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Inequality of Opportunity in a Multiperiod Framework

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ABSTRACT

This paper offers a simple model to evaluate and measure inequality of opportunity in a multiperiod framework, in which both circumstances and effort may change over time. We adopt a norm-based approach and an axiomatic methodology: we first characterise two alternative definitions of a 'fair distribution', associated respectively with the ex ante and ex post views of equality of opportunity; then we characterise a family of indexes of multiperiod inequality of opportunity expressed as an appropriate distance between the fair and the actual distributions. The proposed framework is then applied to evaluate the Korean distribution of income from a multiperiod and opportunity egalitarian perspective.

JEL Classification: D31, D63, I32, J62

1 | Introduction

Understanding the origins of inequality and its trend over time has become the focus of an increasing number of contributions in various branches of economic literature. At the same time, these themes have garnered much attention in the policy agenda. Economists and policymakers have investigated the role of inequality in determining different macroeconomic events and the distributive consequences of these events.

One perspective that has proven to be particularly successful in analysing the characteristics of economic inequalities in recent years is represented by the equality of opportunity (EOp) approach. According to this approach, one should distinguish between outcome inequalities that are due to factors beyond individual control, such as, for example gender, social origin or colour of skin and outcome inequalities due to factors that lie within the sphere of individual responsibility and control. The EOp theory postulates that the former inequalities are unfair and should be eliminated as much as possible, while the latter inequalities, due to individual effort and choices, might be considered more acceptable.

Beyond theoretical reasoning proposed by prominent political philosophers such as [1–6], the EOp approach rests on compelling empirical evidence that people indeed disapprove inequalities rooted in factors beyond individual control: elicited preferences for redistribution show that individuals are more willing to accept income differences which are due to effort rather than exogenous circumstances [7–9]. Furthermore, the distinction between effort-based and circumstance-based inequalities may offer a solid argument against the view that defends existing outcome inequalities as a necessary price to pay for incentivizing individuals in a market economy. Along this line of reasoning, recent contributions in the literature have proposed to distinguish between 'good' and 'bad' inequalities (see [10–12]). The idea is that income differences that arise from the reward of different effort levels might be efficiency enhancing and associated with faster economic growth; while other kinds of differences, arising from unequal opportunities associated with predetermined circumstances, might be detrimental to growth.

Mainly inspired by the philosophical debate on responsibility-sensitive egalitarian justice, [13–17] have proposed formal economic models. In these models, the concept of EOp is articulated into two independent principles: the first principle, called Compensation, states that people should be compensated for unequal circumstances. A prominent formulation of this principle—ex ante compensation—postulates that the value of opportunity sets should be equalised across people with different circumstances. The principle is ex ante in the sense that opportunity sets are evaluated before the individual level of effort is revealed. An alternative expression—ex post compensation—starts from the identification of individual effort and requires that individuals with the same effort should obtain the same outcomes, regardless of circumstances. Hence, while the ex post approach focuses on the inequality between achievements of individuals exerting the same level of effort, the ex ante approach focuses on the inequality between individual opportunity sets. The second principle inherent to the concept of EOp—the principle of Reward—states that individuals should be rewarded for differences in effort. While there are different formulations of this idea, one prominent version is the principle of utilitarian reward, stating that social preferences should express neutrality with respect to outcome inequalities among individuals with the same circumstances.

Following the models above, a rich theoretical and empirical literature has flourished in the last decades and has proposed different approaches and methodologies to measure the degree of inequality of opportunity (IOp): see [18–20] for comprehensive surveys. However, most existing contributions propose cross-sectional and unitemporal measures.[1] On the other hand, over the last decades, increasing discontent has been expressed with respect to distributional analyses based on observations of income for a single period. Different authors have argued in favour of the extension of the time horizon when making individual and social welfare evaluations. The line of reasoning is that high annual inequality might occur side by side with little or no inequality in long-term incomes, if individuals' positions in annual income distributions change over time. Moreover, income fluctuations over time may affect individual welfare 'per se', and hence need to be accounted for when making welfare comparisons. This has led to a spur of research on inequality and social welfare in long-term incomes according to the traditional Equality of Outcome view [23–26].

The present paper fills a gap in the existing literature: we propose a framework for the measurement of IOp that accounts for individuals' income streams, thereby introducing a multiperiod perspective. Our framework includes the possibility that both circumstances and effort change over time. This assumption is novel in the literature, usually concerned with circumstances at birth, hence fixed over time.

To obtain our measures of multiperiod IOp, we follow a norm-based approach [27–29], according to which a measure of inequality is derived by looking at the distance between the actual distribution and a reference (or norm) distribution. Both the norm distribution and the distance functions are derived using an axiomatic methodology, which clarifies the normative judgements implied. In particular, we propose two norm distributions, inspired by the two alternative interpretations of the EOp view discussed above (see [30, 31], for a discussion). Once the norm distribution is defined, we characterise a family of measures that evaluate pairs of observed and norm distributions by looking at the history of opportunity (dis)advantage experienced by individuals. Interestingly, our family contains (the negative of) the average across time of the Mean Logarithmic Deviation (MLD) of the time-specific distributions. Finally, we provide an empirical application of our measurement model by analysing the Korean distribution of incomes from a multiperiod and opportunity egalitarian perspective.

Our paper is especially related to Aaberge et al. [21], who propose an evaluation of multiperiod income distributions from an opportunity egalitarian perspective. Their approach is based on long-term incomes, in the spirit of the permanent income hypothesis à la Milton Friedman: their first step consists of aggregating the income stream of each individual into an interpersonally comparable measure of permanent income; the second step consists in applying measures of inequality of opportunity to the distribution of permanent incomes. We depart from Aaberge et al. [21] in several respects. First, we allow for time-varying circumstances, while their framework allows only for fixed circumstances. Second, we implement a norm-based and axiomatic approach to IOp measurement, which, in our judgement, renders more explicit the value judgements implied by our measures. Most importantly, their measure of permanent income is an exclusive function of the individual income stream; that is to say, they ignore the variation over time in the effect of circumstances, hence in the distribution of opportunities over time. On the other hand, we propose a framework which explicitly recognises that not only income, but both (the effect of) circumstances and effort might change over time. Our framework recognises this and is able to express different value judgements on the distribution of opportunities over time.

Our work is also related to [32] and Almås et al. [33], who propose a criterion to rank distributions according to EOp based on the concept of individual fairness gap. However, they employ an unitemporal framework and do not provide an axiomatic characterisation of the proposed measure. A recent application of EOp in an intertemporal setting has been proposed by [22]. While [22] assesses EOp in a stationary state, which can be considered the end of a (long) time span, we suggest assessing opportunity inequality between the beginning and the end of this period, in order to give more weight to the history of each individual.

The rest of the paper is organised as follows: Section 2 introduces the necessary notation. Section 3defines two norm distributions inspired by the EOp principle. Section 4 presents the axiomatic characterisation of the societal measure of multiperiod EOp. Section 5 presents the empirical application. Section 6 concludes. All proofs are gathered in the S1.

2 | Preliminaries

We assume to observe for $T \in \mathbb{N}_{++}$ periods a population of $N \in \mathbb{N}_{++}$ individuals. The income of an individual $i \in \{1, \ldots, N\} = \mathcal{N}$ at time $t \in \{1, \ldots, T\} = \mathcal{T}$ is denoted $x_{it} \in \mathbb{R}_{++}$ and is assumed to be a function of his circumstances and effort at time t. Hence, an individual i with circumstances $c_{j,t} \in \left\{c_{1,t}, \ldots, c_{n,t}\right\} = \mathcal{C}_t$ and effort $e_{k,t} \in \left\{e_{1,t}, \ldots, e_{m,t}\right\} = \mathcal{E}_t$ at time t will have income $x_{it} = f_t\left(c_{j,t}, e_{k,t}\right)$.

We do not distinguish between observed and market incomes, where the former should account for government intervention (taxes and transfers). While the above f_t is closer to the concept of market income, the following analysis can also be performed using observed incomes by including transfers and taxes as determinants of individual income.[2] This extension would have no impact on the results. In the rest of the paper, we focus on market income as it allows to use a simpler notation.

In line with the standard framework proposed by [14], we assume that all factors influencing income can be classified as either circumstances or effort. This implies that, whenever effort partially depends on circumstances, we adopt Roemer's [14] convention of including, among circumstances, the portion of effort influenced by circumstances.[3] Consequently, $e_{k,t}$ must represent only the component of effort that is independent of circumstances. As will become evident in Section 3, this assumption is less critical for ex ante approaches to measuring IOp. In contrast, when the measurement of IOp requires the identification of individual effort, one can rely on [13]'s pragmatic strategy to clean effort from the influence of circumstances: the well-known Roemer's Identification Assumption (RIA).[4] The current multiperiod framework accommodates the possibility that present effort depends on past effort and present circumstances on past circumstances, which remains fully consistent with our approach. However, the framework excludes cases where present circumstances depend on past effort or vice versa, as such cases would violate the classification assumption.

The time span T, taken as fixed across individuals, refers to a number of life sub-periods. In principle, T could be the entire life span, if one is willing to assume that individuals have identical life durations. We do not constrain the population to belong to the same age cohort. While nothing prevents the evaluator from making such an assumption, in a population with heterogeneous birth dates, we can still account for the effect of age on income by adequately defining effort and circumstances.[5]

The problem at hand can be formalised as follows: Let $\mathcal{C} = (\mathcal{C}_t)_{t=1,\dots,T}$ and $\mathcal{E} = (\mathcal{E}_t)_{t=1,\dots,T}$ be the lists of circumstance and effort sets and let $f = (f_t)_{t=1,\dots,T}$ be the list of income generating functions that generate the income distribution $X = (x_{it})_{t=1,\dots,T}^{i=1,\dots,N}$. We seek to define a measure $\phi(X, f, \mathcal{C}, \mathcal{E})$ of inequality of opportunity in X, given $(f, \mathcal{C}, \mathcal{E})$. In this setting, we assume that the construction of ϕ is decomposable along two steps: (i) defining an opportunity egalitarian distribution, (ii) measuring the divergence between actual and fair income distributions. By separating the measurement from the definition of fairness, we obtain a flexible framework which can be adapted to different norm distributions. Defining a measurement criterion that is specific to a given norm distribution would force us to choose a 'favorite' definition of EOp. While we do not want to make this choice here, we should also notice that it may be interesting to assess whether a given population is closer to, say, an ex ante or an ex post definition of EOp. Ensuring that the evaluation criterion is independent of the norm distribution is functional to give meaning to such comparisons.

