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Measuring the Dynamics of Inequality of Opportunity by Income Sources

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Abstract

Decomposing the inequality into several factor components makes it possible to understand where most of the observed inequality comes from. In this paper, we offer a methodological proposal for the identification of the drivers of inequality of opportunity through a non-parametric estimation strategy. Specifically, we propose to merge existing techniques for inequality decomposition by factor components (Shorrocks, 1982, 2012; Lerman & Yitzhaki, 1985) with non-parametric strategies for inequality of opportunity estimation in order to identify the contribution of different income sources (e.g. work income, capital income, transfers) to observed overall inequality of opportunity in societies. This analysis may be of particular interest for policy-makers because once the channels of transmission are identified, public policies can be better targeted toward mitigating – and eliminating – inequality of opportunity. Our proposal is validated through a simple application to SHIW (Survey on Household Income and Wealth), by which it emerges that inequality of opportunity amounts to 10% of overall inequalities in Italy, with a greater contribution (8%) originating from capital income and a compensation role of social transfers (-1%).

Keywords: inequality, opportunity, decomposition, measurement.

JEL Classification: D630.

1. Introduction

Within the egalitarianism of opportunity tradition, a distinction has to be made between fair and unfair inequalities. The latter may originate from factors beyond individual control (circumstances, such as ethnicity, gender, family background). Conversely, choices that imply individual responsibility (effort in education, in job) may also have a role in generating inequalities. Given that the factors generating

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inequalities may be different, it is therefore crucial to investigate their origins using parametric and non-parametric techniques. To our knowledge, the inequality decomposition technique has never been applied in the analysis of inequality of opportunity.

In this paper, in order to measure the contribution of each income source to the observed level of inequality of opportunity, we propose to merge the existing technique for inequality decomposition by income sources with a non-parametric strategy for inequality of opportunity estimation. Consequently, this paper may be of particular interest for policy-makers, since the promotion of equality of opportunity strongly relies on the definition of ad hoc measurement strategies, which can be optimally defined only if the specific drivers of inequality are precisely identified.

The nineties – due to pillar contributions (Rawls, 1958, 1971; Roemer, 1998) – have been characterised by the estrangement from the utilitarian tradition, which focus only on the level of utility reached by individuals, without considering the path's fairness. From that moment on, ethics takes place in the egalitarian scenario, and political philosophers start to include responsibility into the judgment of inequality. Thanks to these contributions, there has been an ongoing interest in measuring inequality of opportunity, and large literature has emerged in this field. For instance, Checchi and Peragine (2010) compute inequality of opportunity within the population of Italian workers differentiated by regions; Ferreira and Gignoux (2011) employ parametric and non-parametric approaches to measure inequality of opportunity between-group in Latin America; Abatemarco (2015) proposes a decomposition of the Gini index for the measurement of opportunity inequality and its contribution to inequality of outcome. Our proposal has been validated using the SHIW (Survey on Household Income and Wealth) database for the year 2022. The methodology we propose is based on the initial subdivision and grouping of individuals into *types* – groups of individuals with the same circumstances (i.e. factors beyond individual control) – in order to construct the counterfactual income distribution (i.e. the income that would be observed if all individuals had the same circumstances). Then, in order to capture the effect of different circumstances in each component of income, – following Shorrocks (1982) – we apply the decomposition technique on both the real and counterfactual income distribution. Lastly, the measure of inequality of opportunity by income source has been computed by applying the indirect ex-post measure proposed by Checchi and Peragine (2010). Note that, although circumstances and effort may not be independently distributed, to carry out the empirical exercise, we assume that the distribution of effort is independent of the circumstances. Undoubtedly, our proposal has several advantages. Precisely, decomposing inequality and emphasising differences in factors beyond individual control allows us to (i) investigate the contribution of each source of income to inequality of opportunity and (ii) examine the channel of transmission through which circumstances affect overall inequality. This is crucial from a policy perspective because, knowing the specific sources and causes of inequality, the design of policy measures can be better targeted towards

eliminating and reducing it. In addition, knowing the share of unfair inequality in the distribution of transfer income, we emphasise how much existing public policies are already reducing inequality of opportunity by means of generic subsidies transfers.

