"Equality of opportunity: Theory and measurement*"

by

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1. Introduction

In the welfarist tradition of social-choice theory, egalitarianism means equality of welfare or utility[1]. Conservative critics of egalitarianism rightly protest that it is highly questionable that this kind of equality is ethically desirable, as it fails to hold persons responsible for their choices, or for their preferences, or for the way they process outcomes into some interpersonally comparable currency that one can speak of equalizing. In political philosophy, beginning with John Rawls (1958, 1971), this critique was taken seriously, and a new approach to egalitarianism developed, which inserted personal responsibility as an important qualifier of the degree of equality that is ethically desirable. Thus, the development of egalitarian theory, since Rawls, may be characterized as a project to replace equality of outcomes with equality of opportunities, where opportunities are interpreted in various ways. Metaphors associated with this view are 'leveling the playing field,' and 'starting gate equality.' The main philosophical contributions to the discussion were, following Rawls, from Amartya Sen (1980), Ronald

* We thank Tony Atkinson, François Bourguignon, Steven Durlauf, Marc Fleurbaey, Pedro Rosa Dias, Erik Schokkaert and two referees for their comments and advice on previous drafts of this article. A somewhat different version has appeared in the *Handbook of Income Distribution* (Roemer and Trannoy [2015]).

[1] Welfarism is the view that social welfare (or the social objective function) should be predicated only on the utility levels of individuals; that is, that the only information required to compare social alternatives is that summarized in the utility-possibilities sets those alternatives generate. (Thus, considerations of property rights, or the processes by which the social state came about, are irrelevant, if they cannot be recovered from utility information.) Welfarism is a special case of consequentialism, which says that the ranking of social alternatives should depend only on outcomes.

Dworkin (1981a, 1981b), Richard Arneson (1989) and G.A. Cohen (1989)[2]. The debate is said to be about 'equality of what,' and the philosophical view is sometimes called 'luck egalitarianism,' a term coined by Elizabeth Anderson (1999).

Economists (besides Sen) have been involved in this discussion from 1985 onwards. John Roemer (1993, 1998) proposed an algorithm for calculating policies that would equalize opportunities for achievement of a given outcome in a population. Marc Fleurbaey and François Maniquet contributed economic proposals beginning in the 1990s (see Fleurbaey (1995)), and recently summarized in Fleurbaey (2008) and Fleurbaey and Maniquet (2011). Other authors who have contributed to the theory include Dirk Van de gaer (1993), Walter Bossert (1995, 1997) and Vito Peragine (2004). An empirical literature is rapidly developing, calculating the extent to which opportunities for the acquisition of various outcomes are unequal in various countries, examining the opportunity-equalizing effects of policy, and inquiring whether people hold views of justice consonant with equality of opportunity.

There are various ways of summarizing the significance of these developments for the economics of inequality. Prior to the philosophical contributions that ignited the economic literature that is our focus in this article, there was an earlier skirmish around the practical import of equalizing opportunities. Just before the publication of Rawls's magnum opus (1971), contributions by Arthur Jensen (1969) and Richard Herrnstein (1971) proposed that inequality was in the main due to differential intelligence (IQ), and so generating a more equal income distribution by equalizing opportunities (for instance, through compensatory education of under-privileged children) was a chimera. Economists Samuel Bowles (1973) and John Conlisk (1974) disagreed; Bowles argued that inequality of income was almost all due to unequal opportunities, not to the heritability of IQ. A thorough refutation of Jensen's view was given several years later by Goldberger (1979). Despite this important debate on the degree to which economic

[2] The philosophical literature generated by these pioneers is too large to list here. Book-length treatments that should be mentioned are Rakowski (1991) , Van Parijs (1997), and Hurley (2003) .

inequality is immutable, prior to Rawls, economists' discussions of inequality were in the main statistical, focusing on the best ways of measuring inequality.

The post-Rawls-Dworkin inequality literature changed the focus by pointing out that only some *kinds* of inequality are ethically objectionable, and to the extent that economists ignore this distinction, they may be measuring something that is not ethically or politically salient. This distinction between morally acceptable and unacceptable inequality is perhaps the most important contribution of philosophical egalitarian thought of the last forty years. From the perspective of social-choice theory, equal-opportunity theory has sharply challenged the welfarist assumption that is classically ubiquitous, maintaining that more information than final outcomes in terms of welfare is needed to render social judgment about the ranking of alternative policies – in particular, one must know the extent to which individuals are responsible for the outcomes they enjoy – and this is non-welfare information.

One must mention that another major non-welfarist theory of justice, but an inegalitarian one, was proposed by Robert Nozick (1974) who argued that justice could not be assessed by knowing only final outcomes; one had to know the process by which these outcomes were produced. His neo-Lockean view, which proposed a theory of the moral legitimacy of private property, can evaluate the justness of final outcomes only by knowing whether the history that produced them was unpolluted by extortion, robbery, slavery, and so on. Simply knowing the distribution of final outcomes (in terms of income, welfare, or whatever) would not suffice to pass judgment on the distribution's moral pedigree. So the period since 1970 has been one in which, in political philosophy, non-welfarist theories flourished, on both the right and left ends of the political spectrum.

The literature we review in this article represents a rare collaboration between political philosophy and economics. Not since the nineteenth century, when utilitarianism, developed by philosophers Jeremy Bentham, John Stuart Mill and Henry Sidgwick profoundly influenced economics for at least a century has there been a comparable episode. We begin by summarizing the philosophical debate concerning equality since Rawls (section 2). The next two sections (3,4) review economists' reactions to this debate, and present economic algorithms for computing policies that equalize opportunities, inspired by the debate -- or, more generally, methods of ordering

social policies with respect to their efficacy in opportunity equalization. Section 5 applies the approach to the conceptualization of economic development. Section 6 reviews measurement issues, with a summary of the empirical literature on the measurement of inequality of opportunity to date. Section 7 concludes.

2. Egalitarian political philosophy since Rawls

John Rawls (1958) first published his ideas about equality over fifty years ago, although his magnum opus did not appear until 1971. His goal was to unseat utilitarianism as the ruling theory of distributive justice, and to replace it with a type of egalitarianism. He argued that justice requires, after guaranteeing a system that maximizes civil liberties, a set of institutions that maximize the level of 'primary goods' allocated to those who are worst off in society, those who receive the least amount of these goods. Economists call this principle 'maximin primary goods;' Rawls called it the difference principle. Moreover, he attempted to provide an argument for the recommendation, based upon construction of a 'veil of ignorance' or 'original position,' which shielded decision makers from knowledge of information about their situations that was 'morally arbitrary,' so that the decision they came to regarding the just allocation would be impartial. Thus Rawls's (1971) project was to derive principles of justice from rationality and impartiality.

Rawls did not advocate maxi-mining utility (even assuming interpersonal utility comparisons were available), but rather maxi-mining some index of primary goods. This was, in part, his attempt to embed personal responsibility into the theory. For Rawls, welfare was best measured as the extent to which a person is fulfilling his plan of life: but he viewed the choice of life plan as something up to the individual, which social institutions had no business passing judgment upon. Primary goods were deemed to be those inputs that were required for the success of any life plan, and so equalizing primary-goods bundles across persons (or passing to an allocation that would dominate an equal allocation for all individuals) was a way of holding persons responsible for their life-plan choice. The question of how to aggregate the various primary goods into an index that would allow comparison of bundles was never successfully solved by Rawls

(and some skeptical economists said that the subjective utility function was the obvious way to aggregate primary goods).

Rawls defended the difference principle by arguing that it would be chosen by decision makers who were rational, but were deprived of knowledge about their own situations in the world, to the extent that this knowledge included information about their physical, social, and biological endowments, which were a matter of luck, and therefore whose distribution Rawls described as morally arbitrary. He named the venue in which these souls would cogitate about justice the 'original position.' In the original position, souls representing persons in the real world were assumed to know the laws of economics, and to be perfect agents of their self-interested principals. They were, moreover, to be concerned with the allocation of primary goods, because they did not know the life plans of their principals, or even the *distribution* of life plans in the actual society. Nor were they to know the *distribution* of physical and biological endowments in society.

Here we believe Rawls committed a major conceptual error. If the veil of ignorance is intended to shield decision makers from knowledge of aspects of their situations that are morally arbitrary, and only of those aspects, they *should* know their plans of life, which, by hypothesis, are not morally arbitrary, because Rawls deems that persons are responsible for their life plans. Secondly, although a person's *particular* endowment of resources, natural and physical, might well be morally arbitrary (to the extent that these were determined by the luck of the birth lottery), the *distribution* of these resources is a fact of nature and society, and should be known by the denizens in the original position, just as they are assumed to know the laws of economics. Therefore, Rawls constructed his veil too thickly, on two counts, given his philosophical views.

In 1981, Ronald Dworkin published two articles that addressed the problems in the Rawlsian argument to which we have alluded, although he did not use the Rawlsian language (original position, primary goods). His project was to define a conception of equality that was ethically sound. In the first of these articles, he argued that 'equality of welfare' was not a sound view, mainly because equality of welfare does not hold persons responsible for their preferences. In particular, Dworkin argued that if a person has expensive tastes, and he identifies with those tastes, society does not owe him an additional complement of resources to satisfy them. (The only case of expensive tastes,

says Dworkin, that justifies additional resources are tastes that are addictions or compulsions, tastes with which the person does not 'identify,' and would prefer he did not have.) In the second article, Dworkin argues for 'equality of resources,' where resources include (as for Rawls) aspects of a person's physical and biological environment for which he should not be held responsible (such as those acquired through birth).

But how can one 'equalize resources,' when these comprise both transferable goods, like money, and inalienable resources, like talents, families into which persons are born, and even genes? Dworkin proposed an ingenious device, an insurance market carried out behind a veil of ignorance, where the 'souls' participating represent actual persons, and know the preferences of those whom they represent, but do not know the resources with which their persons are endowed in the world. In this insurance market, each participant would hold an equal amount of some currency, and would be able to purchase insurance with that currency against bad luck in the birth lottery, that is, the lottery in which nature assigns souls to persons in the world (or resource endowments to souls). Dworkin argued that the allocation of goods that would be implemented after the birth lottery occurred, the state of the world was revealed, and insurance policies taken behind the Dworkinian veil were settled, was an allocation that 'equalized resources.' It held persons responsible for their preferences – in particular, their risk preferences—and was egalitarian because all souls were endowed, behind the veil, with the same allotment of currency with which to purchase insurance. Impartiality with respect to the morally arbitrary distribution of resources was accomplished by shielding the souls from knowledge of their endowments in the actual world associated with the birth lottery (genetic and physical). Thus, Dworkin retained Rawls's radical egalitarian view about the moral arbitrariness of the distribution of talents, handicaps, and inherited wealth, but implemented a mechanism that held persons responsible for their tastes that was much cleaner than discarding preferences and relying on primary goods, as Rawls had done.

Despite the cleverness of Dworkin's construction, it can lead to results that many egalitarians would consider perverse. Because Dworkin only discussed the hypothetical insurance market informally, he did not perceive this problem. Modeling the

hypothetical insurance market behind the veil of ignorance shows that it is possible for wealth to be transferred from a disabled person to an able person, when both have identical preferences over risk, and their endowments in the birth lottery are equal in wealth. This constitutes a pathology for a resource-egalitarian, because the disabled person should end up with more of the transferable resource than the able one, as she has less of the non-transferable resource. This pathology is discussed in Roemer (1985), Moreno-Ternero and Roemer (2008), and Fleurbaey (2008, Chapter 6).