We do not impose any structure on the elements of $\mathcal{C}_t$ and $\mathcal{E}_t$; they can contain numbers, vectors or sets: this has no impact on our framework. To simplify the exposition in Section 3, we assume that each combination of circumstances and effort $(c_{j,t}, e_{k,t})$ occurs exactly once per time period and that circumstances and effort sets are countable with fixed cardinality, so that $|\mathcal{C}_t| = n \geq 2$, $|\mathcal{E}_t| = m \geq 2$, for all $t \in \mathcal{T}$, and $nm = N$. We make this assumption for notational simplicity; the extension to the general case is straightforward (see [35], for example) and is implemented in our application. The use of time-specific functions f_t accounts for changes in the way circumstances (and effort) influence outcomes over time.

Let us shorten the notation by denoting with $x_{jk,t}$ the income of an individual with circumstances $c_{j,t} \in \mathcal{C}_t$ and effort $e_{k,t} \in \mathcal{E}_t$ at time t. Under these assumptions, for all time periods t, we can write the unitemporal income distribution, $X_t \in \mathbb{R}_{++}^{n\times m}$, in the following matrix form:

$$X_t = \begin{bmatrix} x_{11,t} & \cdots & x_{1k,t} & \cdots & x_{1m,t} \\ \vdots & & \vdots & & \vdots \\ x_{j1,t} & \cdots & x_{jk,t} & \cdots & x_{jm,t} \\ \vdots & & \vdots & & \vdots \\ x_{n1,t} & \cdots & x_{nk,t} & \cdots & x_{nm,t} \end{bmatrix}.$$

This matrix describes the income distribution in the population in a period t. Each jth row represents the income distribution of individuals sharing the same circumstances $c_{j,t}$ (called *type j of t*), while each kth column contains the income of individuals exerting the same level of effort $e_{k,t}$ (called *tranche k of t*).

The multiperiod income distribution is represented by a matrix $X \in \mathbb{R}_{++}^{N\times T}$ such that each column represents an unitemporal income distribution, each row is the multiperiod income stream of a single individual, and the element $x_{it} \in X$ is the income of agent i at time t:

$$X = \begin{bmatrix} x_{11} & \cdots & x_{1t} & \cdots & x_{1T} \\ \vdots & & \vdots & & \vdots \\ x_{i1} & \cdots & x_{it} & \cdots & x_{iT} \\ \vdots & & \vdots & & \vdots \\ x_{N1} & \cdots & x_{Nt} & \cdots & x_{NT} \end{bmatrix}.$$

The matrix $X \in \mathbb{R}_{++}^{N\times T}$ is therefore obtained by listing the elements of the unitemporal income distributions $\left(X_t \in \mathbb{R}_{++}^{n\times m}\right)$ in such a way that each column t of X contains all the elements of X_t, and in each row of X we have the income levels of a unique individual across time.[6] Therefore, $x_{it} \in X$ is the income of individual i at time t which, assuming she has circumstances $c_{j,t}$ and effort $e_{k,t}$, corresponds to the element $x_{jk,t}$ in X_t.

We denote by $\tilde{X} \in \mathbb{R}_{++}^{N\times T}$ the norm or benchmark distribution such that, for all $\tilde{x}_{it} \in \tilde{X}$, $\tilde{x}_{it}$ is the norm income level that an individual i at time t would have enjoyed if the society were to fully achieve EOp. As for the multiperiod income distribution, each column of $\tilde{X}$ can be rewritten as a matrix $\tilde{X}_t \in \mathbb{R}_{++}^{n\times m}$ whose element $\tilde{x}_{jk,t}$ is the norm income of an individual with circumstance $c_{j,t}$ and effort $e_{k,t}$.

The norm-based approach, roughly speaking, requires evaluating a given distribution on the basis of a measure of the divergence between observed incomes and norm incomes (see [27–29]). In what follows, we propose two norm distributions derived from the opportunity egalitarian paradigm; then, we proceed with the derivation of a measure of multiperiod inequality of opportunity.

3 | Norm Distributions

Let us call $\mathcal{X}(X) = \mathbb{R}_{++}^{N\times T}$ the set of all possible norm distributions $\tilde{X}$ that we can assign to X. Recall that $x_{jk,t}$ and $\tilde{x}_{jk,t}$ denote, respectively, the actual and norm income of an individual with circumstances $c_{j,t} \in C_t$ and effort $e_{k,t} \in \mathcal{E}_t$, and that each $x_{jk,t} \in X_t$ (resp. $\tilde{x}_{jk,t} \in \tilde{X}_t$) corresponds to exactly one $x_{it} \in X$ (resp. $\tilde{x}_{it} \in \tilde{X}$).

The first basic requirements we impose on a norm distribution are feasibility and efficiency. While the former constraint ensures that the total income in the society is sufficient to achieve the norm, the latter requires that, in the redistribution process no resources are wasted. Following the literature, we collapse these two requirements into the following strong version of feasibility:

- *Strong feasibility*—For all $X \in \mathbb{R}_{++}^{N\times T}$, $\tilde{X} \in \mathcal{X}(X)$ is such that $\sum_{j,k=1}^{n,m} \tilde{x}_{jk,t} = \sum_{j,k=1}^{n,m} x_{jk,t}$, for all $t \in \mathcal{T}$.

We now focus on the properties explicitly inspired by the EOp theory. The first principle we introduce, called *strong ex post compensation*, is based on the idea that in a fair society, individuals who exert the same level of effort should obtain the same outcome. This is a recurrent normative principle in the EOp literature, since early contributions (see, e.g., [14, 16, 36]). In a model where effort is the only choice variable, income differences between two individuals exerting the same effort are caused by factors out of individual control (circumstances), hence deemed unfair. In its most common version, ex post compensation requires a redistribution mechanism to reduce inequalities among individuals with the same effort. In other words, it imposes *some* degree of aversion to inequality within tranches. For the normal distribution, we interpret this principle in a strong way and require that individuals exerting the same level of effort should receive the same income:

- *Strong ex post compensation*—For all $X \in \mathbb{R}_{++}^{N\times T}$, $\tilde{X} \in \mathcal{X}(X)$ is such that $\tilde{x}_{jk,t} = \tilde{x}_{hk,t}$, for all $t \in \mathcal{T}$, $j, h \in \{1, \ldots, n\}$ and $k \in \{1, \ldots, m\}$.

In words, if $\tilde{X}$ satisfies strong ex post compensation, then at each time period, any pair of individuals exerting the same level of effort should also have the same income.

The next property, inspired by the reward principle, it proposes a way to preserve the inequality induced by differences in individual effort. One of the most compelling expressions of this principle is the 'liberal' or 'natural' reward, widely discussed in Fleurbaey [17]. It imposes that redistribution mechanisms respect the absolute income differences between individuals with the same circumstances and different efforts. This condition would impose $\tilde{X}$ to be such that $\tilde{x}_{jk,t} - x_{jk,t} = \tilde{x}_{jr,t} - x_{jr,t}$ for any pair of individuals k and r belonging to the same type j of t. Despite its appeal, it is well known that liberal reward is incompatible with the above strong ex post compensation principle (see [16, 36, 37]).

We propose here to implement the weaker[7] requirement put forward by Trannoy [38]. This axiom imposes that the absolute income differences between individuals with different effort are preserved *on average*. Intuitively, if liberal reward cannot always be satisfied, we demand that it holds at least in expectation.[8] Following Trannoy [38], we call this principle *mean natural reward*.

- *Mean natural reward*—For all $X \in \mathbb{R}_{++}^{N\times T}$, $\tilde{X} \in \mathcal{X}(X)$ is such that $\frac{1}{n}\sum_{j=1}^{n}(\tilde{x}_{jk,t} - x_{jk,t}) = \frac{1}{n}\sum_{j=1}^{n}(\tilde{x}_{jr,t} - x_{jr,t})$, for all $t \in \mathcal{T}$ and $k, r \in \{1, \ldots, m\}$.

The following proposition shows that there is only one multiperiod opportunity egalitarian distribution that satisfies strong feasibility, strong ex post compensation and mean natural reward: the *ex post EOp distribution*.[9]

Proposition 1. *For all $X \in \mathbb{R}_{++}^{N\times T}$, $\tilde{X} \in \mathcal{X}(X)$ satisfies strong feasibility, strong ex post compensation and mean natural reward if and only if, for all $i \in \mathcal{N}$ and $t \in \mathcal{T}$, if $e_{k,t} \in \mathcal{E}_t$ is the effort level of the individual i at t, then $\tilde{x}_{it} \in \tilde{X}$ is*

$$\tilde{x}_{it} = \frac{1}{n}\sum_{j=1}^{n} f_t(c_{j,t}, e_{k,t}) \tag{1}$$

with $c_{j,t} \in C_t$. We refer to this as the Ex post EOp distribution.

