_{i=1}^{N} \frac{1}{N} y_{ij}^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}} \qquad (5.32)$$

The measurement of inequality, according to the Atkinson index proposed in Eq. (5.23), can be even expressed under the spatial evaluation of subgroups,

$$A = 1 - \frac{y_e}{\mu} = 1 - \frac{\left[\frac{1}{m} \sum_{j=1}^{m} \sum_{i=1}^{N} \frac{1}{N} y_{ij}^{1-\epsilon} \right]^{\frac{1}{1-\epsilon}}}{\mu} \qquad (5.33)$$

This measure is compatible with the discussion of the previous section. It suggests the interconnection between inequality and welfare and the advantage of decomposing the inequality to capture the spatial dimension at subgroup or regional level.

5.5 Concluding Remarks

Theory and empirical evidence in the income inequality literature has reached a consensus about the important role that the evaluation of spatial pattern assumes in the measurement of inequality and welfare. The analysis of spatial inequality was observed from different views.

According to the definition of spatial disparities, we have focused on different decomposition methodologies at the local level, mainly related to inequality of opportunity. Formally, we proposed a novel framework of spatial inequality of opportunity by revising the traditional decompositions by population subgroups and income sources. We first look at emphasizing the effect of spatial variation within and between groups. Then we look at capturing the marginal contribution of each factor component with the help of Shapley (1953) procedure. The second part of the investigation is devoted to different policy proposals adopted in the last decade. The evaluation is made by taking into account the mobility of individuals, the technological externalities, and the transportation costs across regions. We have thus observed that the implementation of a single policy is not effective as several aspects should be taken into account in the redistribution process. For instance, we have suggested that favoring the construction of infrastructure building can paradoxically be harmful. It reduces the transaction costs, inducing companies to relocate in richer regions due to the agglomeration effect. This result implicitly suggests that the sustainability of population across areas requires a mix of targeting interventions associating pure redistribution to innovation policies. The traditional trade-off between equity and efficiency aspects breaks if a particular condition in terms of transportation cost and innovation mechanism realizes. We observe how the spatial dimension contributes to enrich the design of the public evaluation and how the relationship between inequality and welfare is important to identify the correct intervention. This is the reason why a spatial relationship between inequality and welfare is then finally described, according to Atkinson (1970).

Despite several recent empirical analyses investigating the issue of spatial inequality, which is the best procedure to decompose the income profile is far from being clear. The same problem exists for the mixture of public interventions according to the initial resources . Economic research on this front is in its infancy, and we call for further in-depth study of the issue.

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