Slightly before Dworkin's articles were published, Amartya Sen (1980) gave a lecture in which he argued that Rawls's focus on primary goods was misplaced. Sen argued that Rawls was 'fetishist' in focusing on goods, and should instead have focused on what goods provide for people, which he called 'functionings' – being able to move about, to become employed, to be healthy, and so on. Sen defined a person's *capability* as the set of vectors of functionings that were available to him, and he called for equality of capabilities[3]. Thus, although a rich man on a hunger strike might have the same (low) functioning as a poor man starving, their capabilities are very different. While not going so far as to say utilities should be equalized, Sen defined a new concept between goods and welfare – functionings—which G.A. Cohen (1993) later described as providing a state of being that he called 'midfare.' For Sen, the opportunity component of the theory was expressed in an evaluation not of a person's actual functioning level, but of what functionings were *available* to him, his 'capability.' The capability approach has led to a large interdisciplinary literature that is not surveyed here; see Alkire (2002) for how the capability approach has been used in poverty analysis and Fleurbaey (2009) for how it has inspired alternatives to GDP to measure aggregate welfare. To a large extent, the social choice literature that proposes an axiomatic approach to rank opportunity sets in terms of freedom of choice are inspired by the capability approach (see Pattanaik and Xu (1992) and the survey by Barbera, Pattanaik and Xu (2004)).

The contributions of Arneson (1989) and Cohen (1989) were phrased as critiques or amendments to Dworkin (1981a,b). Arneson argued that Dworkin's emphasis on responsibility was important, but that the objective should not be to equalize resources

[3] Sen has not proposed an ordering of sets that would enable one to compare capabilities.

but rather 'opportunities for welfare,' which he formulated in a somewhat abstract way. Thus, he recommended less of a departure from welfare considerations than Dworkin had. Cohen also appreciated Dworkin's transformative contribution, but argued that the right moral cut was not between preferences or choices and resources. Persons might well not be responsible for (all aspects of) their preferences, if these were formed under disadvantageous circumstances. Furthermore, deficits in welfare might well be compensable at the bar of egalitarian justice even should they not be traceable to resource deficits. The right question was whether the person was responsible for them.

A question that arises from the discussion of responsibility is its relationship to freedom of the will. If responsibility has become central in the conceptualization of just equality, does one have to solve the problem of free will before enunciating a theory of distributive justice? We believe the practical answer, which should suffice for practicing economists, is to view the degree of responsibility of persons as a parameter in a theory of equality. Once one assigns a value to this parameter, then one has a particular theory of equality of opportunity, because one then knows for what to hold persons responsible. The missing parameter is supplied by each society, which has a concept of what its citizens should be held responsible for; hence there is a specific theory of equality of opportunity for each society, that is, a theory that will deliver policy recommendations consonant with the theory of responsibility that that society endorses.[4] This is a political approach, rather than a metaphysical one. We will be explicit in the next section on how societies may choose the degree of responsibility that they wish people to bear.

The philosophical literature on 'responsibility-sensitive egalitarianism' continues beyond the point of this quick review, but enough summary has been provided to proceed to a discussion of economic models.

3. Roemer's model and algorithm for equal-opportunity policy

A. The baseline model

[4] The legal system in each country propounds a specific view about individual responsibility that judges and jurors apply in everyday life, and the view clearly evolves over time.

We describe the approach of Roemer (1993, 1998). Consider a population, whose members are partitioned into a finite set of *types*. A type comprises the set of individuals with the same circumstances, where *circumstances* are those aspects of one's environment (including, perhaps, one's biological characteristics) that are beyond one's control, and influence outcomes of interest. Consistent with what we said above, what kinds of action are deemed to be within a person's control may vary across societies. Denote the *typology* $\mathbf{T} = \{1, 2, ..., T\}$. Let the population fraction of type *t* in the population be f^t . There is a desirable *outcome* for which a planner, or society, wishes to equalize opportunities. The degree to which an individual will achieve the outcome is a function of his circumstances, his *effort,* and the social policy: we write the value of the outcome as $u^t(e, \varphi)$, where *e* is a measure of effort and $\varphi \in \Phi$, the set of social policies. Indeed, $u^t(e, \varphi)$ should be considered to be the average achievement of the outcome among those persons of type *t* expending effort *e* when the policy is φ. Here, we will take effort to be a non-negative real number.[5] Effort is assumed to be a choice variable for the individual, although that choice may be severely constrained by circumstances, a point to which we will return below. Economists would normally say that effort is chosen by the individual to maximize a preference order, but preferences are not the fundamentals of this theory.

u^t is not, in general, a subjective utility function: indeed u^t is assumed to be monotone *increasing* in effort, while subjective utility is commonly assumed to be decreasing in effort. Thus, *u* might be the adult wage, circumstances could include several aspects of childhood and family environment, and *e* could be years of schooling. The data for the problem consist of the distributions of effort within types as a function of policy: for the policy φ, denote the distribution function of effort in type *t* as $G^t_\varphi(\cdot)$ and then the data are $\{\mathbf{T}, G^t_\varphi, f^t, u, \Phi\}$.

[5] If actual effort is a vector, then a unidimensional measure *e* would be constructed, for example, by regressing the outcome values against the dimensions, thus computing weights on the dimensions of raw effort.

Defining the set of types and the conception of effort assumes that the society in question has a conception of the partition between responsible actions and circumstances, with respect to which it wishes to compute a consonant approach to equalizing opportunities. Effort comprises those choices that are thought to be the person's responsibility. However, the *distribution function* of effort in a type at a policy, G_{φ}^{t}, is not due to the actions of any person (assume here a continuum of agents), but is a characteristic of the type. If we are to indemnify individuals against their circumstances, we cannot hold them responsible for being members of a type with a poor distribution of effort.

We require a measure of *accountable* effort, which, because effort is influenced by circumstances, cannot be the raw effort *e*. (Think of years of education acquired – raw effort—that is surely influenced in a major way by social circumstances.) Roemer proposed to measure accountable effort as the rank of an individual on the effort distribution of her type[6]: thus, if for an individual expending effort *e*, $G_{\varphi}^{t}(e) = \pi$, we say the individual expended the *degree* of effort π, as opposed to the *level* of effort *e*. The rank provides a way of making inter-type comparisons of the efforts expended by individuals. A person is judged accountable, that is to say, by comparing his behavior only to others who share his circumstances. In comparing the degrees of effort of individuals across types, we use the rank measure, which sterilizes the distribution of raw effort of the influence of circumstances upon it[7].

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[6] Using the rank of an individual in the distribution as a measure of a relevant characteristic is akin to the "rank-and-replace" method in the disparity literature. For a survey that links the equality of opportunity problem to the disparity problem, see Fleurbaey and Schokkaert (2012,).

[7] Some authors (Ramos and Van de gaer (2012)) have called this move – of identifying the degree of effort with the rank of the individual on the objective distribution of his type – the Roemer Identification Assumption (RIA). While the name is lofty, the idea is simple: persons should not be held responsible for characteristics of the distribution of effort in their type, for that distribution is a circumstance.

Because the functions u^t are assumed to be strictly monotone increasing in *e*, it follows that an individual will have the same rank on the distribution of the outcome, within his type, as he does within the distribution of effort of his type Define:

$$v^t(\pi,\varphi) = u^t(e^t(\pi),\varphi)$$

where $e^t(\pi)$ is the level of effort at the πth quantile of the distribution G^t_φ, that is, $G^t_\varphi(e^t(\pi)) := \pi$. Inequality of opportunity holds when the *quantile functions* $\{v^t \mid t \in \mathbf{T}\}$ are not identical. In particular, because we are viewing persons at a given rank π, across types, as being equally accountable with respect to the choice of effort, the vertical difference between the functions $\{v^t(\cdot,\varphi)\}$ is a measure of the extent of inequality of opportunity (or, equivalently, the horizontal distance between the cumulative distribution functions of the outcome).

What policy is the optimal one, given this conception? The verbal statement of the goal is to find that policy which nullifies, to the greatest extent possible, the effect of circumstances on outcomes, but allows outcomes to be sensitive to effort. We do not simply want to render the functions v^t identical at a low level, so we need to adopt some conception of 'maxi-mining' these functions. We want to choose that policy which pushes up the lowest v^t function as much as possible – and as in Rawlsian maximin, the 'lowest' function at a particular value of π may itself be a function of what the policy is. A natural approach is therefore to maximize the area below the lowest function v^t, or more precisely, to find that policy which maximizes the area under the *lower envelope* of the functions $\{v^t\}$. The formal statement is to:

$$\max_{\varphi\in\Phi} \int_0^1 \min_{t\in\mathbf{T}} v^t(\pi,\varphi)\,d\pi \quad . \qquad (3.1)$$

We call the solution to this program the *opportunity-equalizing policy*, φ^{EOp}. (Computing (3.1) is equivalent to maximizing the area to the left of the left-hand envelope of the type-distribution functions of the outcome, and bounded above by the horizontal line at height one.)

In the case in which the lower envelope of the functions $\{v^t\}$ coincides with the v function of a single type (the unambiguously most disadvantaged type), what we have done is simply to maximize the average value of the outcome for the most disadvantaged type, because $\int_0^1 v^t(\pi,\varphi)\,d\pi$ is simply the mean value of the outcome for type t at policy φ.

Thus, the approach implements the view that differences between individuals caused by their circumstances are ethically unacceptable, but differences due to differential effort are all right. Full equality of opportunity is achieved not when the value of the outcome is equal for all, but when members of each type face the *same chances for acquiring the outcome*, as measured by the distribution functions of the outcome that they face.

One virtue of the approach taken here is that it is easy to illustrate graphically. In Figure 1, we present two graphs, to illustrate inequality of opportunity in Hungary and Denmark. In each graph, there are three cumulative income distributions, corresponding to male workers of three types: those whose more educated parent had no more than lower secondary education, those whose more educated parent just completed secondary education, and those whose more educated parent had at least some tertiary education. (The data are from EU-SILC-2005.) The inverses of these distribution functions are the quantile functions $v^t(\cdot,\varphi)$ defined above. It seems clear that, with respect to this one circumstance (parental education), opportunities for income have been more effectively equalized in Denmark than in Hungary, because the distributions functions are closer to being equal in Denmark than in Hungary[8].

[8] We say 'seems' clear, because the horizontal-axis Euro scale is different in the two figures.

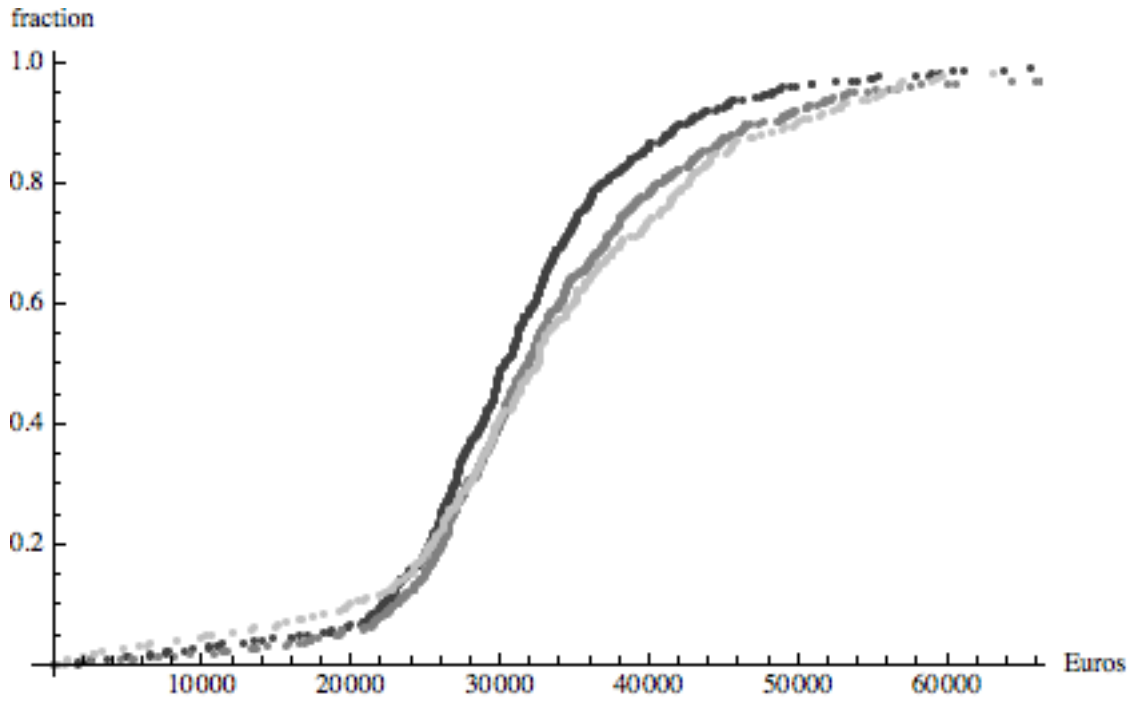

Figure 1a Three income distribution functions for Danish male workers, according the circumstance of parental education. (Darkest hue are from least highly educated backgrounds) From Roemer (2014).