In words, in the Ex post EOp distribution, at each period, each individual receives the average income across individuals who exert the same effort level. Notice that the Ex post EOp distribution $\tilde{X}$ is obtained from X through a series of within-tranche progressive transfers at each t. Therefore, while ensuring that the average difference between the fair and current income in a given tranche of a given period is always the same—because $1/n\sum_{j=1}^{n}(\tilde{x}_{jk,t} - x_{jk,t}) = 1/n\sum_{j=1}^{n}\left(\left(1/n\sum_{j=1}^{n} x_{jk,t}\right) - x_{jk,t}\right) = 0$ for all tranches k and periods t—this norm distribution also realises equality between incomes of individuals exerting the same effort in the same period.[10]

We now turn to the alternative interpretation of the compensation principle, which requires the reduction of inequality between individual opportunity sets. In the standard formal EOp framework, the individual opportunity set is represented by the income distribution of the type the individual belongs to. Hence, reducing inequality in opportunity sets amounts to reducing the inequality between types' income distributions. Following Fleurbaey & Peragine [37], we refine this principle by evaluating individual opportunity sets via the type's average incomes and impose the following *ex ante mean compensation*:

- *Ex ante mean compensation*—For all $X \in \mathbb{R}_{++}^{N\times T}$, $\tilde{X} \in \mathcal{X}(X)$ is such that $\frac{1}{m}\sum_{k=1}^{m} \tilde{x}_{jk,t} = \frac{1}{m}\sum_{k=1}^{m} \tilde{x}_{hk,t}$, for all $t \in \mathcal{T}$ and $j, h \in \{1, \ldots, n\}$.

Therefore, an optimal distribution that satisfies ex ante mean compensation realises equality between the average incomes of the types, at each of the considered periods. To deal with within-type inequality, we impose a proportional reward, according to which income redistribution is allowed as long as each individual holds the same share of the type income. This reward principle preserves the (relative) inequality in the type distribution. We can also interpret it as a solidarity principle which asks individuals in each type to contribute, in proportion to their income, to the between-type redistribution needed to realise EOp:

- *Proportional reward*—For all $X \in \mathbb{R}_{++}^{N\times T}$, $\tilde{X} \in \mathcal{X}(X)$ is such that $\frac{\tilde{x}_{jk,t}}{\sum_{r=1}^{m}\tilde{x}_{jr,t}} = \frac{x_{jk,t}}{\sum_{r=1}^{m}x_{jr,t}}$ for all $t \in \mathcal{T}$, $j \in \{1,\dots,n\}$ and $k \in \{1,\dots,m\}$.

In words, according to the proportional reward principle, if an individual has an income that constitutes a fraction y of the total income of his type, then his norm income must still be a fraction y of the total norm income of his type.[11] This requirement implies that the relative position of each individual within a type does not change when moving from the actual to the fair income distribution. The following proposition shows that there is only one multiperiod opportunity egalitarian distribution that satisfies strong feasibility, ex ante mean compensation and proportional reward: the *ex ante EOp distribution*.[12]

Proposition 2. *For all $X \in \mathbb{R}_{++}^{N\times T}$, $\tilde{X} \in \mathcal{X}(X)$ satisfies strong feasibility, ex ante mean compensation and proportional reward if and only if, for all $i \in \mathcal{N}$ and $t \in \mathcal{T}$, if $c_{j,t} \in C_t$ is the circumstance of individual i at t, with income $x_{it} \in X$, then $\tilde{x}_{it} \in \tilde{X}$ is*

$$\tilde{x}_{it} = x_{it}\,\frac{\frac{1}{nm}\sum_{h=1}^{n}\sum_{k=1}^{m} f_t\left(c_{h,t}, e_{k,t}\right)}{\frac{1}{m}\sum_{k=1}^{m} f_t\left(c_{j,t}, e_{k,t}\right)} \tag{2}$$

with $e_{k,t} \in \mathcal{E}_t$. We refer to this as the Ex ante EOp distribution.

In words, at any of the considered periods, the fair income of an individual according to ex ante mean compensation and proportional reward is obtained by rescaling his actual income by the ratio between the overall mean income and the mean income of their type. Interestingly, the norm distribution obtained using this rescaling operation coincides with the *standardized distribution* used in the literature to capture *within group* inequality and to decompose overall inequality into a between and within-group components.[13] Thus, Proposition 2 provides a normative justification for this standard decomposition procedure, widely adopted in the literature.

These two multiperiod norm distributions need not be interpreted simply as a succession of static ones. While this can, of course, be the case, in principle, one could also define a norm distribution $\tilde{X}$ that, for example, remunerates individuals for past effort by granting them higher norm incomes. Moreover, since we do not impose any structure on the elements of $\mathcal{E}_t$, one can define effort at time t as the history of effort up to t. The same, of course, can be done for circumstances, provided we are still able to clearly distinguish effort history from circumstance history.

We now turn to the assumption that each combination of circumstances and effort occurs exactly once. If we relax this simplifying assumption, technical adjustments are required; however, the substance of the analysis remains unchanged. More precisely, Equations (1) and (2) become, respectively:

$$\tilde{x}_{it} = \sum_{j=1}^{n_t} \frac{f_t\left(c_{j,t}, e_{k,t}\right)p\left(c_{j,t}, e_{k,t}\right)}{\sum_{j=1}^{n_t} p\left(c_{j,t}, e_{k,t}\right)} \tag{3}$$

$$\tilde{x}_{it} = x_{it}\,\frac{\frac{1}{N}\sum_{h=1}^{n_t}\sum_{k=1}^{m_t} f_t\left(c_{h,t}, e_{k,t}\right)p\left(c_{h,t}, e_{k,t}\right)}{\frac{1}{\sum_{k=1}^{m_t} p\left(c_{j,t}, e_{k,t}\right)}\sum_{k=1}^{m_t} f_t\left(c_{j,t}, e_{k,t}\right)p\left(c_{j,t}, e_{k,t}\right)} \tag{4}$$

where n_t denotes the number of circumstances in the set C_t, m_t denotes the number of elements in the set $\mathcal{E}_t$, and $p\left(c_{j,t}, e_{k,t}\right)$ is the number of individuals with characteristics $\left(c_{j,t}, e_{k,t}\right)$, such that $\sum_{h=1}^{n_t}\sum_{k=1}^{m_t} p\left(c_{h,t}, e_{k,t}\right) = N$. This formulation makes it clear that each observed income $f_t\left(c_{j,t}, e_{k,t}\right)$ must be weighted by the number of individuals who earn it. Consequently, if there exists a pair $\left(c_{j,t}, e_{k,t}\right)$ such that $p\left(c_{j,t}, e_{k,t}\right) = 0$, it is sufficient to set $f_t\left(c_{j,t}, e_{k,t}\right)$ to a constant β to ensure that norm incomes are well defined.

We conclude this section with a comment on the relationship between Pareto efficiency and the norm distribution. Our theoretical framework does not incorporate individual preferences, making it difficult to directly assess Pareto efficiency. Nonetheless, due to our strong feasibility constraint, the norm distribution can be interpreted as a redistribution of total income. This has two important implications.

First, even in the simple case where individuals derive utility solely from their income, it is impossible for a norm distribution to represent a Pareto improvement over the status quo. Formally, assume that all individuals share the same monotonic utility function $u : \mathbb{R}_+ \to \mathbb{R}$. For simplicity, consider a single time period. If $\sum_{j,k=1}^{n,m}\tilde{x}_{jk,t} = \sum_{j,k=1}^{n,m}x_{jk,t}$ but $X_t \neq \tilde{X}_t$, then there must exist at least one pair (j,k) such that $u\left(x_{jk,t}\right) > u\left(\tilde{x}_{jk,t}\right)$. Thus, $\tilde{X}_t$ cannot be a Pareto improvement over X_t. More broadly, Pareto efficiency is often at odds with fairness and egalitarian principles [42].

Second, the strong feasibility condition imposes an upper bound on the total resources that can be sacrificed to achieve a fair distribution. Continuing with the same formalisation, it rules out the possibility that $u\left(x_{jk,t}\right) > u\left(\tilde{x}_{jk,t}\right)$ for all (j,k). In words, strong feasibility excludes norm distributions in which everyone has a lower income than in the current one.

This observation becomes more compelling when considered alongside the empirical regularity that unequal distributions often have a mean income higher than the median. As a result, in a majority vote between the current distribution and a fully egalitarian one, the latter is likely to win majority support. As we will demonstrate in the empirical analysis, a similar dynamic emerges within the opportunity-egalitarian framework, where more than half of the population tends to earn less than their fair income.

4 | Ranking Criteria

The previous section showed that, given some opportunity egalitarian criteria, for each income distribution $X \in \mathbb{R}_{++}^{N\times T}$ there exists an optimal distribution $\tilde{X} \in \mathbb{R}_{++}^{N\times T}$ that assigns a unique fair income to each individual in the population. This allows us to implement the norm based approach and take the divergence between X and $\tilde{X}$ as a measure of multiperiod IOp.

Let $D = \{(A,B) \in \mathbb{R}^{N\times T}_{++} \times \mathbb{R}^{N\times T}_{++} : N, T \in \mathbb{N}_{++}\}$ be the set of all pairs of matrices of dimension $N \times T$. In this section we axiomatically define a social evaluation function $\gamma : D \to \mathbb{R}$ such that $\gamma(X, \tilde{X})$ evaluates X with respect to the norm distribution $\tilde{X}$. To the extent that $\tilde{X}$ is a multiperiod opportunity egalitarian distribution, like those introduced in the previous section, γ is a measure of multiperiod IOp in X.

We begin by normalising our social evaluation function to be zero whenever every individual obtains their fair income.

- Normalization (NORM)—For all $(X, \tilde{X}) \in D$, if $x_{it} = \tilde{x}_{it}$ for all $(i,t) \in \mathcal{N} \times \mathcal{T}$, then $\gamma(X, \tilde{X}) = 0$.