2. Problem Statement

In recent decades, there has been a growing academic interest in understanding the origins of inequality. This interest has led to the development of a large literature on techniques for decomposing inequality, such as the decomposition by income source and the decomposition by population subgroups (Shorrocks 1980, 1982, 2013; Lambert & Aronson, 1993; Lerman & Yitzhaki, 1985), which allow the analysis and the identification of the roots of inequality. Other studies (Fields, 1987; Pyatt, 1980; Shorrocks, 1982) focus on measuring inequality by decomposing income into different factor components. The latter is a useful technique to find out from which income sources the overall inequality comes from. Shorrocks (1980, 1982) that decomposition generates as many separate contributions as there are income components, under the assumption that the impact of each factor could be summarised in a single term, and he derives the "natural" decomposition rule for the variance and for the Gini index. However, what has been proven for the variance also holds for the Coefficient of Variation (CV) – which belongs to the class of generalised entropy measures $GE(\alpha)$. In this paper, we restrict our attention to $GE(2)$, which is known to be half the squared CV.

Despite scholars have focused for a long time on inequality in income distribution, there is also a non-income dimension of inequality that matters and that gives emphasis to the differences that exist in opportunities. A traditional approach to measuring inequality of opportunity might start from the distinction proposed by Roemer (1998) between circumstance and effort variables. The former refer to factors beyond individual control and generate unfair inequalities. Effort variables result from responsible choices made by individuals and, therefore, the resulting inequalities are usually considered as fair. Starting from this distinction, large literature has emerged in recent years (Bourguignon et al. 2007; Lefranc et al., 2008; Pistolesi, 2009; Checchi & Peragine, 2010; Almas et al., 2011; Ferreira & Gignoux, 2011; Bjorklund et al., 2012; Abatemarco, 2015). According to Ramos and Van de Gaer (2021), the most commonly used techniques to measure inequality of opportunity can be grouped into different categories; however, for the purpose of this paper, we focus our attention on indirect measures. Particularly, in the literature on the measurement of inequality of opportunity, a counterfactual analysis has been developed that allows to consider a virtual income distribution through which the share of inequality of opportunity can be identified. In fact, one of the categories accounts for the way in which this virtual distribution can be constructed: direct and indirect approaches. The latter measure inequality of opportunity among individuals of the same type. These measures are implemented by comparing the counterfactual income distribution, in which all inequality due to circumstances has been eliminated, with the actual income distribution. On the other hand, direct measures directly allow us to calculate the amount of inequality of opportunity, because the

virtual income distribution is constructed by dropping all disparities that exist in outcomes due to effort variables.

To our knowledge, the inequality decomposition technique has never been applied in the analysis of inequality of opportunity.

3. Aims of the Research

Given that the promotion of equality of opportunity strongly relies on the definition of ad hoc measurement strategies, which can be optimal defined only if the specific drivers of inequality are precisely identified, we propose to merge existing technique for inequality decomposition by income sources with non-parametric strategy for inequality of opportunity estimation. Indeed, despite the importance of investigating the origins of inequality – which may be different – the decomposition technique has never been applied in the analysis of inequality of opportunity. Through this proposal, we aim to measure the contribution of each income source to the observed level of inequality of opportunity. In particular, decomposing inequality and emphasizing differences in individual opportunities allows us to (i) examine the determinants of inequality of opportunity, (ii) investigate the contribution – of each circumstance – and the channels of transmission through which circumstances affect overall inequality, and (iii) identify the share of inequality of opportunity in each factor component. In order to do this, with this paper we examine how different sources of income contribute to overall inequality and attempt to determine what proportion of this overall inequality is attributable to each of these sources.

This approach may be of particular interest from a policy perspective because decomposing inequality into several factor components makes it possible to understand where the most of inequality comes from, and this represents a fundamental pillar for the policy-makers' decisions, as by knowing which specific source of income is generating the most inequality within a society, they could define an ad hoc policy measure, not only in order to promote the social justice, but also in order to reach the best solution in terms of resource allocation.

4. Research Methods

Let Y_i be the income of individual i with $i = 1, \dots n$, and let Y_i^k be the income of individual i from source k with $k = 1, \dots K$. As a source of income, we consider work income w, capital income c, and transfer income t. So, $Y = (Y^w, Y^c, Y^t) \in \Omega$ with $Y^K = (Y_1^K, \dots Y_n^K)$ with $K = w, c, t$ indicating the distribution of total income – from source k within the population of n individuals. So, $Y = Y^w + Y^c + Y^t$ is the overall income.

Shorrocks (1982) shows that if we want to use the variance to measure inequality by income sources, we have to consider

$$\sigma^2(Y) = \sum_k \sigma^2\left(Y^k\right) + \sum_{j \neq k} \sum_k \rho_{jk} \sigma(Y^k) \sigma(Y^j) \qquad (1)$$

where the second term on the right hand-side is zero in the case of no correlation between two income sources.