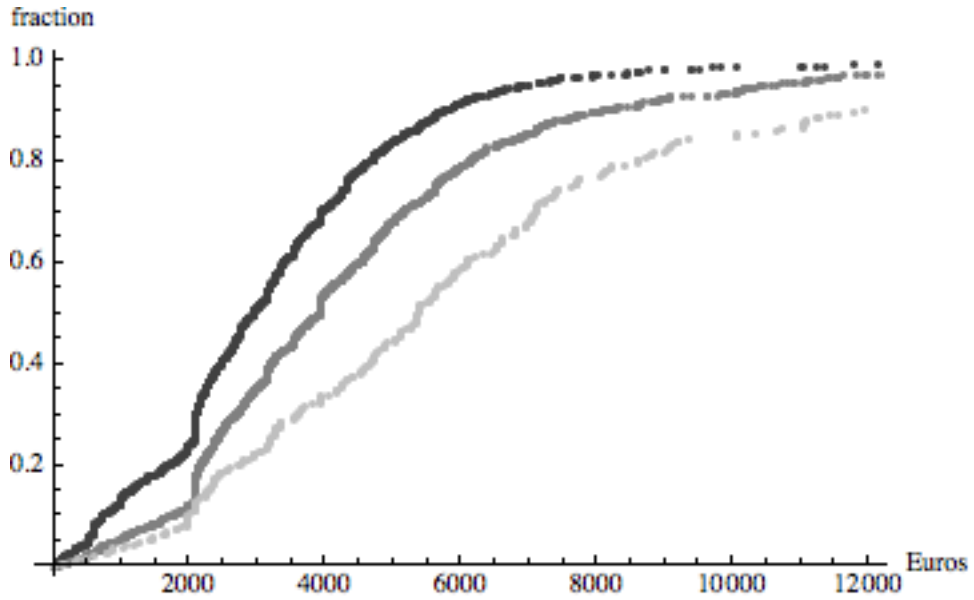

Figure 1b. As in Figure 1a, but for Hungary. From Roemer (2014).

The approach inherent in (3.1) is one that treats all causes of inequality not accounted for by a person's type as being due to effort. For example, with respect to figure 1, there are many circumstances that influence outcomes not accounted for in the definition of type, and so the inequality of opportunity illustrated in that figure should be considered to be a lower bound on the true inequality of opportunity. Nevertheless, it is often the case that delineating only a few circumstances will suffice to illustrate obvious inequality of opportunity, and one can say that social policy should attempt to mitigate at least that inequality.

Let us note that the equal-opportunity approach is *non-welfarist* and moreover *non-consequentialist.* Circumstances are non-welfare information. Informally, consequentialism only considers the final results of policies (outcomes), and not the causes of those consequences. Here, we say there are two kinds of cause of outcomes with different moral status: circumstances and effort. We must distinguish between these causes, and social policy should attempt to mitigate the inequality effects of one of them, but not necessarily of the other.

An alternative to program (3.1) was proposed by Van de gaer (1993): order policies according to the value of

$$\max_{\varphi\in\Phi}\min_{t\in\mathbf{T}}\int_0^1 v^t(\pi,\varphi)d\pi \ . \qquad (3.2)$$

In other words, maximize the average outcome value of the 'most disadvantaged' type. Formally, this proposal simply commutes the integral and 'min' operators compared to Roemer's approach in (3.1) and therefore they are referred respectively as the mean-of-mins and the min-of-means in the following Its virtue is that it is sometimes easier to compute than (3.1). If there is an unambiguously worst off type (that is a type t such that for all policies φ and for all types t', and all $\pi\in[0,1]$ we have $v^t(\pi,\varphi)\le v^{t'}(\pi,\varphi)$), then (3.1) and (3.2) are equivalent. Ooghe, Schokkaert and Van de gaer (2007) compare the orderings over social policies induced by (3.2) and (3.1) by introducing a number of axioms that distinguish between the two. They argue that Roemer's approach (3.1) is a 'compensating outcomes' approach, while Van de gaer's (3.2) is an 'equalizing opportunity sets' approach, in the sense that the integral $\int_0^1 v^t(\pi,\varphi)d\pi$ can be viewed as a

measure of the degree of opportunity available to type *t*. Therefore, these authors link Van de gaer's proposal to the large literature on equalizing opportunity sets (e.g., Kranich (1996), Ok (1997), Bossert (1997), Ok and Kranich (1998), Weymark (2003), Foster (2011)), which derived its inspiration from Sen's capability approach.

A simple example borrowed from Fleurbaey and Maniquet 2011b will illustrate the basic difference between Roemer's and Van de gaer's proposals, and other proposals to come. It will also enable us to introduce the compensation principle which is a cornerstone of the EOp theory.

Example

Consider a society in which individuals are of two types, 'low social background' and 'high social background.' The social background, which can take values 1 or 3, is represented by *c* (for circumstance). Within each social-background type, individuals exhibit either 'low' or 'high' effort, denoted *e*, which can also take on values either 1 or 3. There are identical frequencies of these four kinds of people in the society. There is an external resource, of which there is an endowment of 4 units per capita, which can be distributed among the population. If an individual with circumstance *c* who expends effort *e* receives *x* units of resource, her well-being will be $u = (x + c)e$.

The purpose of equal-opportunity policy is to compensate persons for their disadvantaged social background, but to hold them responsible for their effort. In this example, the effort distribution is identical in the two types, so we do not have to worry about the fact, emphasized earlier, that in real problems, the effort distribution generally varies with the type. Thus, no distinction is needed between the 'level' and 'degree' of effort.

The formulation of program (3.1) for this problem is:

$$\begin{aligned} &\max_{x} \frac{1}{2}\sum_{e=1,3} \min[(1+x_{1e})e,(3+x_{3e})e] \\ &\text{subj. to } \frac{1}{4}(x_{11}+x_{13}+x_{31}+x_{33}) = 4 \ , \qquad (3.3) \\ &\text{and } x_{1e}, x_{3e} \geq 0, \ e = 1,3 \end{aligned}$$

where x_{ce} is the allocation of the resource to an individual of type *c* and effort *e*.

The solution of this problem is given in Table 1:

c\e	1	3
1	3(2)	27(8)
3	3(0)	27(6)

Table 1. Roemer's allocation ($u_{ce}(x_{ce})$)

This is the allocation that maximizes the per capita well-being averaged across effort levels, of those who have the lowest well-being (due to social disadvantage) at each effort level. Indeed, the allocation equalizes the well-being at each effort level: those with effort level 1 sustain a well-being of 3 and those with effort level 3 enjoy a well-being of 27. The value of the outcome function in (3.3) is 15.

In this example, Roemer's solution is able to respect what is called *the principle of compensation*, that is, two individuals with identical degrees of effort have the same level of the outcome. The effect of differential circumstances is completely sterilized by policy, so that outcomes are simply a function of effort. In realistic applications, respecting this principle to the letter is almost never feasible, and compromises must be made.

Now interestingly, the Van de gaer solution which maximizes (3.2) under the same constraints as in (3.3) does not respect the principle of compensation, as shown in table 2.

c\e	1	3
1	1(0)	31(8 +4/3)
3	3(0)	29(8 – 4/3)

Table 2. Van de gaer's allocation $u_{ce}(x_{ce})$

The prospects on average are the same across types and the value of the outcome function is greater than with Roemer's solution (16 instead of 15).[9] However, with a low degree of effort, it is better to belong to type 3 than to type 1. The mean-of- mins (objective

[9] In this case, Van de gaer implements an allocation that also maximizes the sum of individual outcomes.

(3.1)) is better able to realize the neutralization of the impact of circumstances on the outcomes than the min-of-means objective (3.2). But there is a price to pay in terms of a decrease in the total welfare computed as the sum of individual outcomes[10].

B. What are the proper rewards to effort?

Formula (3.1) gives an ordering on policies, with regard to the degree to which they equalize opportunities, after the set of circumstances has been delineated. It implements the view that inequalities due to differential circumstances for those who expend the same degree of effort are unacceptable. There is, however, a conceptual asymmetry: while the instruction to eliminate inequalities due to differential circumstances is clear, the permission to allow differential outcomes due to differential effort is vague. How much reward does effort merit? Providing a social-welfare function (or a preference order over policies) answers that question, at least implicitly. In formula (3.1), the preference order is determined by stating that, if there is a society with just one type, then policies will be ordered according to how large the average outcome is for that society. Fleurbaey (2008) therefore calls formula (3.1) a 'utilitarian approach' to equality of opportunity. More precisely, the *utilitarian reward principle* says that when the only source of differences between individuals is their effort, the social criterion should exhibit no aversion to inequality, corresponding to maximizing a utilitarian social welfare function . Clearly, Van de gaer's criterion also respects the utilitarian reward principle.

What are possible alternatives? At a policy $\varphi \in \Phi$, the *lower envelope* of the outcome functions $v^t(\cdot,\varphi)$ is defined as:

$$\theta(\pi,\varphi) = \min_{t\in \mathbf{T}} v^t(\pi,\varphi) \quad . \qquad (3.4)$$

Formula (3.1) measures the 'size' of the lower envelope function θ by taking its integral on the interval [0,1]. But many other choices are possible. For instance, consider the mappings $\Gamma : \Theta \to \Re$, where Θ denotes the set of non-negative, weakly increasing functions on [0,1], given by

[10] There is no efficiency cost to Roemer's solution with respect to Van de gaer's because the efforts do not depend on the allocation rule in the example.

$$\Gamma^{(p)}(\theta) = \left(\int_0^1 \theta(\pi)^p \, d\pi \right)^{1/p} \quad \text{for } -\infty < p \leq 1 \ . \quad (3.5)$$

Each of the functions $\Gamma^{(p)}$ provides an increasing order on Θ . As p becomes smaller, we implement more aversion to inequalities that are due to effort. As p approaches negative infinity, the order becomes the maximin order, where no reward to effort is acceptable.

Ordering policies according to the value of (3.5) can be called a generalized theory of equal opportunity. We (the present authors) do not have a clear view about what the proper rewards to effort consist in, and hence remain agnostic on the choice of how to order the lower envelope functions θ. The problem of rewards-to-effort goes back to Aristotle, who advocated 'proportionality' of rewards to efforts.[11] We believe that considerations outside the realm of equality of opportunity must be brought to bear to decide upon how much inequality with respect to differential effort is ethically desirable. For instance, G.A. Cohen (2009) has suggested that the inequalities allowed by an equal-opportunity theory should, if they are large, be reduced by appealing to the value of social unity (what he calls 'community'), which will be strained if outcome inequalities are too large[12].

We reiterate the main point of this section. Because we possess no compelling theory of what comprise the just rewards to effort, we should not be dogmatic on the exact way to order policies. In Roemer's approach, the ordering of policies must come

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[11] In production economies, there are two historically important conceptions of just allocation of the product of collective labor: allocation of output in proportion to labor expended, and equal division of the output. (See Roemer (2014).) One may view these as corresponding to two simple notions of responsibility : in the former case, one is responsible for one's labor input, and in the latter, one is responsible for nothing.