A minimal, normative requirement for γ is to be increasing in the observed income, for a fixed norm distribution.[14]

- Monotonicity (MON)—For all $(X, \tilde{X}), (X', \tilde{X}) \in D$, if $x_{it} \geq x'_{it}$ for each pair $(i,t) \in \mathcal{N} \times \mathcal{T}$ and $x_{jt} > x'_{jt}$ for at least one pair $(j,t) \in \mathcal{N} \times \mathcal{T}$, then $\gamma(X, \tilde{X}) > \gamma(X', \tilde{X})$.

Our third requirement, which is standard in the literature, is anonymity. As is often the case in the EOp literature, one needs to impose a partial version of this principle in order to accommodate different treatment of individuals in different circumstances. In the current framework, we require individuals to be treated symmetrically, conditional on having the same histories of observed and fair incomes.

- Anonymity (AN)—For all $(X, \tilde{X}) \in D$, let π be a row-permutation operator, then $\gamma(X, \tilde{X}) = \gamma(\pi X, \pi \tilde{X})$.

The next axiom requires the evaluation of X, with respect to the norm distribution $\tilde{X}$, to depend on pairs $(x_{it}, \tilde{x}_{it})$ of observed and fair incomes. For any of such pairs, it assumes the existence of a measure of the advantage that individual (i,t) experiences with respect to its norm income. The literature (see, e.g., [33, 43]) often relies on the difference between observed and fair incomes. We instead adopt a more general approach that assumes the existence of such an advantage measure without specifying it a priori.

- Additive separability (AS)—There exist differentiable functions $u_i : \mathbb{R}^T \to \mathbb{R}, i \in \mathcal{N}$, and a function $a : \mathbb{R}^2_{++} \to \mathbb{R}$ with $a(y,y) = 0$ for all y, such that for all $(X, \tilde{X}) \in D$,

$$\gamma(X, \tilde{X}) = \sum_{i=1}^{N} u_i\left(a(x_{i1}, \tilde{x}_{i1}), \ldots, a(x_{iT}, \tilde{x}_{iT})\right).$$

This axiom imposes γ to independently assess histories of advantages, and perform a simple additive aggregation across individuals. The additive structure of the social evaluation function is recurrent in the literature (see, e.g., [27–29]). It ensures that, when comparing two distributions, only the situation of those experiencing changes matters. Moreover, it allows us to compute the total change in social evaluation by directly summing the changes in the individual evaluations. We should stress here that, additivity is imposed only across individuals. At the individual level, instead, the above axiom applies a weaker form of separability, which requires individual assessments to be performed by looking at streams of opportunity advantages. One can notice a parallel between $u_i\left(a(x_{i1}, \tilde{x}_{i1}), \ldots, a(x_{iT}, \tilde{x}_{iT})\right)$ and an individual intertemporal utility function that ranks profiles of advantages, or deviations from a time-specific reference outcome. Individual preferences are, however, absent from this framework and $u_i(.)$ should be seen as an expression of the social evaluator's preferences over advantage streams for individual i. Because of Monotonicity, advantages can take negative values, which are to be interpreted as opportunity disadvantages.

Additive separability defines a complete and continuous ranking of pairs of distributions $(X, \tilde{X}) \in D$. It is well known that, for AS to be compatible with AN, we must have $u_i = u$ for all $i = 1, \ldots, N$. Therefore, the ranking on D naturally induces a ranking on $\mathbb{R}^T_{++} \times \mathbb{R}^T_{++}$, which is represented by the function u in combination with a. The next axiom builds on this ranking to define a consistent notion of aversion to multiperiod IOp. To shorten notation, for all $(X, \tilde{X}) \in D$ and $i \in \mathcal{N}$, let $\mathbf{a}_i(X, \tilde{X}) = \left(a(x_{i1}, \tilde{x}_{i1}), \ldots, a(x_{iT}, \tilde{x}_{iT})\right)$.

- Inequality aversion (IA)—For all $(X, \tilde{X}), \left(X', \tilde{X}'\right) \in D$ such that $\mathbf{a}_i(X, \tilde{X}) = \mathbf{a}_i\left(X', \tilde{X}'\right)$ for all $i \in \mathcal{N} \setminus \{j,k\}$, if $u\left(\mathbf{a}_j(X, \tilde{X})\right) \geq u\left(\mathbf{a}_k(X, \tilde{X})\right)$, and there exists $\epsilon \in \mathbb{R}^T_{++}$ such that $\mathbf{a}_j\left(X', \tilde{X}'\right) = \mathbf{a}_j(X, \tilde{X}) + \epsilon$ and $\mathbf{a}_k\left(X', \tilde{X}'\right) = \mathbf{a}_k(X, \tilde{X}) - \epsilon$, then $\gamma(X, \tilde{X}) \geq \gamma\left(X', \tilde{X}'\right)$.

The previous axiom defines a multiperiod version of the Pigou-Dalton transfer principle that is consistent with the ranking of the individual histories. In words, IA states that a progressive transfer from an individual with a better historical advantage to one with a worse history reduces IOp.

The previous axioms are formulated without much emphasis on the time component, which we have so far treated simply as an additional dimension of heterogeneity. The following two axioms deal explicitly with the role of time. More precisely, they define how γ responds to the exact moment in which an opportunity advantage occurs.

Following Amartya Sen's [44] discussion of the *happy slaves* condition, the literature has investigated if and how individuals adapt to income shocks and deprivation [45, 46, among others]. Using Sen's words: *A thoroughly deprived person, leading a very reduced life, might not appear to be badly off in terms of the mental metric of utility, if the hardship is accepted with non-grumbling resignation. In situations of longstanding deprivation, the victims do not go on weeping all the time, and very often make great efforts to take pleasure in small mercies and cut down personal desires to modest—'realistic'—proportions* [44, p. 45]. In line with this view, it is likely that individuals change behaviour, hence effort, after experiencing a negative opportunity shock. Depending on the evaluator's assumption about preferences, one can consider these changes to be more or less permanent, hence sensitive to the length of the time span. There is, however, wide evidence about the consequences of negative shocks during childhood and early adulthood on future outcomes, and we believe that the social evaluation should capture these potential spillovers. Therefore, the opportunity advantage at period t should matter more than the same advantage occurring at $t+1$, because the former may have influenced the latter, as well as subsequent opportunity advantages. The following axiom formalises this idea.

- Early Advantages (EA)—For all $(X, \tilde{X})$, $(X', \tilde{X})$, $(X'', \tilde{X}) \in D$ such that $\mathbf{a}_i(X, \tilde{X}) = \mathbf{a}_i(X', \tilde{X}) = \mathbf{a}_i(X'', \tilde{X})$ for all $i \in \mathcal{N} \setminus \{j\}$, if there exist $\epsilon^t, \epsilon^s \in \mathbb{R}^T_{++}$, with $\epsilon^t_k = 0$ for all $k \in \mathcal{T} \setminus \{t\}$, $\epsilon^s_k = 0$ for all $k \in \mathcal{T} \setminus \{s\}$ and $\epsilon^t_t = \epsilon^s_s > 0, t < s$, such that $\mathbf{a}_j(X', \tilde{X}) = \mathbf{a}_j(X, \tilde{X}) + \epsilon^t$ and $\mathbf{a}_j(X'', \tilde{X}) = \mathbf{a}_j(X, \tilde{X}) + \epsilon^s$, then $\gamma(X', \tilde{X}) \geq \gamma(X'', \tilde{X}) > \gamma(X, \tilde{X})$.

Consider now two opportunity advantage histories: $\mathbf{a}_i(X, \tilde{X}) = (0, 0, y, y, 0, 0)$ and $\mathbf{a}_j(X, \tilde{X}) = (0, y, 0, 0, y, 0)$, with $y < 0$ (resp $y > 0$). Depending on the time aggregation performed by the function $u()$, agents i and j may be considered equally advantaged by the social evaluator—that is, $u(\mathbf{a}_i(X, \tilde{X})) = u(\mathbf{a}_j(X, \tilde{X}))$. However, we argue that i's advantage history, with consecutive disadvantages (resp. advantages) are less (resp. more) desirable than the one of j in which the bad (resp. good) periods are more spread-out.

In line with the justification for EA, a persistent status of opportunity disadvantage can induce even stronger changes in future behaviour. Under our opportunity egalitarian approach, individuals incur disadvantages when, due to factors beyond their control, they achieve lower incomes than they deserve. This negative event can evoke emotions—such as frustration and stress—or lead to changes in preferences and risk attitudes. The behavioral economics literature (see, e.g., [47–49]) often assumes that the welfare effects of negative shocks propagate to subsequent periods with a decay rate. Following this logic, the instantaneous welfare effect of an opportunity disadvantage at time t should be greater if the individual experienced an opportunity disadvantage in the previous period as well. From a more standard economic perspective, if opportunity disadvantages are caused by negative income shocks, they may induce liquidity constraints that are easier to smooth out if the shock is not persistent. Opportunity disadvantage can also be linked to poverty status; in such cases, prolonged inability to make ends meet may exacerbate the health and welfare consequences of low income. From a multiperiod fairness perspective, the persistence of opportunity disadvantages may signal systematic discrimination.

This concern for the persistence of opportunity disadvantage is captured by the following axiom. Let $\mathbf{0}_T$ denote a T dimensional vector of zeros,

- Disadvantage persistence (DP)—For all $(X, \tilde{X})$, $(X', \tilde{X}) \in D$ such that $\mathbf{a}_i(X, \tilde{X}) = \mathbf{a}_i(X', \tilde{X})$ for all $i \in \mathcal{N} \setminus \{j\}$, let $\epsilon(s,t), \epsilon(r,v) \in \mathbb{R}^T$ be such that $\epsilon(s,t)_k = 0$ for all $k \neq s, t \in \mathcal{T}$, $\epsilon(r,v)_k = 0$ for all $k \neq r, v \in \mathcal{T}$, and $\epsilon(s,t)_s = \epsilon(s,t)_t = \epsilon(r,v)_r = \epsilon(r,v)_v < 0$, with $1 \leq r < s < t < v \leq T$ and $s - r = v - t$. If $\mathbf{a}_j(X, \tilde{X}) = \mathbf{0}_T + \epsilon(s,t)$ and $\mathbf{a}_j(X', \tilde{X}) = \mathbf{0}_T + \epsilon(r,v)$, then $\gamma(X', \tilde{X}) \geq \gamma(X, \tilde{X})$.