However, since we want to obtain the contribution of factor k on total income inequality, we should consider – as in Shorrocks (1982) – the following

$$S_k^*(\sigma^2) = \sigma^2(Y^k) + \sum_{j \neq k} \rho_{jk}\sigma(Y^k)\sigma(Y^j) \quad (2)$$

where covariance factors between factor k and all the rest of factors are "naturally" assigned to the contribution of factor k.

Provided that $cov(Y^k, Y^j) = \rho_{jk}\sigma(Y^k)\sigma(Y^j)$, from (1) it follows that (2) can be rewritten as

$$S_k^*(\sigma^2) = cov(Y^k, Y) \quad (3)$$

that is a measure of the contribution of factor k to overall variance.

Now, according to Shorrocks, since the variance is not mean independent, it is possible to extend what has been said so far to the square of the coefficient of variation, $I_2(Y)$, which is not affected by this problem. So,

$$if\ \rho_{jk} \neq 0\ \forall\ j \neq k \Rightarrow S_k^*(I_2) = \frac{cov(Y^k, Y)}{\mu^2(Y)} \quad (4)$$

Since the aims of this paper is to carry out an inequality decomposition by income source, it is preferable to use the generalized entropy measures because – in line with Shorrocks' point – they are additive decomposable by sources.

The generalized class of entropy measures $GE(\alpha)$ – with $\alpha \in \mathbb{R}$ – is defined as follows

$$GE(\alpha) = \begin{cases} \dfrac{1}{n\alpha(\alpha-1)} \displaystyle\sum_{i=1}^{n} \left(\left(\frac{Y_i}{\mu(Y)} \right)^{\alpha} - 1 \right) & \alpha \neq 0,1 \\ \dfrac{1}{n} \displaystyle\sum_{i=1}^{n} \frac{Y_i}{\mu(Y)} \ln \frac{Y_i}{\mu(Y)} & \alpha = 1 \\ -\dfrac{1}{n} \displaystyle\sum_{i=1}^{n} \ln \frac{Y_i}{\mu(Y)} & \alpha = 0 \end{cases}$$

Note that α is a parameter indicating the weight given to the distances between incomes at different part of the income distribution. Given that incomes may have a value equal to zero, and since we know that the Coefficient of Variation is additive decomposable, we restrict our attention to $GE(2)$, which is known to be half the square Coefficient of Variation (CV), that is,

$$GE(2) = \frac{1}{2}\frac{\sigma^2(Y)}{(\mu(Y))^2} = \frac{1}{2}CV^2 \quad (5)$$

In order to measure the contribution of the three-factor components, we use (4) that here becomes

$$CV = \sum_{k=1}^{3} \frac{cov(Y^k, Y)}{(\mu(Y))^2} \quad (6)$$

so that the proportional k-factor contribution to overall inequality of income is

$$CV_k(\%) = \frac{cov(Y,Y^k)}{\sigma^2(Y)} \tag{7}$$

that sum up to unity for all factors.

Now, in order to obtain a measure of inequality of opportunity, we consider the assumption that the only information we observe regarding the income of individuals concerns their circumstances and their effort, so we have m^C distinct circumstances and m^E distinct efforts. Consequently, individual i's income is a function of her observed circumstances and effort, a_i^C – with $a_i^C \in \mathbb{R}^{d^C}$ a vector of circumstances – and a_i^E – with $a_i^E \in \mathbb{R}^{d^E}$ a vector of efforts – unobserved variables u_i, and random variables ε_i. Formally,

$$Y_i = f\,(a_i^C, a_i^E, u_i\,, \varepsilon_i)$$

whit $f: \mathbb{R}^{d^C} \times \mathbb{R}^{d^E} \times \mathbb{R}^{d^u} \times \mathbb{R} \rightarrow \mathbb{R}^+$.

Starting from the definition – proposed by Roemer (1993) – of a type, that is, the set of individuals with the same circumstances for each $a_i^C \in d^C$, we use a non-parametric procedure in order to obtain the average income within each type of the N-population, that is computed as

$$\bar{Y}|i \in N_{k.} = \frac{1}{|N_{k.}|}\sum_{i \in N_{k.}} Y_i \tag{8}$$

where $N_{k.} = \{i \in N | a_i^C = a_n^C\}$. Then, considering the proportion (Y_i): $(\bar{Y}|i \in N_{k.}) = (\hat{Y})$: $(\bar{Y})$ we obtain the non-parametric indirect strategy proposed by Checchi and Peragine (2010) to construct the counterfactual income distribution, $\hat{Y}$, that is expressed as follows:

$$\hat{Y} = Y_i \frac{\bar{Y}}{\bar{Y}|i \in N_{k.}} \tag{9}$$

where $\hat{Y}$ is the income that would be observed if all individuals had the same circumstances.