[12] In the sharpening debate on the rising inequality in the United States, many believe that the returns to effort at the top are too great. Some object to these huge incomes on grounds that the effort of those who receive them is not so large, but even those who admit that those recipients are exercising rare and socially valuable skills do not in general support the degree to which those skills are remunerated.

from some increasing order on the set of lower-envelope functions, where the lower-envelope function induced by a policy φ is given by (3.4). This indeterminacy in the theory introduces a degree of freedom, the choice of the preference order Γ. Considerations outside of the theory of equal opportunity might put constraints on the degree of overall inequality that is desirable/admissible in a society, and this can guide the choice of Γ.

We have thus argued that the theory of equal opportunity is not intended as a complete theory of distributive justice, for two reasons. First, we have emphasized its pragmatic nature. We do not have a complete theory telling us for what people are, indeed, responsible, and have advocated the present approach as one that should be viewed as providing policy recommendations for societies that are consonant with the society's conception of responsibility. Thus, the choice of the set of circumstances, and even of the policy space, will be dictated by social norms. The society in question must choose a set of circumstances, which will define types, that is consonant with its conception of personal responsibility. Secondly, the theory does not include a view on what the proper rewards to effort consist in, and this is reflected in the openness of the choice of Γ in program (3.5).

Roemer views the approach as most useful when the outcome in question is something measurable like income, or life expectancy, or wage-earning capacity. He views the usefulness of the approach for policy makers who are concerned with narrower outcomes than overall utility: the health ministry has an objective of life expectancy or infant survival, the education ministry is concerned with the secondary- school graduation rate, the labor ministry is concerned with opportunities for the formation of wage-earning capacity, or for employment, and so on. All these objectives are cardinally measurable, and it makes sense to use any of the operators defined in (3.5) to generate an ordering on policies[13].

[13] See Calsamiglia (2009) for a theoretical study about problems that may arise when each of several ministries attempts to equalize opportunities for outcomes with which they are concerned, without accounting for what other ministries are doing.

4. The Fleurbaey-Maniquet approach

Marc Fleurbaey and François Maniquet, in a series of writings (their work[14]is summarized in Fleurbaey's monograph (2008) and Fleurbaey and Maniquet (2011b)), have proposed a number of ways for ordering policies with respect to the degree to which they equalize opportunities, which are similar in spirit to those discussed above, but different in detail. In particular, they agree about the starting point of the theory, which is the partition of the set of characteristics that describe the situation of an individual, between circumstances and effort variables. The general inspiration of their approach is the concept of envy-freeness and the theory of fair allocations, pioneered in the works of Duncan Foley (1967) , Serge-Christophe Kolm (1972), Hal Varian (1975), and Elisha Pazner and David Schmeidler (1978). Here, we summarize their approach, which differs from the one outlined in sections 3, in three ways.

First, they advocate another principle of reward (than the principle of utilitarian reward), the *principle of natural or liberal reward*. Second, they propose allocation rules that are ordinal in essence, that is, that do not depend on the cardinalization of the outcome function. This contribution is especially valuable if the individual outcome is welfare but less so if it is some intermediate goal such as life expectancy or income attainment, which is cardinally measurable. Third, their approach does not clearly acknowledge the important fact that effort is in part determined by circumstances.

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[14] The first articles date back twenty years ago, Fleurbaey (1994) and (1995b), Bossert (1995) and Bossert and Fleurbaey (1996) where the conflict between the compensation principle and the responsibility principle is explained, and methods for resolving the conflict are described.

[15] The leximin (or lexicographic minimum) ordering orders vectors as follows. Given two vectors A and B of the same dimension, we say $A \succ_{lex} B$ if A's smallest component is bigger than B's smallest component. If these two components are equal, we say $A \succ_{lex} B$ if its second smallest component is bigger than B's second smallest component. If the smallest two components are identical, we proceed to examine the third smallest components. Two vectors are leximin indifferent if and only if one is a permutation of the other.

As a starting point, it is useful to return to the earlier example. Fleurbaey and Maniquet propose a different policy that fully respects the principle of compensation: namely, that those with the same effort levels should enjoy the same outcome (that is, that equality of opportunity should attempt to produce a result in which outcomes are insensitive to social background).

c\e	1	3
1	6(5)	18(5)
3	6(3)	18(3)

Table 3. Fleurbaey and Maniquet's solution $u_{ce}(x_{ce})$

Indeed, for each level of effort, the outcome does not depend on circumstances, as in Roemer's solution. However, the value of the objective (3.4) at the allocation in table 3 is 12, much less than 15. On the other hand, the within-type inequality is much lower because the Fleurbaey-Maniquet allocation perfectly compensates for social disadvantage, in the sense that the value of $x+c$ is equal to 6 for all individuals, and so the variation in well-being is entirely due to differential effort. As shown in the table 3, a distinctive feature of the allocation proposed by Fleurbaey and Maniquet is that the transfers are identical for all members in a type.

What is the principle that Fleurbaey and Maniquet employ that leads to this allocation? They are guided, as we said, by a *principle of natural reward*, which says that individuals with identical circumstances, that is, those within a type, receive the same resource transfer. More generally, the resource allocation should be independent of individuals' efforts. The authors also call this the liberal reward principal, as it accepts the 'laissez-faire' outcome, once circumstances have been compensated for. No further redistribution should be performed beyond that which is required by the principle of compensation. In contrast, in an environment in which everyone has the same circumstances, program (3.1) would not accept laissez-faire: it would further redistribute resources in order to maximize the average value of the outcome (of the single type). Clearly, the principle of utilitarian reward may recommend within-type redistribution to

the benefit of those who exert more or less effort depending of the marginal return of effort in terms of the individual outcome.

The simplest way to observe the difference between the approaches of Roemer and Fleurbaey and Maniquet is in a problem where all individuals have the same circumstances. Roemer's proposal allocates the public resource to maximize the average value of the social outcome, and Fleurbaey-Maniquet's proposal divides the resource equally among all. As we wrote earlier, we do not believe there is a clear ethical instruction concerning what the proper rewards to effort are. We think that the Fleurbaey-Maniquet approach is attractive when the outcome is assumed to be non-comparable across persons: the main example is when outcome functions are said to be only ordinal representations of preferences. When, however, outcomes are cardinally measurable and interpersonally comparable (incomes, life expectancies, wages, etc.) then we find the 'utilitarian' approach or one of its cousins (see (3.5)) attractive.

On the basis of the above example, it might seem that Fleurbaey and Maniquet can achieve the summum bonum of equality of opportunity in their perspective, an allocation that both realizes the principle of compensation and the principle of natural reward. However, the two principles are generally incompatible when the outcome function is not separable in extended resources (circumstances plus external resources) and effort. The intuition for the clash between these principles can easily be grasped in a discrete setting where we can construct an outcome matrix u_{ce} and an allocation matrix x_{ce}, both of whose rows correspond to types, and whose columns to effort levels. The principle of compensation requires that inequality within columns in the outcome matrix be eliminated (columns should be constants), while the principle of natural reward demands that the rows in the allocation matrix be constant. It is clear that these two injunctions can conflict, as was established by Walter Bossert (1995) and Fleurbaey (1995b). If the outcome can be written in a weakly separable way (that is, there are functions *f* and *g* such that $u(x,c,e) = f(g(x,c),e)$) then the conflict can be avoided. Interestingly, this conflict arises even in the quasi-linear case, $u(x,c,e) = x + f(c,e)$. One of the virtues of the axiomatic approach has been to show that the tradeoff between these principles is inescapable in a fully general setting. Fleurbaey (2008) and Fleurbaey and

Peragine (2013) also prove that the clash between the compensation principle and the reward principle extends to the principle of utilitarian reward and weaker versions of the reward principle than natural reward..

We have given an example of how Fleurbaey and Maniquet equalize opportunities, but we have not yet fully described their allocation rule. Because of the conflict between the compensation principle and the natural reward principle, their strategy is to weaken both principles until they become compatible. There are various ways of carrying out this program. We summarize two prominent examples of compromise orderings, which give different weight, so to speak, to the principles of natural reward and of compensation. A common feature of these solutions is to define a reference value either for effort or for circumstances. The principle that is sacrificed in the compromise is at least fulfilled for the reference effort or circumstance. For the allocation rule of *conditional equality*, natural reward is respected everywhere and in addition the principle of compensation is satisfied at least for the reference effort level. For the allocation rule of *egalitarian equivalence* , circumstances are fully compensated for, while transfers obey the natural reward principle for the reference type. Both solutions will depend upon the choice of the reference value of circumstances or effort.

In the conditional equality criterion, imagine a counterfactual where all individuals expend the same reference level of effort, but maintain their actual circumstances. In this case, that allocation is most preferred which most closely equalizes the value of the outcome -- that is, each person should be indifferent to how she would feel if she had the circumstances of any other person. The conditional equality policy is defined as that policy $\varphi = (\varphi_1, ..., \varphi_T)$ solving :

$$(\forall t, t' \in \mathbf{T}) \qquad u^{t'}(e^*, \varphi_{t'}) = u^t(e^*, \varphi_t) \qquad (4.1)$$

where *t* indicates the individual's type , e^* is the reference effort level, and φ_t is the resource transfer to members of type *t*.

The justification of this approach is that if persons all types expend the same value of effort, then there is no ethical basis for their having different outcomes. The principle of compensation is then satisfied for the reference effort level.

A kind of dual to conditional equality is the egalitarian equivalent rule. Fleurbaey and Maniquet consider a counterfactual where each individual faces the same circumstances but exerts his own effort. Suppose the policy consists in an allocation of a resource. Fix a type t^*, perhaps the most disadvantaged type. Find an allocation of the resource to all individuals, $\{\varphi_{it} \mid t \in \mathbf{T}, i \in t\}$, which exhausts the amount of resource available, and which equalizes the value of the outcome, for every individual, to what her outcome value would be at the reference type, at some perhaps infeasible allocation of the resource $\{\hat{\varphi}_{it*}\}$. That is:

$$\text{for all } t \text{ and } i \in t \qquad u^t(e_i, \varphi_{it}) = u^{t*}(e_i, \hat{\varphi}_{it*}) \ , \qquad (4.2)$$

where *i* indicates the individual. Thus, at the executed policy, each individual is as well off as she would be in some hypothetical allocation where she were of type $t*$ but exerting her actual effort e_i. This approach tells us how to order any pair of feasible policies φ and φ': we say that φ is preferred to φ' if the counterfactual distribution $\hat{\varphi}$ is 'more equal' than $\hat{\varphi}'$; to be precise

$$\varphi \succ \varphi' \Leftrightarrow \hat{\varphi} \succ_{lex} \hat{\varphi}' \ ,$$

where $\succ_{lex}$ is the leximin ordering[15].

The authors call this particular version of the egalitarian-equivalent approach to responsibility *min egalitarian equivalence* (min-EE), because the standardization takes place by counterfactually making everyone a member of the worst-off type. Of course, standardizing with respect to some other type would do as well, although each choice of how to standardize will (generally) produce a different ordering over policies. One virtue

[15] The leximin (or lexicographic minimum) ordering orders vectors as follows. Given two vectors A and B of the same dimension, we say $A \succ_{lex} B$ if *A*'s smallest component is bigger than *B*'s smallest component. If these two components are equal, we say $A \succ_{lex} B$ if its second smallest component is bigger than *B*'s second smallest component. If the smallest two components are identical, we proceed to examine the third smallest components. Two vectors are leximin indifferent if and only if one is a permutation of the other.

of the approach is that an ordinal outcome function u is all that is required, as we only need to compare the outcome for individuals to variants of themselves (where they have different circumstances), which contrasts with the approach of program (3.1), that requires cardinality to give meaning to the integral (or average) of outcome values.