Given our multiperiod perspective, we should be careful in distinguishing changes in opportunities from average income growth or inflation. As an example, an individual with a current income of 100 and fair income 200 realises half of his fair consumption possibilities. If, after a generalised increase in incomes of 10% of his current and norm income were to be respectively 110 and 220, then he would still be realising half of his fair consumption possibilities, despite the fact that the absolute advantage has changed from −100 to −110. It is then desirable to assess opportunity advantages in relative terms. The following scale invariance property requires social evaluation to be invariant to proportional changes in both individual and fair incomes. Let $\odot$ denote the element-wise product:[15]

- Scale Invariance (SI)—For all $(X, \tilde{X}) \in D$, and $\lambda \in \mathbb{R}^{N \times T}_{++}$, $\gamma(X, \tilde{X}) = \gamma(\lambda \odot X, \lambda \odot \tilde{X})$.

As mentioned above, in this paper we implement the idea that unfairness can be measured as the distance between X and $\tilde{X}$. The next axiom is a reminiscence of the symmetry property of distance measures, that can be express[16] as $|\gamma(X, \tilde{X})| = |\gamma(\tilde{X}, X)|$, which we adapt to the current framework that distinguishes advantages from disadvantages. Particularly, it defines social opportunity advantage as the opposite of the social opportunity disadvantage.

- Symmetry (SYM)—For all $(X, \tilde{X}) \in D$, $\gamma(X, \tilde{X}) = -\gamma(\tilde{X}, X)$.

We conclude by formalising two standard requirements, necessary to compare distributions of different sizes. Specifically, to ensure comparability of multiperiod IOp across populations of different size, we impose the standard population replication invariance principle.

- Population Invariance (PI)—For all $(X, \tilde{X}) \in D$, if $(X', \tilde{X}') \in D$ is obtained from $(X, \tilde{X})$ by replicating each row $P \in \mathbb{N}_{++}$ times, then $\gamma(X, \tilde{X}) = \gamma(X', \tilde{X}')$.

Last, we impose the next axiom to ensure comparability across different period spans.

- *Time Normalization (TN)*—For all $(X, \tilde{X}) \in D$, if $(X', \tilde{X}') \in D$ is obtained from $(X, \tilde{X})$ by replicating each column $P \in \mathbb{N}_{++}$ times, then $\gamma(X, \tilde{X}) = \gamma(X', \tilde{X}')$.

The previous properties allow us to characterise a family of societal multiperiod EOp functions. The following proposition formalises this result.

Proposition 3. *The multiperiod IOp function $\gamma : D \to \mathbb{R}$ satisfies NORM, MON, AN, AS, IA, EA, DP, SI, SYM, PI and TN if and only if, for all $(X, \tilde{X}) \in D$ there exist*

i. *a strictly increasing, concave and differentiable function $\sigma : \mathbb{R} \to \mathbb{R}$, with $\sigma(0) = 0$,*

ii. *a weight function $\alpha : \mathbb{N}^2_{++} \to (0, 1]$ decreasing and concave in its first argument, with $\sum_{t=1}^{T} \alpha(t, T) = 1$, and*

iii. *a strictly increasing, differentiable and odd function $f : \mathbb{R} \to \mathbb{R}$, such that $f \circ \ln$ is concave and $f(0) = 0$, such that*

$$\gamma(X,\tilde{X}) = \frac{1}{N}\sum_{i=1}^{N}\sigma\left(\sum_{t=1}^{T}\alpha(t,T) f\left(\ln\frac{x_{it}}{\tilde{x}_{it}}\right)\right). \quad (5)$$

The social opportunity advantage is measured by the average of concave transformations of the time-weighted average instantaneous opportunity advantage. It is interesting to observe that, despite the weak assumptions about the advantage function a, opportunity advantages turn out to be increasing transformations of the logarithm of the ratio between observed and fair incomes.[17] Equation (5) allows us to compare and order different states of the world according to their compliance with EOp allocation criteria that define the norm distributions. Moreover, thanks to its decomposability, we can perform meaningful subgroup comparison and highlight groups of individuals that benefit (or suffer) from the multiperiod unfairness.

Two additional features characterise Equation (5). First, independently of the implemented norm—Proposition 1 or 2-γ is always negative (see Online Appendix B for details). Therefore, we should read Equation (5) as a multiperiod measure of IOp that is zero if there is equality of opportunity and decreases (becomes more negative) as inequality of opportunity increases. Consequently, any instance of Equation (5) defines a complete ranking of multiperiod opportunity advantage distributions. A second interesting feature arises if we set:

$$\gamma(X,\tilde{X}) = -\sum_{t=1}^{T}\alpha(t,T)\underbrace{\frac{1}{N}\sum_{i=1}^{N}\ln\left(\frac{\tilde{x}_{it}}{x_{it}}\right)}_{\text{MLD}}. \quad (6)$$

Equation (6) highlights that there is a clear link between this specification of γ and the mean log deviation (MLD): a standard and a widely implemented inequality index that is obtained when the norm income is equal to the average income in the distribution. In fact, if we implement an egalitarian norm distribution such that $\tilde{x}_{it} = \frac{1}{N}\sum_{i=1}^{N} x_{it}$ for all $i \in \mathcal{N}$ and $t \in \mathcal{T}$,[18] Equation (6) becomes a time-weighted average of the inequality in each period, where the standard MLD is implemented as the inequality index. Importantly, when σ is linear as in Equation (6), our societal measure becomes *path independent*. Indeed, according to Equation (6) our approach that aggregates first across time and then across individuals would coincide with an alternative one that aggregates first across individuals.

Our social evaluation function differs from the solution proposed by [33]. First, Equation (5) is based on ratios $x_{it}/\tilde{x}_{it}$, while [33] consider differences $x_{it} - \tilde{x}_{it}$. For this reason, [33] suggest using a Gini-type measure of inequality,[19] while the MLD constitutes a more natural candidate in our setting. Third, [33]'s framework is built in a unitemporal context, issues related to effort and circumstances variation over time are not discussed in their work. And even if we were to derive a multi period counterpart of their proposal, this would correspond to a weighted sum of their Gini measures in different periods. Hence, it would first measure IOp in each period, and then aggregate across time. Our approach, instead, follows the opposite order: we first aggregate across time, and then aggregate across individuals.

The following section implements the proposed framework to assess multiperiod IOp in South Korea.

5 | Multiperiod Inequality of Opportunity in South Korea

South Korea is among the most developed countries in the world, as witnessed by its per capita GDP and speed of technological innovation. According to World Bank data from 2022, per capita GDP in this country is about 32,423 US$ and its annual growth rate fluctuated around 5% in the previous twenty years. According to the OECD, in 2023, South Korea is second-ranked in terms of investment in research and development as a share of GDP among other advanced countries (Israel ranks first): South Korea spent about 4.5% of its GDP in R&D. The World Bank also ranks South Korea as East Asia's most egalitarian society. But it has not always been like that. In fact, in the 1960s, South Korea ranked among the world's poorest nations. However, the post-1960 Korean economy underwent a remarkable transformation. It is widely acknowledged that Korea achieved one of the most successful economic developments over several decades. Remarkably, this prosperity persisted until the onset of the Asian financial crisis in 1997. While conventional wisdom suggests that Korean economic growth stalled after this crisis, at least in terms of per adult national income growth, it continued to expand even in the 2000s. Nevertheless, many ask whether what is called 'miracle on the Han river' can be interpreted as an inclusive miracle of growth. It is then legitimate to ask whether this economic growth process truly improved Koreans' living standards without exacerbating inequalities.

It is, indeed, rightly after the Asian financial crisis in 1997 that there has been an increasing interest towards understanding inequality in South Korea. Most analyses found that, for some decades, inequality in this country remained low, thus inducing to judge the miracle as offering ample opportunities for upward social mobility. However, in recent years, this narrative has undergone a stark reversal. South Korea can no longer be considered a society characterised by moderate levels of inequality. Instead, income inequality has worsened and this has become one of the most pressing social issues in contemporary Korea, alongside widespread job insecurity, with the two phenomena intricately intertwined (see [50]).

Among the few quantitative studies, [51] represents the most recent one, that offers an in-depth quantitative analysis of the inequality trend in Korea in the last decades. They find that, following the Asian financial crisis in 1997, income inequality in South Korea has exacerbated, exhibiting particularly high levels of gender inequality and lower shares of old-age income. However, in comparison to other East Asian nations, South Korea is still more egalitarian thanks to the more equitable distribution of national income during the initial stages of economic growth in the 1980s.

Although extremely informative, [51] analysis focuses on unitemporal inequality dose not distinguish between good and bad inequalities. Reference [52] goes a step further and investigates the origins of inequalities. They show that exogenous factors such as the region where individuals grew up, their gender, and their father's occupation during childhood are the primary contributors to inequality of opportunity, corroborating previous evidence on the significant impact of regional disparities and social environments in perpetuating gender inequality within South Korean society. Still, they endorse a unitemporal perspective and adopt a machine learning approach that is neither normatively nor axiomatically grounded, unlike the approach introduced in this paper.