Once the virtual income distribution has been constructed, given an inequality index, we can compute both the inequality in the actual and in the counterfactual (i.e., income inequality that would be observed if all individuals had the same circumstances) income distribution. By applying the indirect measure $I(Y) - I(\hat{Y}) = I^{OP}(Y)$ we obtain a measure of inequality of opportunity. We choose to use an indirect measure rather than a direct one. The motivation behind this stems from the fact that in Y there are inequalities due to effort, circumstances and unobserved variables, while in $\hat{Y}$ all differences due to circumstances are eliminated, so here only inequalities due to effort and unobserved variables remain. Consequently, we obtain $I^{OP}(Y)$ that effectively is a measure of inequality of opportunity because in this distribution the effect of effort and unobserved variables is cancelled out. In other words, we can control for unobserved variables, and this result would not have been achieved if we had used direct measures.

Remarkably, so far, the decomposition by income sources has never been applied in the analysis of inequality of opportunity. Therefore, we propose to standardise Y

in order to get $\hat{Y}$. However, given that $Y = Y^W + Y^C + Y^T$ and, given that we are interested in differentiating the impact of circumstances by income sources, it would be ineffective to directly standardize Y. So, we have to apply the (8) separately on Y^W, Y^C and Y^T and then, compute $\hat{Y}$ as $\hat{Y} = \hat{Y}^W + \hat{Y}^C + \hat{Y}^T$. The motivation behind this is that the two standardisations are not equivalent; in fact, if we assumed that they were, we would get

$$\frac{\bar{Y}}{\bar{Y}|\, i\in N_{k.}} = \frac{\overline{Y^W}}{\overline{Y^W}|\, i\in N_{k.}} = \frac{\overline{Y^C}}{\overline{Y^C}|\, i\in N_{k.}} = \frac{\overline{Y^T}}{\overline{Y^T}|\, i\in N_{k.}} \quad \forall_{\boldsymbol{i}} \tag{10}$$

that is, circumstances generate the same relative effect on each income source, which would be a very demanding assumption.

At that stage, we introduce the decomposition by income sources technique as follows

$$\begin{aligned}[I(Y^W) + I(Y^C) + I(Y^T)] - \left[I\left(\hat{Y}^W\right) + I\left(\hat{Y}^C\right) + I\left(\hat{Y}^T\right)\right] = \\ = I^{OP}(Y^W) + I^{OP}(Y^C) + I^{OP}(Y^T) = I^{OP}(Y^K)\end{aligned} \tag{11}$$

this allows us to obtain the contribution of each source of income to overall inequality, as well as to understand how the impact of circumstances is differentiated by work, capital, and transfer income.

Our proposal has been validated using the SHIW (Survey on Household Income and Wealth) database. We carry out the analysis by considering information about individual incomes and restrict our analysis to people aged 20-57 in order to consider all individuals who are active in the labour market and exclude pensioners.

As source of income, we use work income,, capital income and transfer income. Table 1 shows the main statistical information for each source of income and of total income. Among different income components, by comparing the mean values, it can be seen that work income, capital income, and transfer income, respectively, account for 69.11%, 29.75%, and 1.14% of total income.

Table 1. Summary statistics of incomes

Income	*Obs.*	*Mean*	*Std. Dev*	*Min*	*Max*
Y^W	3402	22383.99	33660.04	-5000	420000
Y^C	3402	9638.216	12228.34	-1381.831	338523
Y^T	3402	369.6786	1783.811	0	15600
Y	3402	32391.89	40228.73	0.155	425491.9

Source: author's computation.

As circumstance variables, we consider gender, parents' level of education, and the unemployment rate of the region of birth. Note that parents' level of education is used as a proxy of parental background and this variable has been obtained considering the average of the educational level of both parents. The unemployment rate of the region of birth is a proxy of socioeconomic conditions of the place of origin. Table 2 shows information about income according to these circumstances.

The combination of the three circumstance variables produces eight *types*, each with specific characteristics.

Table 2. Summary statistics of source of income and circumstances

Circumstances	*Obs.*	*Mean* Y	Y^W	Y^C	Y^T
Male	1673	31141.58	21678.2	9156.155	307.2209
Gender *Female*	1729	33753	23152.33	10163	437.6716
Low	1492	38979.56	27196.41	11631.55	151.6037
Unemployment rate *High*	1910	23623.06	15978.2	6984.898	659.9572
Low	1445	21039.11	13704.79	6685.892	648.4241
Parental background *High*	1957	43220.44	30662.42	12454.21	103.8045

Source: author's computation.