An essential feature of the egalitarian-equivalent approach is the liberal or natural reward principle, according to which if everyone were of the same type, then no redistribution is called for. To be specific, in his EOp approach, Roemer closes the model by saying that if everyone were of the same type, then policies are preferred if they produce higher *average* outcomes, while Fleurbaey (2008) declares that policies are better in this case, the closer they are to *equal resources*. Both approaches are incomplete: program (3.6), as has been discussed, does not dictate a choice of the operator Γ, and egalitarian equivalence does not dictate a choice of the way to standardize circumstances.[16] Of course, the two approaches will in general give a different ordering of policies. Roemer (2012) calculates some examples. The trade-off between reward and compensation for the four allocation rules discussed here is summarized in table 4, taken from Fleurbaey and Maniquet (2011b).

	Natural Reward	Utilitarian Reward

[16] Depending on the context, the worst and the best circumstances can be described as natural candidates. For instance, it has been argued (see Tungodden (2007)) that the former solution is worth considering if one wants to minimize ex post inequalities.

[17] The proposal in this section is similar although not identical to that advanced in Roemer (2014).

Priority on compensation	*Egalitarian-Equivalent*	*Mean-of-Mins*
Priority on reward	*Conditional equality*	*Min-of-Means*

Table 4. Summary of attributes of four EOp allocation rules

One disadvantage of the egalitarian-equivalent approach is that the notation does not force the practitioner to come to grips with the fact that effort choices people make are themselves influenced by circumstances. Recall that in Roemer's approach, it was the *degree* of effort rather than the *level* of effort that was taken as reflecting responsibility, and this distinction was made because the type distributions of levels of effort are influenced by circumstances. Now one can model the same idea in the egalitarian-equivalent approach, but the influence on the distribution of effort by circumstances is not built into the model, and there may be a tendency of practitioners to take *e* as *observed* levels of effort and choices of various kinds, and this would fail to take account of the fact that the distribution of effort in a type is itself a characteristic of the type, and something that calls for compensation. So a literal application of the egalitarian-equivalent model, which is insensitive to this fact, will ascribe to persons responsibility for choices that are perhaps heavily influence by circumstances, and should therefore call for compensation.

In the example, we have assumed that effort is given and in particular does not respond to policy. Once behavorial responses have been reintroduced, one of the innovative applications of the egalitarian-equivalent approach by the authors is to tax policy. From among feasible tax policies, that policy should be chosen which is most preferred according to the egalitarian-equivalent preference order. As noted, this approach provides a theory of optimal taxation that does not rely on any cardinalization of the utility function. See Fleurbaey and Maniquet (2006) and Fleurbaey and Maniquet (2011, chapter 11).

Our final topic of this section is the incorporation of luck into the theory of equal opportunity. Of course, luck has already largely been incorporated, as circumstances are viewed as the most important aspects of luck -- the luck of birth lottery assigns genes,

654 families, and social environments to persons. Besides the luck inherent in circumstances,
655 however, there are two other kinds of luck that are important: first, what might be called
656 episodic luck, which is randomly distributed across individuals, and is often unobservable
657 to third parties (being in the right place at the right time), and the luck due to the
658 outcome of chosen gambles. Dworkin's view was that no compensation is due to anyone
659 who suffers a bad outcome due to a voluntarily chosen gamble – such 'option luck' is due
660 to an exercise of preferences for which the person is held responsible. Fleurbaey (2008),
661 however, contests this view. He splits gambles into two parts: the decision to take the
662 gamble, which is the person's responsibility, and the outcome of the gamble, which is an
663 aspect of luck. Let us view the risk-taking preference of the individual as a responsibility
664 characteristic, and the outcome of the gamble as a circumstance – something over which
665 the individual has no control. Fleurbaey then proposes to apply conditional equality and
666 egalitarian equivalence to this particular context. As can be anticipated, the former
667 criterion gives more room to risk loving activities since it gives priority to the principle of
668 natural reward. The most cautious individuals are chosen as the reference responsibility-
669 group and they should be fully insured (if possible). Less risk-averse individuals will
670 receive the same transfers as the most cautious, which means that they will bear the extra
671 risk they take. As a result, one can say that conditional equality leads to a watered down
672 version of option luck.
673 Applying the egalitarian-equivalence approach to luck, Fleurbaey distinguishes
674 between those who gamble only because of the possibility of increasing their wealth and
675 those who derive a thrill from gambling (whom he calls 'super risk lovers'). He
676 advocates, ideally, equalizing ex post wealth from the gamble among those of the first
677 category, but allowing those in the latter category to assume the full risk of the gamble.
678 It is unclear how this distinction could be implemented in social policy.
679 Lefranc, Pistolesi and Trannoy (2009b) believe that the project of separating
680 influences into circumstances and effort is too binary. They call 'residual luck' a third
681 influence, and recommend something weaker than compensation for residual luck,
682 namely, that the correlation between such luck and circumstances be eliminated. These
683 authors are agnostic about what comprises residual luck although they point to a
684 consensus that social background should be counted as a circumstance. The following

examples are illustrative of what a society might count as residual luck: the chance meeting of another person who offers one a good job; rare productive talent; the winnings of national lotteries (Belgium, France, UK) . The luck inherent in these examples (especially the first two) is often considered to be part of life, something that policy should not attempt to eliminate. The first example could be brute luck or due to special effort; the second example is brute luck; the third is option luck. These authors maintain that a minimal requisite of equality of opportunity is that these kinds of luck should be equally distributed across types, at any given level of effort.

Suppose the income-generating process is given by:

$$y = g(c,e,l)$$

where *c*, *e,* and *l* are circumstances, effort, and residual luck, respectively. The distribution of income, conditional upon *c* and *e* is defined as:

$$H(y \mid c,e) = F_{c,e}(g^{-1}(y,c,e))$$

where $F_{c,e}$ is the distribution of luck in the element of the population characterized by (c,e) . The above-described principle says that

$$\text{for any } (c,c') \quad H(\cdot \mid c,e) = H(\cdot \mid c',e) = K(\cdot \mid e) \ .$$

This permits the distribution of residual luck to depend on effort but not on circumstances. It is one formulation of the principle of compensation: at a selected allocation, it should be possible to express individual well-being as a function of responsibility characteristics only. (Fleurbaey [2008, p.26]). If all luck factors are named as circumstances, then the distribution *K* is simply a point mass. More generally, the support of this distribution can be made as small as the decision-maker wishes, as the set of circumstances becomes larger, thus reducing the role for residual luck. It is also true that the theory does not put a limit on inequalities due to residual luck. The authors propose further refinements using stochastic-dominance arguments.

Empirically, the problem of brute luck is important. The data sets that enable one to measure inequality of opportunity usually contain information on only a small set of circumstances (such as the education of the parents). Consequently, if one measures effort as the residual determinant of outcomes, once these few circumstances have been accounted for, it appears as if differential effort is massively responsible for outcomes. In

fact, luck, meaning the effect of unobservable circumstances, plays a large role. We will return to this point below.

5. Economic development[17]

It stands to reason that the way we measure economic development will be a corollary to our ethical ideas about the just society. The standard measure of economic development, GDP per capita, is inspired by the utilitarian ethic. If we identify utility with income, then average utilitarianism calls for maximizing average income. Hence this popular conception of economic development is a corollary to an ethical view. As utilitarianism was ubiquitous in economic thinking until Rawls (1971), and continues to be extremely influential in economics after Rawls, especially in growth theory and policy analysis, it is unsurprising that our central measure of economic development has a basis in utilitarian thought.

There are various ways we might alter our measurement of economic development, based on other ethical views. Indeed, some alterations can be made within utilitarianism. By recognizing that some needs are more urgent than others, we could apply a concave transformation to income, say the logarithm, and measure economic development by $\sum \log y_i$, where y_i is the income of individual *i*, which is ordinally equivalent to maximizing $\prod y_i$. Of course, this would place much more policy focus upon avoiding poverty, as a single very low income is socially catastrophic. Another tack, inspired by the capability approach (see Anand and Sen (1993, 1999)) is to include other arguments besides income in the utility function – education and health, in particular – but to take the average of an index of these goods over the nation. This is the approach of the UNDP's human development index.

But if equalizing opportunities is an attractive ethic, then we should construct measures of economic development that are consonant with it. We will propose, here, a two-dimensional index of economic development, based upon the EOp approach. The

[17] The proposal in this section is similar although not identical to that advanced in Roemer (2014).

first component of the index is the value of (3.1), and the second is a measure of the extent to which opportunities have been equalized in the society.

There are various methods for defining the second component; here is a simple one. For a given society, where types have been defined, let $\bar{Y}$ be average income, Y^D be the average income of the most disadvantaged type, and let $\eta = Y^D / \bar{Y}$. To the extent that opportunities for income have been equalized, η will be close to one. One approach is to measure economic development by the ordered pair $d = (Y^D, \eta)$. Y^D replaces GDP per capita: it is the average income of those who belong to the most disadvantaged type. Thus, *d* presents both a level of welfare and a degree of opportunity equality.

There are other proposals for ways of measuring the degree of inequality due to inequality of opportunity, that can substitute for η. The aggregate distribution function of income (for instance) for a society is the weighted sum of the distribution functions of incomes of its types. There is a family of inequality measures (the general entropy measures) that are decomposable, in the sense that one can represent the inequality in the aggregate distribution as the sum of the inequalities in the component type distributions, and inequality 'between' the type distributions. The second term can be interpreted, in this case, as the inequality due to differential circumstances, while the first is inequality due to effort. Ferreira and Gignoux (2011) define the 'inequality of opportunity ratio (IOR)' using one of these decomposable measures of inequality (the mean logarithm deviation). The same idea for measuring the degree of inequality due to circumstances is proposed in Checchi and Peragine (2010), and Roemer (2014) provides another variation.

In figure 2, we present a graph plotting the points *d* for a set of European countries, where the data are taken from EU-SILC (2005) and the population of male workers is partitioned into three types, depending on the level of education of the more educated parent. (Type 1: Parent completed only lower secondary education; type 2: parent completed upper secondary; type 3: parent had some tertiary education.)

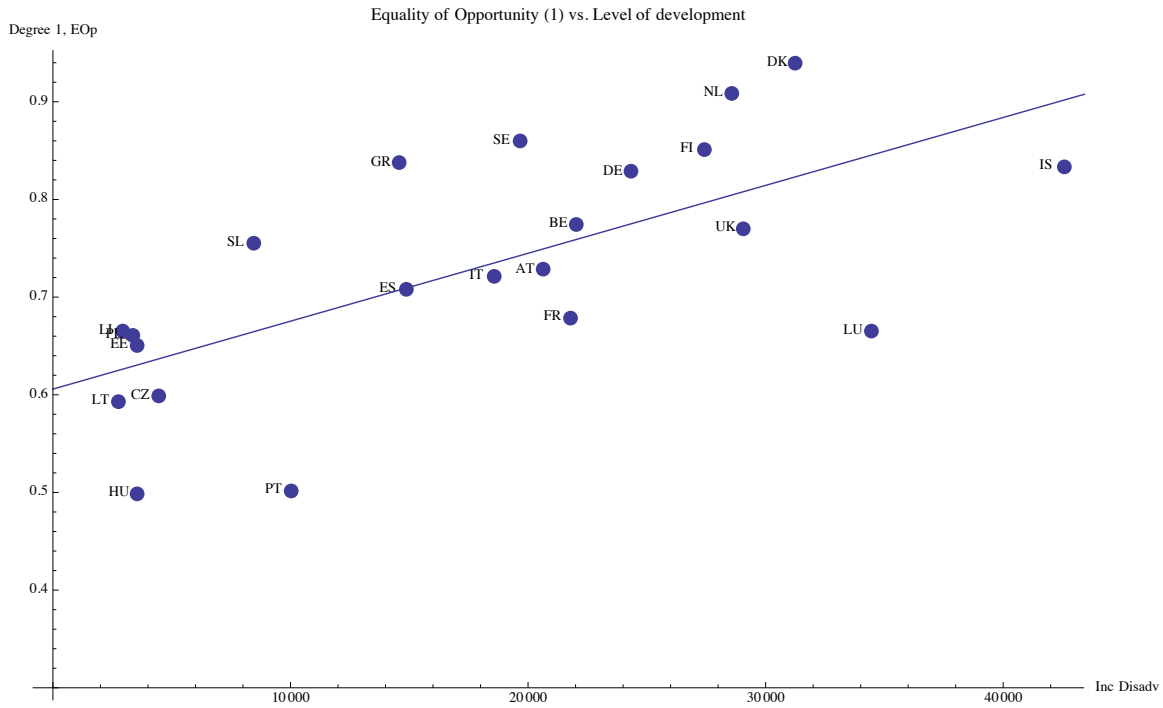

Figure 2. The points $d = (Y^D, \eta)$ for a set of European countries (EU-SILC 2005 data)

Several remarks are in order. (1) Iceland's (IS) strong position on the first component, it must be remembered, is from data before the bank crisis. (2) No country dominates all others on both components of *d*. But Denmark (DK) dominates all other countries except Luxemburg (LU) and Iceland. (3) Greece's component η is high because there were very few survey respondents in types 2 or 3, so average income is close to average income of the most disadvantaged type. (4) The Eastern European countries (Lithuania, Latvia, Estonia, Poland, Czech Republic, and Hungary) perform relatively poorly. Finally, recall that we are looking at highly developed countries; were we to calculate the point *d* for developing countries, there would be a much larger spread.