Recently, inequality has also emerged as a prominent theme in Korean public debate. Among the different issues, one particularly sensitive topic for young Koreans is the growing awareness of social injustices stemming from recent political controversies.[20]

It is, thus, of interest to shed further light on the fairness aspects of this country.

5.1 | Data

Our empirical analysis is based on the KLIPS (Korean Labor and Income Panel Study),[21] which is a Korean census conducted every year on a sample of about 5,000 households. Started in 1998, it collects data at both household and individual level and it is one of the few panel surveys that contains information on individual socio-economic background. For our analysis we use 14 waves ranging from 2001 to 2014.

The unit of observation is the individual, in particular we consider all individuals aged between 20 and 65 and interviewed in each wave. This implies that for each individual, we compute multiperiod IOp over the same number of periods, which makes our estimates readily comparable across individuals. This is a common choice in the literature involved in multiperiod distributional phenomena. The measure of living standards is equivalised disposable household income, expressed in constant 2005 prices, using country and year-specific price indexes, and adjusted for differences in household size by dividing incomes by the square root of the household size.[22]

KLIPS surveys all incomes as after-tax income, and the household income is obtained as the sum across each household members of the following components: labour income, financial income (interest from banks and financial institutions, interest from private loans, gains from securities and bond transactions, dividends, etc.), real-estate income (rent, gains from real estate transactions, rent from land lease, premium money, etc.), social insurance income (amount of one-time benefit payments), transfer income (receipts of the National Basic Livelihood Protection payments, other government subsidies, social group subsidies, family/relatives' support, etc.), other incomes (insurance payment receipts, severance pay, gifts or inheritances, other celebratory/condolence money, lottery, racetrack winnings, disaster compensations). This variable is recorded in 10,000 KRW (Korean Won). Individuals with zero sampling weights are excluded, since our measures are calculated using sample weights designed to make the samples nationally representative.

A fundamental step to operationalise our measurement framework is the identification of the vector of observable circumstances. This is a normative choice, subject to the constraint of data availability. Our data contain information on a small set of basic circumstances, but nonetheless of prominent importance. For each wave, in fact, we can observe the following: gender, birthplace, parental education, parental support.

Birthplace is categorised following the major administrative divisions of the country. The first category is represented by individuals born in the special city—namely Seoul. The second category is represented by individuals born in one of the metropolitan cities (self-governing cities that are not part of any province)—namely Busan, Daegu, Incheon, Gwangju, Daejeon, Ulsan—or in the autonomous metropolitan city—namely Sejong. The third category is represented by individuals born in other provinces—namely Gyeonggi, Gangwon, North Chungcheong, South Chungcheong, North Jeolla, South Jeolla, North Gyeongsang, South Gyeongsang, Jeju—or outside South Korea. Parental education—measured by the highest educational attainment between mother and father, is also coded into 3 categories: individuals whose parents have elementary education or no education; individuals with at least one parent with middle/secondary education; individuals with at least one parent having attained tertiary education. The last circumstance used is parental support that is a binary variable indicating whether or not the individual received any material/financial support from the parent(s) during the year preceding the survey. Notice that differently from gender, birth place and parental education—circumstances that are fixed over time—parental support is a variable circumstance. In particular, in our sample, it results that around 60% of individuals experienced a change in this circumstance at least once over the time horizon considered, and around 45% experienced a change at least twice. This provides further support for the application of our framework, which is flexible enough to account for the possibility that circumstances may vary over time.

Individuals with missing information for one or more circumstances are excluded from the analysis; therefore, our final sample is composed of 3061 observations. Descriptive statistics on this sample are reported in Table 1.

As explained above, in order to compute our measure, one needs to identify the optimal distributions. In this empirical analysis, this is done by implementing the ex post and ex ante criteria defined in Section 3. To implement the ex post approach, we approximate the individual effort with the position in the relative type distribution after dividing it into 10 quantiles.[23]

We also compare the opportunity egalitarian approach with the outcome egalitarian one. Within this scope, we construct the egalitarian optimal distribution, according to which the fair income for all individuals is set at the average income for each period considered.

In the empirical application, we consider the following two specifications of Equation (5):

I. $\gamma_{1,Lin} = \frac{1}{N}\sum_{i=1}^{N}\frac{1}{T}\sum_{t=1}^{T}\ln(\frac{x_{it}}{\tilde{x}_{it}})$;

II. $\gamma_{1,EG} = \frac{1}{N}\sum_{i=1}^{N}\sum_{t=1}^{T}\frac{\sqrt{\frac{T-t+1}{T}}}{\sum_{t=1}^{T}\sqrt{\frac{T-t+1}{T}}}\ln(\frac{x_{it}}{\tilde{x}_{it}})$.

Here, x_{it} is the individual outcome proxying the individual's standard of living, measured by the equivalised disposable

TABLE 1 | Descriptive statistics.

Year	Mean income	Gini coefficient	Individuals with parental support (%)
2001	855.71	0.3801	18.41
	(15.5)	(0.0079)	
2002	1041.78	0.3583	16.64
	(18.60)	(0.0085)	
2003	1071.81	0.3654	19.48
	(17.58)	(0.0072)	
2004	1151.41	0.3795	22.94
	(25.49)	(0.0108)	
2005	1183.96	0.3667	22.01
	(20.40)	(0.0075)	
2006	1304.48	0.3758	22.70
	(27.19)	(0.0103)	
2007	1365.33	0.3640	24.94
	(23.44)	(0.0075)	
2008	1391.66	0.3637	22.96
	(25.21)	(0.0084)	
2009	1326.76	0.3591	20.02
	(20.79)	(0.0067)	
2010	1439.10	0.3566	16.44
	(28.63)	(0.0100)	
2011	1465.08	0.3461	16.80
	(26.43)	(0.0089)	
2012	1489.93	0.3261	17.51
	(21.92)	(0.0064)	
2013	1530.43	0.3251	22.12
	(21.87)	(0.0060)	
2014	1606.73	0.3314	19.66
	(24.84)	(0.0072)	
Female (%)		55.54	
Parents with no/elementary education (%)		58.07	
Parents with medium/secondary education (%)		34.52	
Parents with higher education (%)		7.41	
People born in Seul (%)		9.79	
People born in other metropolitan city (%)		12.54	
People born in other province or outside Korea (%)		77.66	
Sample size		3061	
People in younger cohort (%)		57.50	

Note: The top part of the table reports for each year the sample mean income and Gini coefficient, standard errors in parentheses. It also reports the percentage of individuals that receive a material and/or financial support from parents, which is the only circumstances that can vary over time. The bottom part of the table reports information of the sample characteristics that do not change over time.
Source: Authors' elaborations based on KLIPS, 2001-2014.

household income, and $\tilde{x}_{it}$ is its fair counterpart computed using one of the benchmarks discussed above. The first specification expresses neutrality with respect to the time component; the second one is concave with respect to time, and it gives more weight to inequalities of opportunities occurring in early periods.

5.2 | Results

Table 2 (top panel) reports the results of our estimates for the whole sample and the 14 years considered. Standard errors for these and all the other estimates are shown in parenthesis and computed non-parametrically, using 500 bootstrap replications.

TABLE 2 | Multiperiod IOp in Korea, 2001–2014.

	Egalitarian	Ex ante	Ex post
Absolute indexes			
$\gamma_{1,Lin}$	−0.2692	−0.0082	−0.0707
	(0.0119)	(0.0019)	(0.0048)
$\gamma_{1,EG}$	−0.2881	−0.0089	−0.0834
	(0.0123)	(0.0020)	(0.0061)
		Ex ante	**Ex post**
Relative indexes			
$\gamma_{1,Lin}$		0.0030	0.2626
$\gamma_{1,EG}$		0.0309	0.2895

Note: Egalitarian refers to the index computed using the egalitarian benchmark; Ex ante refers to the index computed using the ex ante benchmark; Ex post refers to the index compute using the ex post benchmark (see Section 3). Standard errors in parenthesis.
Source: Authors' elaborations based on KLIPS, 2001–2014.

TABLE 3 | Evolution over time of IOp in Korea, 2001 to 2014.

Year	Egalitarian	Ex ante	Ex post
2001	−0.4487	−0.0123	−0.2040
	(0.0348)	(0.0031)	(0.0249)
2002	−0.2881	−0.0094	−0.0885
	(0.0253)	(0.0028)	(0.0184)
2003	−0.3291	−0.0077	−0.1160
	(0.0288)	(0.0026)	(0.0204)
2004	−0.3259	−0.0139	−0.1051
	(0.0251)	(0.0032)	(0.0164)
2005	−0.2822	−0.0079	−0.0746
	(0.0199)	(0.0026)	(0.0133)
2006	−0.2997	−0.0139	−0.0832
	(0.0206)	(0.0033)	(0.0128)
2007	−0.2690	−0.0096	−0.0689
	(0.0190)	(0.0029)	(0.0118)
2008	−0.2393	−0.0072	−0.0504
	(0.0158)	(0.0023)	(0.0100)
2009	−0.2934	−0.0060	−0.0872
	(0.0226)	(0.0024)	(0.0161)
2010	−0.2222	−0.0075	−0.0275
	(0.0128)	(0.0025)	(0.0050)
2011	−0.2099	−0.0045	−0.0261
	(0.0125)	(0.0020)	(0.0046)
2012	−0.1810	−0.0041	−0.0182
	(0.0121)	(0.0019)	(0.0039)
2013	−0.1803	−0.0062	−0.0192
	(0.0121)	(0.0021)	(0.0039)
2014	−0.1904	−0.0052	−0.0222
	(0.0121)	(0.0019)	(0.0043)

Note: For each year, fairness is measured by $\frac{1}{N}\sum_{i=1}^{N}\ln\left(\frac{x_{it}}{\tilde{x}_{it}}\right)$. Standard errors in parenthesis.
Source: Authors' elaborations based on KLIPS, 2001–2014.