5. Findings

Given the distribution of total income $Y^K = (Y_1^K, .. Y_n^K)$ from sources k with $k = w, c, t$ within the population of n individuals, we compute the contribution of each source of income to overall observed inequality of opportunity (i.e. due to circumstances). The results we obtain through the (actual) income decomposition into three factor components (Table 3) show that work income accounts for most inequality in the total income distribution (80,4%). 19.9% of the contribution to inequality in the total income distribution comes from capital income. The contribution of transfer income (-0.004) is negative because $cov(Y^T, Y) < 0$. In work income, the amount of inequality is 0.50 compared with 0.12 and 0.002 in capital income and transfer income, respectively.

Table 3. Inequality decomposition of actual incomes

$GE(2) = 0.77$ $CV = 1.242$			
	s_k^*	S_k^*	$I(Y^k)$
Y^W	0.804	0.999	0.50
Y^C	0.199	0.248	0.12
Y^T	-0.004	-0.005	0.002

Source: author's computation.

Table 4 shows the results obtained by applying the decomposition technique in the counterfactual income distribution. As before, most of inequality comes from income from work, even if to a slightly greater extent (81%). When one looks at the third column as expected, the amount of inequality in the counterfactual work and

capital income distribution is smaller than that in the actual distribution, while it is higher in the transfer income distribution.

Table 4. Inequality decomposition of counterfactual incomes

$GE(2) = 0.74$ $CV = 1.215$			
	s_k^*	S_k^*	$I(\hat{Y}^k)$
$\hat{Y}^W$	0.810	0.985	0.49
$\hat{Y}^C$	0.184	0.224	0.11
$\hat{Y}^T$	0.004	0.006	0.003

Source: author's computation.

Merging the two procedures, we compute (11) and obtain the contribution of each source of income to overall observed inequality of opportunity, shown in Table 5. According to the analysis, in Italy in 2022, 10% of the observed inequality stems from factors beyond individual control (circumstances). By adding the decomposition technique, it can also be said this 2% of that inequality originates from work income and 8% from capital income. -50% is the share in transfer income, that is, the reduction in inequality of opportunity that should be reached through generic subsidies transfers.

Table 5. The measurement of inequality of opportunity

	$I(Y)$	$I(\hat{Y})$	$I^{OP}(Y)$	$I^{OP}(Y^K)$	$\frac{I^{OP}(Y)}{I(Y)}$
Y	0.30	0.27	0.03		10%
Y^W	0.50	0.49		0.01	2%
Y^C	0.12	0.11		0.01	8%
Y^T	0.002	0.003		-0.001	-50%

Source: author's computation.

6. Conclusions

Measuring the origins of inequality through its decomposition into several factor components is relevant from a public policy perspective because policy-makers can focus on major drivers of inequality and, as such, they can more accurately target interventions to face this phenomenon. However, starting from relevant contribution (Rawls, 1958, 1971; Roemer, 1998), social justice starts to be incorporated in the analysis of inequality. Thus, various dimensions of inequality, such as inequality of opportunity, began to be discussed and measured. In this paper, we focus on differentiating the impact of circumstances on work, capital, and transfer income to provide a comprehensive understanding of the factors that contribute to income inequality. The relevance of this proposal lies in the possibility of (i) examining the determinants of inequality of opportunity, (ii) investigating the contribution – of each circumstance – and the channels of transmission through which circumstances affect overall inequality, and (iii) identifying the share of inequality of opportunity in each

factor components. In order to assess our proposal, we have run an empirical exercise, and the analysis shows that overall inequality is 0.30 and its main driver is work income (80.4). A minor contribution comes from capital income (19.9), and the contribution of transfer income is negative (-0.004). The amount of overall inequality of opportunity is 0.03. Specifically, applying the proposed methodology, we observe that 10% of the observed inequality is due to different circumstances. By adding the decomposition technique, it can also be seen this 2% of that inequality originates from work income and 8% from capital income. -50% is the share in transfer income, that is, the reduction in inequality of opportunity that should be reached through generic subsidies transfers. This result may be a valuable starting point for the introduction of new types of taxation on capital gains that can lead to the reduction of unfair inequalities. However, this analysis faces a strong limitation: its weakness relates to the use of the database mentioned above, which does not contain the necessary information on all the circumstances we could have considered. Future research will be devoted to improving the methodology, applying it to a database that allows for a better identification of circumstances.

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