Ferreira and Gignoux (2011) calculate their version of the measure η for six Latin American countries as well. There is, as one might expect, a lower degree of opportunity equalization in the Latin American countries than in the European ones.

The World Bank has been an important innovator in bringing considerations of equal opportunity into economic development. Its two important publications, to date,

have been the 2006 World Development Report, *Equity and Development,* and a monograph, *Measuring inequality of opportunities in Latin America and the Caribbean* (Paes de Barros et al., 2009). The more recent publication contains a wealth of information on the effects of social circumstances on various measures of achievement and output.

Paes de Barros et al. (2009) propose a measure of equality of opportunity. Consider a particular kind of opportunity, such as 'attaining the sixth grade in elementary school.' Let the total sixth-grade attendance in a country be *H*, and the total number of children of sixth-grade age be *N*, and define $\bar{p} = \frac{H}{N}$ to be the *access* on average of children to the opportunity of a sixth-grade education. $\bar{p}$ measures the level of this opportunity in the country, but not the extent to which access is unequal to different children, based upon their social circumstances. Now using a logit model, they estimate the probability that each child, *j*, in the country has of attending the sixth grade, where that probability is a function of a vector of circumstances; denote this estimated probability by $\hat{p}_j$. Define $D = \frac{1}{2\bar{p}N}\sum |\hat{p}_j - \bar{p}|$. D measures the variation in access to the opportunity in question across children in the country. The normalization guarantees that $0 \le D \le 1$. Now define the *human opportunity index* as

$$O = \bar{p}(1 - D);$$

note that $0 \le O \le \bar{p}$.

The human opportunity index is a non-consequentialist measure of development, because the probabilities $\hat{p}_j$ can only be computed knowing the circumstances of the children. The measure combines a concern with the level of provision of opportunities and the inequality of the distribution of them. This is to be contrasted with the ordered pair (Y^D, η), which separates these two concerns into two measures. Obviously, some information is lost in using a single measure rather than two measures.

The concern of the 2009 report is in large part with children. In our view, where children are concerned, all inequality should be counted as due to circumstances, and none to effort, and so the fact that the human opportunity index does not explicitly make

the distinction between effort and circumstances is unobjectionable[18]. The same point is made by Kanbur and Wagstaff (2014). However, if the measure is used for addressing inequality of opportunity for adults, this may be a defect.

To study this, let us take an opportunity for adults – earning an income above *M*. Suppose there are three types of worker, according to the level of education of their more educated parent. Denote the distribution of income in type *t* as F^t ; let the population frequency of type *t* be f^t and let *F* be the distribution of income in the society as a whole. Then $\bar{p} = 1 - F(M)$ is the average access to the opportunity in question in the country. For all members *j* of a given type *t*, the access to an income *M* or greater is defined as $\hat{p}^j = 1 - F^t(M)$. The human opportunity measure is:

$$O = \bar{p}\left(1 - \frac{1}{2\bar{p}}\sum f^t \left|1 - F^t(M) - (1 - F(M))\right|\right) = (1 - F(M)) - \frac{1}{2}\sum f^t \left|F(M) - F^t(M)\right| .$$

The first term $1 - F(M)$ measures the level of opportunity in the country, while the second term is a penalty for the degree to which this opportunity is mal-distributed with respect to circumstances (e.g., if there were no inequality of opportunity, then $F^t(M) = F(M)$ for all *t,* and the penalty is zero).

Brunori, Ferreira, and Peragine (2013) compute a version of the human opportunity index for a set of 39 countries. To date, this is the most ambitious international comparison available. Unfortunately, the typologies are different across the countries, and so the degrees of opportunity equality they report are not easily comparable. Data collected for a standardized set of circumstances across countries are sorely needed to give a more complete picture of inequality of opportunity across the globe.

6. Measurement of inequality of opportunity

[18] Children should only become responsible for their actions after an 'age of consent' is reached, which may vary across societies. Both nature and nurture fall within the ambit of circumstances for the child.

This section will focus on measurement issues . An excellent survey of the topic is provided by Ramos and Van de gaer (2012).

A. Methodological issues: general remarks

Measuring inequality of opportunity may mean different things. At the most basic level, we may want to capture the degree of inequality of opportunity with an index, as has been done for inequality of outcomes with the Gini, Atkinson, Theil and other indices. We may be more modest in only wanting to rank distributions of outcomes, and be content with incomplete but robust rankings provided by instruments of a dominance analysis, such as the Lorenz curve. Circumstances, effort, and luck are just sources of outcome inequality, and we may wish to trace their contribution to overall inequality. Decomposition exercises among sources are just as appropriate in EOp empirics as in inequality-of-outcome analysis. Quantifying, ranking, and decomposing are three familiar operations that we may apply to equal-opportunity analysis, and the tools are mainly borrowed from the measurement-of-inequality literature.

A (i). EOp measurement as a multi-dimensional problem

Nevertheless, it seems fair to say that the level of complexity of the analysis is greater because EOp necessarily has a multi-dimensional aspect; as such, one may use the conceptual framework developed by Atkinson and Bourguignon (1987) for multi-dimensional inequality. These authors focus on how to measure income inequality when each income unit belongs to a specific needs group. The information is two-dimensional -- income and needs for each household -- and the aim of the analysis is to rank income distributions taking into account the information provided by the vector of needs. In EOp analysis, we would rank outcome distributions (income, health, education) that are unidimensional, taking into account the information provided by the vector of circumstances, the vector of efforts and perhaps the vector of residuals. EOp measurement then belongs to the family of problems of multi-dimensional inequality when *margins* are fixed, where margins comprise the non-outcome information that matters in EOp assessment (circumstances and effort).

A direct application of the sequential Lorenz quasi-ordering to this setting is not appropriate and it is interesting to see why. Of course, effort can be seen as analytically

similar to needs: that is, at the margin, the more effort one makes, the more income one deserves although this statement has limitations. (We may wish not to reward effort excessively, for reasons discussed in section 3.) Reciprocally, circumstances can be seen as negative needs: the better one's circumstances are, the less one deserves. However, it is the interplay between circumstances and effort that makes the evaluation of the ensuing inequality problematic. We need to know how additional effort should be rewarded across the circumstance dimension; as we discussed, there is no clear answer to this question within the theory and therefore, it is not easy to think of an extension of the sequential Lorenz criterion to inequality of opportunity.[19]

A (ii). EOp as a process

What also distinguishes EOp empirical analysis from inequality-of-outcome analysis is its two-stage nature: one generally requires an econometric-estimation stage, preceding the inequality-measurement stage. It is not so much the difference in circumstances *per se* that matters, but the difference in the impact of circumstances. Socio-economic advantage has to be estimated through parametric and non-parametric estimation techniques, captured by the coefficient of the circumstance variable in a linear model regressing the outcome on a set of circumstances and effort variables. An evaluation of inequality must be concerned with the process that generates it. This leads Fleurbaey and Schokkaert (2009) to state, provocatively, that any EOp empirical analysis must be preceded by an estimation phase to discover the best structural model leading to the results. Only in the second step should we be interested in measuring inequality of opportunity as such.

In principle, we agree. This is, however, more easily said than done. Two observations are in order. The two main obstacles to any causal inquiry are reverse causality and endogeneity due to omitted variables. The good news is that, regarding circumstances, reverse causality can often be dismissed since circumstances are frequently characteristics of states that existed in the past (e.g., one's parents' education).

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[19] As Muller and Trannoy (2011) show in a general three-dimensional setting, it is possible to extend the sequential Lorenz ordering if the well-being function is 'quasi-separable,' that is, $u(x_1, x_2, x_3) = \psi(x_1, x_2) + \varphi(x_1, x_3)$. If x_1 is income, x_2 the circumstance, and x_3 effort, then the sequential Lorenz quasi-ordering can be helpful to rank multidimensional distributions according to EOp.

899 However, endogeneity cannot be discarded in that way because EOp measurement is
900 plagued with informational problems. Omitted variables are widespread; a good example
901 is provided by genetic variables that have been found paramount in income attainment by
902 Björklund et al (2012). Omitted variables in empirical EOp analysis cause skepticism
903 with regard to claims of causality we may wish to assert. The situation is even worse
904 when the outcome is earnings, since according to Bourguignon et al. (2007), '…an
905 instrumental variable strategy is unlikely to succeed, since it is difficult to conceive of
906 correlates of the circumstance variables that would not themselves have any direct
907 influence on earnings. ' Experiments and quasi-experiments enable one to make causal
908 statements, but experiments can usually only study problems that are much more
909 circumscribed than those which interest researchers in this field. We are trying to
910 understand the whole process by which someone reaches an income level, a health status,
911 or an educational attainment. These processes are dynamic and cover part of the lifespan
912 of an individual, and understanding them fully in a causal way seems out of reach at
913 present.

914 Should we worry about this lack of causal interpretation? Of course, if we want to
915 give advice to policy makers about the true effect of leveling-the-playing-field policies,
916 impact evaluation needs to be causal. However, if one merely wants to measure the
917 degree of inequality of opportunity -- that is inequality due to circumstances -- a
918 correlation (with variables which occurred in the past) is already something that is
919 relevant. To illustrate, consider the case where there a positive correlation between
920 children and parents health. Many different features can explain such a link. Genes, life
921 styles, access to medical care, housing conditions (such as the presence of lead in walls or
922 paints) are just examples that come to mind. It is obvious that the remedy, if any, is
923 specific to each case. Whatever the cause, the correlation provides some empirical
924 evidence of violating equality of opportunity.

925 The challenge is even greater if we take the preference view for responsibility
926 variables advocated by Dworkin and Fleurbaey. Retrieving the true parameter of
927 preferences is perhaps the most difficult issue in econometrics in terms of identification
928 conditions (see, however, Fleurbaey et al (2013) for an attempt to estimate the
929 individual's trade-off between health and income and Bargain et al (2013) for the

930 estimation of cross-country preference heterogeneity in the consumption-leisure trade-
931 off).

932 A (iii). Lack of relevant information

933 It should be clear from this discussion that we need a much richer database to
934 perform EOp empirical analysis than a pure inequality-of-outcome analysis. We should
935 have variables describing the situation of the family and social background and variables
936 pertaining to effort. It is quite common that some important background variables are
937 missing and then we have an incomplete description of the circumstances. More
938 importantly, effort variables are generally missing for the very reason that effort is private
939 information, as is emphasized in economic theory. We must use proxies, which are
940 problematical.