All entries of the top panel of Table 2 have values that are different from 0: although South Korea is known as one of the most growing and progressive country, it still suffers from some degree of IOp. As expected, the values in the last two columns are less negative than the corresponding ones in column one. This is in line with the fact that not all the inequalities are deemed to be objectionable, but only the inequalities due to different opportunities—those captured here by the ex ante and ex post approaches.

The literature often proposes two types of IOp measures. An absolute measure, which is the one characterised in the previous section, and a relative measure which is the ratio between absolute IOp and absolute inequality. The first part of Table 2 reports the absolute measures, while the relative ones are reported in the bottom part. According to the ex ante perspective, the share of inequality attributable to the set of considered circumstances is fairly low and never above 3.1%. IOp appears to be a more compelling issue when the ex post perspective is adopted, as the relative index reveals that IOp amounts to more than one-fourth of overall inequality.

It may be observed that $\ln\left(x_{it}/\tilde{x}_{it}\right)$ in Equation (5) represents a measure of the individual fairness gap at time t. By examining the proportion of negative gaps, we can define a headcount ratio, which identifies the share of individuals experiencing opportunity deprivation. Conversely, this ratio also reflects the share of individuals who benefit from transitioning from the observed distribution to the norm distribution.

When considering each year separately, the percentage of opportunity-deprived individuals ranges from [62.9, 67.2] under the Egalitarian norm, [62.8, 77.1] under the Ex ante norm and [58.9, 67.1] under the Ex post norm. Furthermore, when analysing the 14 years collectively, the share of individuals classified as opportunity-deprived never falls below 66%, regardless of the norm or the specification of Equation (5). Therefore, we can conclude that, even though the norm distributions do not constitute Pareto improvements over the observed distributions, the majority of individuals is likely to support the implementation of the norm distributions.

The indexes adopted so far also have the advantage of providing a complementary picture of the one that would emerge from adopting the alternative and standard unitemporal perspective. Table 3 reports the estimates of unitemporal inequality of opportunity for each year considered in the analysis. The indexes are computed by aggregating across individuals the opportunity gap experienced by each individual in each specific year, hence these indexes ignore the individual dynamics. To be more specific, for each year t unitemporal inequality of opportunity is measured by $\frac{1}{N}\sum_{i=1}^{N}\ln\left(\frac{x_{it}}{\tilde{x}_{it}}\right)$. We observe that while the values of the indexes are consistent with the multitemporal perspective (they are all different from 0, with the ex ante and ex post measures being smaller than the egalitarian one), the trend is overall less clear-cut. In particular, when the initial (2001) and final (2014)

TABLE 4 | Multiperiod Iop in Korea by cohort, 2001–2014.

	Egalitarian	Ex ante	Ex post
Younger cohort			
$\gamma_{1,Lin}$	−0.2937	0.0012	−0.0622
	(0.0150)	(0.0026)	(0.0067)
$\gamma_{1,EG}$	−0.3090	0.0024	−0.0744
	(0.0180)	(0.0025)	(0.0098)
Older cohort			
$\gamma_{1,Lin}$	−0.2290	−0.0238	−0.0849
	(0.0176)	(0.0027)	(0.0068)
$\gamma_{1,EG}$	−0.2538	−0.2689	−0.0983
	(0.0190)	(0.0284)	(0.0081)

Note: Egalitarian refers to the index computed using the egalitarian benchmark; Ex ante refers to the index computed using the ex ante benchmark; Ex post refers to the index compute using the ex post benchmark (see Section 3). Standard errors in parenthesis.
Source: Authors' elaborations based on KLIPS, 2001–2014.

periods are compared, equality of opportunity improves according to all three approaches; however, when we focus on the whole period-by-period evolution, there are both upward and downward variations that we want to take into account by using the multiperiod approach proposed in this paper.

South Korea has been characterised by a rapid economic growth process as well as by a rapid process of integration in the world economy. After the Korean war, at the end of 50s, per capita GDP was at the same level of some of the poorest African countries. In our analysis, we can distinguish two cohorts of individuals: one that was involved in the initial phase of South Korean development, and one that was born in the same but more developed country. Thus, it might be informative to deepen our investigation on the structure of multiperiod inequality of opportunity in Korea, by analysing how individuals belonging to two different age cohorts performed in the same period. We consider the cohort of individuals aged between 20 and 40 in 2001 and the cohort of individuals older than 40. We proceed by comparing the actual income of each individual in the two cohorts with the same benchmark distribution—computed at societal level—in order to check whether there is a distinction between the two cohorts in terms of which of the two bears the cost of unfairness.

Because the optimal distributions are computed on the whole sample, the fairness index computed on the two subsamples may take a positive value.[24] This is indeed the case for the younger cohort when the analysis is performed using the ex ante approach, as it can be observed in Table 4. Interestingly, in terms of distribution ranking, the comparison between the two cohorts depends on the optimal benchmark implemented. According to the standard outcome perspective that is endorsed in the egalitarian benchmark, the older cohort performs better than the younger cohort, as the indexes corresponding to the latter subsample are always lower than the indexes corresponding to the former. According to the inequality of opportunity perspective endorsed in the ex ante and ex post approach, the sign of the dominance is inverted; that is, the younger cohort shows more fairness than the older one. Therefore, while the income of an individual in the younger cohort tends to be lower, it is on average less dependent on exogenous factors than the income of the older cohort—meaning that their effort seems to be remunerated in a fair manner.

We deepen our investigation by looking at the generalised Lorenz curve of the two subsamples; this device can help shed some light on how different segments of the distribution fared in terms of multiperiod IOp and establishing more robust dominance between the two periods.[25] For the sake of brevity, we report the generalised Lorenz curve only for the case of time neutrality. Thus, at each percentile p, the generalised Lorenz curve graphs the cumulative average of the lowest $\frac{1}{T}\sum_{t=1}^{T}\ln\left(\frac{x_{it}}{\tilde{x}_{it}}\right)$.

Figure 1 highlights the difference between the standard outcome and the opportunity egalitarian perspective. Focusing on the generalised Lorenz curves under the egalitarian perspective, the two curves overlap almost perfectly at the bottom decile, while they diverge for the rest of the distribution. Under the opportunity egalitarian perspective, a different picture can be drawn. For the bottom half of the distributions, the curves of the older cohort are slightly above the curves of the younger cohort. In second half of the distribution, instead, the younger cohort's curves are higher than the other, to the point that we observe dominance in the ex ante case.

We also investigate whether multiperiod IOp in Korea is affected by the presence of a territorial divide. In particular, we ask whether living in one of the two biggest metropolitan areas in South Korea is associated by a fairness premium due to largest opportunities available, for instance in terms of education and job prospects. To do this, we compare multiperiod IOp estimates in two subsamples: one composed by individuals that lived most of the time—between 2001 and 2014—in Seoul or in Busan (the largest metropolitan cities in South Korea); the other composed by individuals that lived most of the time in places other than Seoul or Busan. As before, we proceed by comparing the actual income of each individual in the two subsample with the benchmark distribution computed at societal level. Table 5 confirms our conjecture. According to all the indexes and independently from the norm, individuals living in areas other then the two biggest metropolitan cities tend to be more opportunity disadvantaged. The difference is striking especially for the case of ex ante IOp, whose indexes are always positive for the subsample encompassing residents in Seoul or Busan and negative otherwise (see also Figure 2).

In Figure 2, the biggest difference between regions is coming from the unfairly advantaged individuals, because the generalised Lorenz curves are similar while they are decreasing (as disadvantaged individuals with negative values are added), but then they diverge when the curves begin to slope upward (as advantaged individuals with positive values are added).[26]

6 | Conclusions

The theoretical and empirical literature on the measurement of inequality of opportunity has been very florid in the last decades. However, the temporal dimension has been almost entirely overlooked by this literature. In this paper, inspired by the opportunity

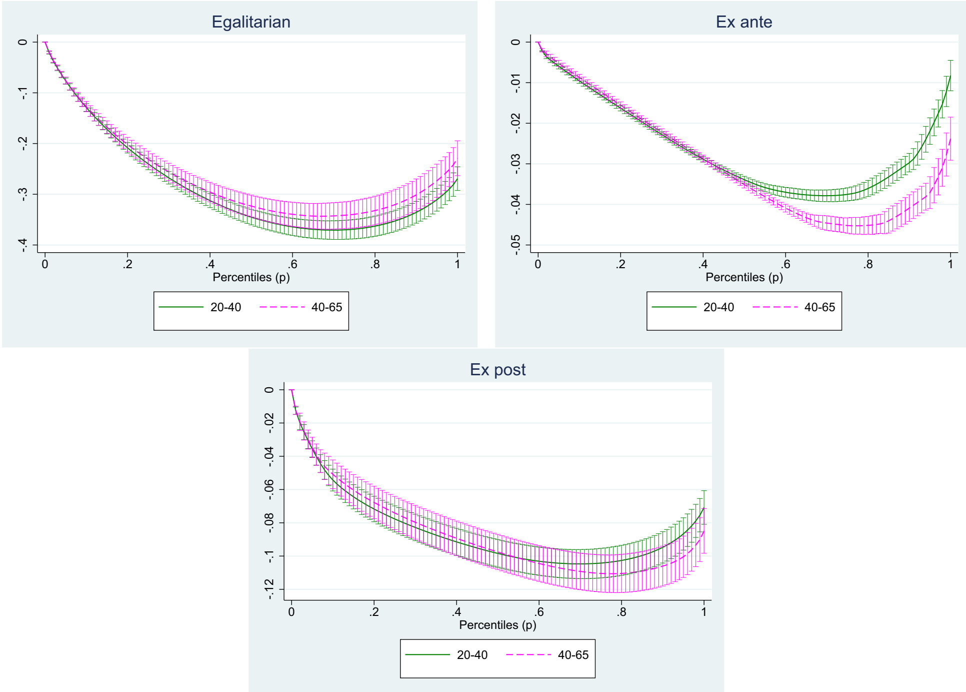

FIGURE 1 | Multiperiod IOp generalised Lorenz curves in Korea by cohort. *Source:* Authors' elaborations based on KLIPS, 2001–2014. The generalised Lorenz curves are constructed on a measure of individual interetemporal fairness given by $\frac{1}{T}\sum_{t=1}^{T}\ln\left(\frac{x_{it}}{\tilde{x}_{it}}\right)$. Non-parametric confidence intervals obtained via bootstrap.