941 The measurement of effort depends upon our view of responsibility. On the one
942 hand, there is the view that effort takes into account what set of actions a person can
943 *access*, where access is a question not simply of physical constraints, but of
944 psychological ones, which may be determined by one's circumstances. On the other
945 hand, there is the view that a person should be held responsible for his preferences, and
946 hence a person is responsible for taking those actions that flow from his preferences.
947 Roemer's measurement of effort as the rank of a person's effort in the distribution of the
948 outcome for his type represents the access (or control) view: one judges the accessibility
949 of actions to members of a type by what people in that type actually do. (This view is
950 also reflected in G.A. Cohen's (1989) phrase 'access to advantage', which he advocates
951 equalizing.) Dworkin and Fleurbaey represent the preference view, in which a person is
952 held responsible for his choices, if they flow from preferences with which he identifies.
953 Because almost all empirical studies (except Fleurbaey et al (2013) and Garcia-Gomez et
954 al (2012)) seem implicitly guided by the control view, the authors should explain in what
955 sense the chosen variables are under the control of the individual. Jusot et al (2013) have
956 argued that lifestyles in health (diet, exercise) are examples of variables under the control
957 of the individual, and inequality of opportunity for achieving health status should be
958 measured with this in mind.

959 Several points should be made about two variables that appear repeatedly in
960 empirical analysis when trying to measure EOp in income attainment: the number of

hours of work and years of education. The number of hours of work is a good effort variable, under the control view, for self-employed occupations, but is clearly less satisfactory for wage-earners. It is true that hours of work correspond to a quantum of effort: the issue is whether they correspond to the *desired* amount of hours. Part-time jobs may be involuntary; overtime work may depend on the orders of the firm, and obviously unemployment may be just bad luck. To a large extent, using hours of work in a given period as an effort variable is therefore problematical for wage-earners. We can be more confident that the number of hours of work over the life span is under the control of the individual because one can compensate for the impact of bad luck and low hours of work during a given period by working more in luckier periods. Using the full data for the lifespan is, however, quite rare (see Aaberge et al. (2011) or Björklund et al (2012) for examples). For snapshot distributions, the question arises of how to purge hours of work of the influence of bad luck, which, by assumption is not under control of the individual. Detecting chosen from involuntary part-time work is a difficult econometric issue. At best, we would estimate a probability that the person works voluntarily part-time, which makes the effort variable a number in the interval [0, 1]. Any empirical study that fails to do so will not respect Fleurbaey and Schokkaert's methodological dictum to do the best to estimate the most thorough structural model before any attempt is made to measure inequality of opportunity.

Years of education is also a popular effort variable in empirical studies. It is controversial to consider it as a variable under individual control, because primary and secondary education take place when the person is a child and adolescent, largely prior to the relevant age of consent. A child's laziness in school might be explained by factors not under his control. Only tertiary education and lifelong learning are immune from this criticism. The problem with tertiary education comes from its path-dependency: one's probability of being accepted to university depends on one's grades in secondary education, which in turn depend upon achievements in primary school. And, of course, there is the problem of endogenous preference formation, discussed above with reference to the cost parameter in the utility function (Keane and Roemer (2009)).

A good starting point is to attempt to account for achievements in early education by circumstances of the family. Socio-economic circumstances may be available in data

992 sets, but parental pressure to achieve is also an important determinant of educational
993 outcomes, and is usually not measured. We cannot, therefore, usually give a complete
994 account of educational achievement. However, if one views all actions of the child as
995 due to either nature or nurture, both of which are beyond his / her control, by hypothesis,
996 before the age of consent, then one should simply take the child's educational
997 accomplishments at the age of consent as a circumstance with respect to determining
998 outcomes in later life. Family circumstances may still be important in explaining choices
999 after the age of consent: for example, a young adult might not attend college both because
1000 his achievements in secondary school were mediocre (which, according to the view just
1001 expressed would be a circumstance) and also because his parents put little value on
1002 tertiary education (another circumstance). Facing these two circumstances, if a low-
1003 achieving eighteen-year–old nevertheless succeeds in going to college, through taking
1004 compensatory courses, that would be ascribed to exceptional effort, ceteris paribus.
1005 In both the hours-of-work and education examples, then, we will often not have
1006 an accurate measure of effort, which will be measured with error and bias. Broadly
1007 speaking, authors do not pay sufficient attention to these problems and overlook their
1008 practical implications. Define a *tranche* as the set of individuals who expend the same
1009 degree of effort. Since effort measurement does not have the same robustness as
1010 circumstance measurement, choosing effort as the conditioning variable as in the tranche
1011 approach (see for instance Peragine (2004 and 2008)) seems risky. True, circumstances
1012 may be only partially described, but generally they are not noisy. Since tranche and type
1013 approaches seem incompatible (see below), conditioning on type seems a better choice
1014 than conditioning on tranches for a measurement error problem.
1015 A (iv). Age and sex
1016 The issue of availability of information cannot be raised about age and sex. The
1017 problem is how to treat these variables.[20] The discussion should not be organized around
1018 the notion of responsibility, since no philosophical approach puts them in the
1019 responsibility sphere, but rather in terms of legitimate inequalities. Are the inequalities
1020 linked to age or gender legitimate? Sometimes, the answer is clear-cut. An example is
1021 provided in the health sphere where most admit that health policies cannot erase the

[20] When one takes a lifetime perspective, as in Almås et al (2011), one does not care about the age factor.

1022 impact of sex. We should not consider males disadvantaged with respect to females if,
1023 due to innate biological factors, their life expectancy is shorter. For earnings
1024 achievement, this stance cannot be easily taken, because differences in returns, linked to
1025 gender and perhaps age, may be related to discrimination, which would obviously be a
1026 violation of EOp.

1027 Under the control view, age and sex are circumstances. Under the preference
1028 view, because age and sex are important determinants of preference, they will implicitly
1029 enter as factors of effort. Because, under this view, preferences should be respected
1030 whatever they are, unless they are not well-informed, they are put on the responsibility
1031 side of the cut. [21] Of course, as Fleurbaey and Schokkaert (2009) point out, we are free,
1032 once the true impact of age and sex has been identified econometrically, to test whether it
1033 matters to put age and sex on one side or on the other (see Garcia-Gomez et al (2012) for
1034 an application). When we are explaining health, it does not come as a surprise to learn
1035 that 45% of the explained variance in health outcomes is due to these two demographic
1036 variables (see Jusot et al (2013)). This is not the thorniest issue in EOp measurement, but
1037 the reader should be aware that the extent of inequality of opportunity may depend on
1038 whether or not one includes these variables in the responsibility set. Another solution
1039 would be to leave the dual world of the model and to admit that there are variables that
1040 are neither under the control of the individual nor for which compensation is due.

1041 As in other domains of econometrics, there is a large issue of what to do with
1042 poor data. The mistake to avoid is pretending that a poor data set is rich. Innovative
1043 methods exist to deal with missing variables. An important methodological issue that has
1044 been raised and partially solved is to deduce what can be said about inequality of
1045 opportunity when we know that the observables are far from recovering the process
1046 through which the outcome has been attained. We should adapt our empirical strategy to
1047 the richness of the informational structure of the database. Basically, we can contrast
1048 situations from the richest informational setting to the poorest one. In the first situation,
1049 we have a good description of the world, that is, a quite comprehensive set of

[21] Of course if age determines both the outcome directly and indirectly through preferences, and if we cannot identify the two effects, it is ad hoc to allocate the impact of age to either circumstances or effort.

circumstances and some candidates for effort variables. In the second situation, no effort variables are available and individuals can be ranked in broad type categories. We will contrast the methods accordingly.

B. The estimation phase

B(i). The case of a rich data set

The first choice is to decide between parametric and non-parametric estimation. Because, by assumption, there are many observable variables, a parametric estimation will fit the data better (see, Pistolesi (2009) for a semi-parametric estimation). Bourguignon et al (2007) took the lead regarding the econometric strategy in this case. We should estimate a system of simultaneous equations. The first equation will describe the process of attainment of the outcome. In the income context, it can be called a return equation, the coefficient of each determinant giving the marginal return (in a linear model) to each determinant whether it is a circumstance, effort, or demographic variable. The other equations (one for every effort variable) will relate the effort variable to circumstances and other control variables. In the control view, we should understand how variables that are outside the control of the individual influence her effort variables. In these 'reaction equations' circumstances must be introduced, including market conditions (prices, any market disequilibrium such as the local rate of unemployment for job decisions) and demographics. One supposes that the reaction of individuals to their environments (market and background conditions) may vary across individuals. We should let the coefficients vary according to demographics. The difference in the value of these coefficients, if any, would be interpreted in a different way according to the control or the preference view. According to the latter, they are preference shifters, whereas according to the former they are driven by circumstances, and belong to the circumstance side of the cut.

Let y_i be the outcome of individual i (the original outcome variable or some function of it), C_i the vector of circumstances, $E_i = (e_{i1},...,e_{ik})$ the vector of effort of dimension k, D_i the vector of demographics, M_i the market conditions prevailing for i, ε_i, the mean-zero residual of the return equation and r_{ij} the mean-zero residual of the

reaction equation of effort j. The other letters employed are for coefficients of both regressions. In the simplest linear model the following equations have to be estimated:

$$y_i = \mu_{y1} + \alpha_c C_i + \alpha_d D_i + \alpha_e E_{i,} + \varepsilon_{i.}, \qquad (6.1)$$

$$e_{ij} = \mu_{e_j} + \beta_c C_i + \beta_d D_i + \beta_m M_{i,} + \gamma_{cd} C_i D_i + \gamma_{cm} M_i D_i + r_{ij} \text{ for each effort variable}$$

$$j = 1, \ldots, k \qquad (6.2)$$

Equation (6.2) is written in a compact way: the β coefficients describe the average reaction of adjusting effort to external conditions while the γ coefficients are the preference shifters that allow individuals to adjust in a different way according to their age and sex group. (The μ terms are constants.)

It is plausible that market conditions do not always explain the outcome (for instance the price of fruit and vegetables may affect the diet, while having no impact on the mortality rate). If this is the case, we may have exclusion restrictions that will be helpful to identify the system.

The omitted variables (perhaps IQ or any measure of innate talent) may affect the residuals of all equations. The structure of residuals may follow some common pattern that can be captured by a correlation between disturbance terms. (See table 1 in Garcia-Gomez et al (2012) for an implementation for mortality outcome.) If the correlation is significant, it may reveal an omitted covariate that matters for the estimation of the full system. However, we cannot tell if the revealed omitted variables are on the circumstances or effort side.

Many authors (Bourguignon et al (2007) and Trannoy et al (2010), for example) have argued that the estimation of the full system is not necessary if we are only interested in determining the full impact of circumstances. Estimating the reduced form (6.3) suffices if we want to measure the impact of observable circumstances:

$$y_i = \mu_{y3} + \delta_c C_i + \delta_d D_i + \upsilon_{i.}. \qquad (6.3)$$

This statement, however, requires some qualification. Neglecting the shift parameter, it is true that in a linear model $\delta_c = \alpha_c + \alpha_e \beta_c$, α_c captures the direct effect of circumstances

and $\alpha_e \beta_c$ captures the indirect effect of circumstances through effort, due to the Frisch-Waugh theorem. (The same goes for demographics.) However, the relation is lost for a non-linear model, such as a logit or probit specification, even if Jusot et al (2013) found that the difference between δ_c and $\alpha_c + \alpha_e \beta_c$ is quite small. More importantly, the reduced form (6.3), which has been repeatedly estimated in empirical studies, does not allow the effect of circumstances on outcomes to be mediated by demographics. The information provided by the preference shifters γ introduced in the reaction equations (6.2) is lost. It will be split into the reduced coefficient of circumstances, the reduced coefficient of demographics, and perhaps the residual. A solution would be to introduce a cross effect of circumstances and demographics in the reduced equation but, to some extent, the effect of demographics as shifters of preferences will go beyond the cross effect in the structural model. The basic message is that, with a reduced form, we cannot isolate the effect of demographics as circumstances from the effect of demographics as shifters of preferences, and therefore responsibility variables: to do so, we would need to estimate the full structural model. We recall the claim of Fleurbaey and Schokkaert (2009) that failing to estimate a structural model is costly in terms of the limitations that are thereby imposed in the measurement phase.