TABLE 5 | Multiperiod IOp in Korea by residence, 2001–2014.

	Egalitarian	Ex ante	Ex post
Residence in Seoul/Busan			
$\gamma_{1,Lin}$	−0.2314	0.0022	−0.0555
	(0.0203)	(0.0037)	(0.0087)
$\gamma_{1,EG}$	−0.2451	0.0025	−0.0670
	(0.0219)	(0.0039)	(0.0107)
Residence out of Seoul/Busan			
$\gamma_{1,Lin}$	−0.2866	−0.0131	−0.0778
	(0.0144)	(0.0023)	(0.0059)
$\gamma_{1,EG}$	−0.3079	−0.0142	−0.0911
	(0.0158)	(0.0024)	(0.0074)

Note: Egalitarian refers to the index computed using the egalitarian benchmark; Ex ante refers to the index computed using the ex ante benchmark; Ex post refers to the index computed using the ex post benchmark (see Section 3). Standard errors in parenthesis.
Source: Authors' elaborations based on KLIPS, 2001–2014.

gap methodology [53], we have proposed one possible answer to fill this gap. Our approach consists of constructing a multiperiod IOp measure using a two-step procedure: (i) defining an opportunity egalitarian distribution, (ii) measuring the divergence between actual and fair income distributions.

We have proposed two benchmark distributions that endorse, respectively, the ex ante and the ex post versions of the opportunity egalitarian principles, witnessing the flexibility of our approach in accommodating different interpretations of the EOp principles. Another feature of our approach is the distinction between positive and negative deviations from the opportunity egalitarian outcome. This allows us to interpret our family of social evaluation functions as the social benefit from multiperiod EOp. We have shown several features of our family of measures, which include a generalised, multiperiod, version of the well-known Mean Log deviation.

Last, we have applied our measurement tool to study inequality of opportunity in South Korea using the KLIPS dataset. According to our measurement model, South Korea is affected by some degree of unfairness. However, the country seems to be on the right path for improving equality of opportunity over time. South Korea's intense GDP growth appears to have reduced opportunity inequality for younger generations, who receive a fairer remuneration for their effort. More attention, instead, should be devoted to individuals who live in areas other than Seoul or Busan.

The proposed norm-based approach to assess IOp incorporates features that allow the empirical literature to deepen the IOp assessment by looking at the multiperiod perspective. Thus, this paper opens room for new theoretical and empirical assessment of multiperiod EOp. From a purely normative perspective, we should emphasise the role of the income generating function. As an alternative to our formulation, we could assume that current income depends on the entire history of individual circumstances and effort up to the considered period. From a mathematical point of view, this is a harmless modification of our framework. However, this would generate normative concerns on the way we should consider past circumstances and effort. A second, probably more relevant, route for expansion of the current work, is the definition and discussion of the Compensation and Reward principles in an intertemporal perspective, where issues like effort

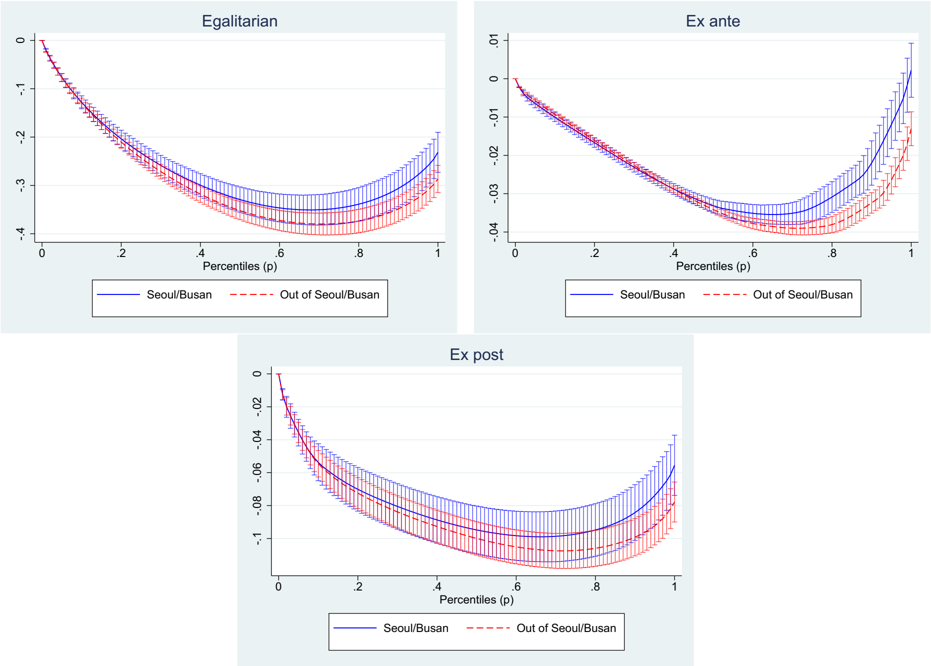

FIGURE 2 | Multiperiod IOp generalised Lorenz curves in Korea by residence. *Source:* Authors' elaborations based on KLIPS, 2001–2014. The generalised Lorenz curves are constructed on a measure of individual interetemporal fairness given by $\frac{1}{T}\sum_{t=1}^{T}\ln\left(\frac{x_{it}}{\tilde{x}_{it}}\right)$. Non-parametric confidence intervals obtained via bootstrap.

smoothing may deserve particular attention. We hope that this work serves this purpose of stimulating the EOp literature to better investigate the role of time in evaluating social justice.

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Endnotes

[1]Two exceptions are [21, 22], which will be discussed later.

[2]Observe that the part of taxes/transfers that depends on circumstances and effort can be captured by the function f_t.

[3][34] demonstrate that accounting for the correlation between circumstances and effort has a limited impact on the estimation of unfair inequality.

[4]According to the RIA the effort of an individual is identified by the rank of that individual in the outcome distribution of the type she belongs to.

[5]For example, if we believe that working eight hours at the age of 30 is not the same as working eight hours at the age of 35, then the two should constitute different categories of effort.

[6]Let us denote $Vec(X_t)$ the vectorisation of the matrix X_t, that is, a linear transformation which converts X_t into a N-dimensional column vector. Then, each column t of X is a permutation of $Vec(X_t)$. Such permutation guarantees that in each row of X we have the income stream of a unique individual.

[7]The requirement is weaker under the assumption that each combination of circumstances and effort occur with the same frequency. When this is not the case, liberal reward and mean natural reward are independent.

[8]This requirement can limit the distortion of incentives caused by redistribution. Indeed, at least in expectation, the absolute change in income due to different effort levels is preserved under Mean natural reward.

[9]In an early contribution, [35] use similar axioms in a uni-temporal context to characterise their fair distribution.

[10]Proposition 1 extends to a multiperiod context Theorem 1(a) in Bosmans & Öztürk [35].

[11]In a unitemporal setting, it can be shown that Proportional reward is equivalent to the Relative ex ante reward axiom introduced in Bosmans & Öztürk [35].

[12]Proposition 2 extends to a multiperiod context the characterisation in [35], which is the relative counterpart of the *Observable Average Conditional Egalitarianism* solution introduced in Bossert et al. [39].

[13]See Foster & Shneyerov [40]. After Checchi & Peragine [41], the application of this decomposition technique to the EOp framework has become a common practice in the EOp literature.

[14]This axiom is even more desirable if one allows the norm and observed distributions to have different total incomes.

[15]For any pair of equal dimension matrices (A, B), $(A \odot B)_{jk} = A_{jk}B_{jk}$.

[16]A standard requirement for a function $m : \mathbb{R}^2 \to \mathbb{R}_+$ to be a metric on $\mathbb{R}$ is $m(x, y) = m(y, x)$. We use the absolute value to account for the possibility that γ takes negative values, which is not a standard property of metrics.

[17]Our solution, therefore, does not include the recurrent $|x_{it} - \tilde{x}_{it}|$ among the admissible measure of instantaneous opportunity advantage.

[18]This norm distribution reflects a standard outcome egalitarian principle and will be used in the empirical application to illustrate the different results that can be obtained when different perspectives to the analysis of inequality are adopted.

[19]Their proposal has the same structure but does not correspond to the Gini coefficient. In particular, the measure in [33] has a maximal value of two.

[20]See the article appeared in October 2023 on the Washington Post: https://www.washingtonpost.com/world/2023/07/06/gangnam-seoul-south-korea-rich-inequality/.

[21]Data are available for download at https://www.kli.re.kr/kli_eng.

[22]Consumer Price Indexes are taken from Korea National Statistical Office KOSTAT.

[23]This approach follows Roemer's [14] identification to approximate effort.

[24]In a context where groups are countries, the standard procedure would lead us to define a norm distribution for each group, rather than one for both as in this case. Diverging from the standard approach, in this case, has the advantage of identifying possible groups of winners and losers from the overall IOp. Results for the case cohort-specific norm distributions are available upon request.

[25]It is easy to show that dominance in terms of generalised Lorenz curve implies higher EOp, for any specification of Equation (5).

[26]Our results are robust to a series of robustness checks related to different degrees of time concern and inequality aversion. The results of these estimates are available upon request to the authors.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Appendix S1.Appendix S2.**