We now comment on the impact of omitted variables on the estimation. The coefficients will be biased and cannot be interpreted as causal. An example from health is the presence of lead in a child's home, which could entail health problems for both children and parents. If this variable is missing in the dataset, a correlation between the health status of children and parents will be observed, whereas there is no causal link. It would then be unwise to base policy recommendations on the estimates of the structural model (6.1) and (6.2) or the reduced model (6.3). Other empirical strategies have to be implemented if we want to use the estimates in this way. Regarding the reduced form, it must be clear that the estimate $\hat{\delta}_c$ [22] conveys the impact of any unobserved variable correlated with observable circumstances. If these variables are circumstances, or if we adopt the viewpoint that any correlation to circumstances should be neutralized, this is fine from a correlation viewpoint. We can thus claim that $\hat{\delta}_c C_i$ gives a fair account of the

[22] A circumflexed variable denotes an estimate.

contribution of observable circumstances to the income of individual *i*. Since not all circumstances are observable, it has been argued by several authors (e.g Ferreira and Gignoux (2011), Niehues and Peichl (2014)) that $\hat{\delta}_c C_i$ gives a *lower* bound estimate of the impact of all circumstances. The argument is acceptable as long as we stick to the ethical stance of neutralizing any correlation with observable circumstances.

Niehues and Peichl (2014) propose computing an *upper* bound of the impact of circumstances, by exploiting the immutable aspect of the influence of family and social background. Everyone bears the weight of her background for better or for worse for a lifetime. This permanent effect is captured as a fixed effect in panel data. Obviously, there are other elements that do not vary so much across the active part of lifetime, such as personal traits (physical appearance, character, cognitive and non-cognitive skills). Not everyone would consider all these factors to be circumstances. The fixed effect captures all circumstances and perhaps more. The econometric implementation of this approach requires two stages. In the first stage, one estimates a fixed-effect model on the lifecycle to obtain a measure of the time-constant unobserved heterogeneity, namely:

$$y_{it} = \alpha_e E_{it,} + c_i + u_t + \varepsilon_{it.}, \qquad (6.4a)$$

where the effort variables E_{it} are supposed to be time-varying, u_t is a time dummy to capture the market conditions, ε_{it} the idiosyncratic time-varying shock and c_i is the individual fixed-effect which accounts for the impact of all circumstances (and perhaps more). In the estimation, we ignore information about observable circumstances.
In the second stage, we return to the cross-section data and regress the annual income on the estimate of the individual fixed-effect $\hat{c}_i$, that is,

$$y_{it} = \delta\hat{c}_i + \upsilon_{it..}, \qquad (6.4b)$$

The upper bound of the impact of circumstances is then given by $\hat{\delta}\hat{c}_i$. Niehues and Peichl also propose a variant of the methodology to take into account the indirect effect of the circumstances on the effort variables *E*.

One of the virtues of the structural model is in enabling one to decompose the impact of the circumstances into a direct and an indirect term (through effort). Bourguignon et al (2007) and Ferreira and Gignoux (2011) acknowledge that sub-decompositions into direct or indirect effects, or into the effects of individual

circumstances, would be strongly affected by the presence of omitted variables. Bourguignon et al (2013) show that it is not so much the magnitude of inequality of opportunity, but rather its decomposition between direct and indirect effects that will be affected by biased estimates of coefficients of circumstances in both the return and the reaction equations.

We conclude with the interpretation of the residuals of the various equations. We first emphasize that they are not orthogonal to the regressors with omitted variables, which is worrying. That said, the residuals of the reaction equation are close in spirit to the Roemerian effort. They are effort sterilized of the impact of circumstances and external conditions. This leads Jusot et al (2013) to estimate an equation where one substitutes Roemerian effort for effort in equation (6.1), namely:

$$y_i = \mu_{y_4} + \delta_c C_i + \delta_D D_i + \alpha_e R_i + \tau_i \qquad (6.5)$$

where R denotes the vector of residuals of equations (6.2). Due to the Frisch-Waugh theorem, the coefficient of Roemerian effort will be the same as the coefficient of true effort, whereas the coefficients of circumstances and demographics will be augmented by their indirect influence through effort and then equal to the coefficients estimated in the reduced equation (6.3)[23]. This enables these authors to offer a decomposition of the inequality into responsibility, non-responsibility, and demographic parts, in the spirit of Roemer. They contrast the results with the estimates obtained with equation (6.1) where the impact of circumstances is only direct and thus follows Brian Barry's recommendation (individuals should be rewarded for their absolute, not relative, effort).

It should be clear from the previous discussion that the residual of the return equation (6.1) is a mixed bag of error terms and omitted variables, which may be circumstances, effort, or luck variables. Generally the error term represents a large part of the variance, more than 70% in Björklund et al (2012) for the residual of the reduced form (6.3). It is quite normal that the explained part remains small on cross-sectional estimation: 30% is already an achievement. Should we assign the residual to the effort or circumstance side? Views clash here. Roemer and his co-authors over the years put the

[23] In fact, this is not quite correct if market conditions and shift parameters are introduced as in (6.2). The statement is valid for a simple form of (6.2).

residual of the reduced equation on the effort side while Almås et al (2011) put the residual of the structural return equation on the circumstance side[24]. Lefranc et al (2009) and Jusot et al (2013) argue that these solutions are ad hoc. They maintain that we cannot tell what the residual represents. Furthermore, when it represents 50% of the variance or more, putting it on one side or the other will determine the relative magnitude of inequality of opportunity. Consequently, they prefer to discard it in any decomposition analysis and move on with the explained part of the outcome, from (6.1):

$$\hat{y}_i = \hat{\mu}_{y1} + \hat{\alpha}_c C_i + \hat{\alpha}_d D_i + \hat{\alpha}_e E_i, \quad . \qquad (6.6)$$

Parametric methods try to estimate the conditional expectation $\mathbf{E}(y|C,E)$.[25] Non-parametric methods are more ambitious because they try to estimate the conditional distribution $F(y|C,E)$. O'Neill et al (2000) were the first to use a kernel density approach to estimate the distribution of income conditional on parental income. It is not by accident that the authors chose a continuous variable (parental income) to perform a non-parametric analysis. The parametric estimation already offers some flexibility for discrete variables. Pistolesi (2009) borrows a semi-parametric estimation technique from Donald et al (2000). In a nutshell, since the hazard rate is defined as,

$$H(y) = \frac{f(y)}{1-F(y)} = \frac{f(y)}{S(y|C,E))} \quad ,$$

with $S(\cdot|\cdot)$ the conditional survivor function, one can write :

$$f(y|C,E) = H(y|C,E)\big(S(y|C,E)\big).$$

The trick is then to estimate a hazard-function-based estimator and introduce covariates using a proportional-hazards model. In a second step, the necessary transformations using the above equation are made to obtain an estimate of the associated conditional density function. It is known that the estimation of duration models is more flexible than of linear models. In substance, Pistolesi (2009) estimates the conditional distributions corresponding to equations (6.1) and (6.2) with this estimation technique.

B (ii). The case of a poor dataset

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[24] They also present robustness results where the residual belongs to the responsibility set. Almås (2008) considers both alternatives.

[25] **E** denotes the expectation operator.

The distinctive feature of a poor data set is that no effort variable is available, but we may still have a rich set of circumstances and a large sample. We can construct types but we cannot a priori build tranches. The approach here comes from Roemer (1993, 1996, 1998) with his identification axiom. It is the only assumption that enables us to say something about inequality of opportunity in the poor-information case. It is non-parametric in essence, since effort is deduced from the distribution of outcomes for a type, $F(y|C)$. Two individuals located at the same quantile of their type-conditional distribution are defined as having exerted the same effort, which will be denoted e_{RO}. Formally, starting from the income generating process given by

$$y = g(C, E),$$

the Roemer identification axiom (RIA) reads:

$$F_y(g(C,E)|\, C) = F_y(g(C',E')|\, C') \Rightarrow e_{RO} = e'_{RO}$$

By construction, this effort, which is simply a rank, is distributed uniformly over [0, 1] for all types. This way of identifying effort has been used by O'Neill et al (2000) in a non-parametric setting to depict the opportunity set of an heir defined as the income range that she can reach for all levels of Roemerian efforts belonging to [0, 1]. The opportunity sets are contrasted according to the level of advantage given by the decile of parental income.

This manner of identifying effort has also been used by Peragine (2004, 2008) to build a tranche approach to EOp where the multivariate distribution is described by a matrix whose typical element is the income for a given type and percentile of the type-conditional income distribution. However, this approach is not immune to the omitted variable problem that was discussed above. As was correctly pointed out by Ramos and Van de gaer (2012), omitted circumstances induce an incorrect identification of the Roemerian effort unless the unobserved circumstances, after conditioning on observed circumstances, no longer affect income (see their Proposition 6). This is a strong condition that will be rarely be satisfied in empirical work.

The identification axiom may be questionable from an analytical point of view (see Fleurbaey (1998)), because it is not clear how multi-dimensional effort can be aggregated into one indicator, and luck factors can interact with effort in a complex way. The view that the *distribution* of effort specific to a type is a circumstance makes sense in

the control view but not in the preference view. Let us call this the *type-independent effort distribution* axiom: the relevant normative effort distribution should be independent of type. This axiom is weaker than Roemer's identification axiom. It has inspired fruitful empirical strategies, both in parametric and non-parametric settings. In the former case, Björklund et al (2012) estimated a reduced form as in (6.3) with υ_i a Gaussian white noise. They assimilate the distribution of the residual to the distribution of effort. However, the distribution of the residual can vary across types and this variation is a non-responsibility characteristic. They have corrected for variation in the second moment by adding and subtracting to the regression equation a residual term that has the overall variance. Hence the relevant effort in each type is renormalized to have the same variance.

In a non-parametric setting, Lefranc et al (2009) retain this independence view of effort, which is postulated in the Roemer identification axiom, without assuming that one can identify effort with the quantile of the type-conditional income distribution. Let the distribution of effort conditional on type (supposed to be unidimensional) be given by $G(e|C)$. They assume that the relevant effort is the relative effort denoted e_r given by the quantile within the effort distribution of an individual's type:

$$e_r = G(e|C). \qquad (6.7)$$

Equipped with this conception of effort, they are able to link what we can check (in a poor setting) with what we would want to check if all the information about effort were available. What we can check is obviously the equality of the distribution of income conditional on the observables -- here, only the vector of circumstances:

For any (C, C'), $F(\cdot \mid C) = F(\cdot \mid C')$. (*conditional-distribution equality*) (6.8)

We have already stated (see section 5) that we would like luck to be even-handed in a world where all circumstances and effort are observed:

for all (C, C', e) $F(\cdot \mid C, e) = F(\cdot \mid C', e) = K(\cdot \mid e)$ (*equal-luck opportunity*). (6.9)

This allows the distribution of episodic luck to depend on effort but not on circumstances. Their main result, mathematically obvious but of practical importance, is that a necessary condition for equal-luck opportunity to be satisfied is conditional-distribution equality, if

we use relative effort. Mathematically, if we replace e by e_r, in (6.9), then (6.9) implies (6.8). Is this result false if some circumstances are not observed? Proposition 5 in Lefranc et al (2009) proves that it is not false. Checking the conditional-distribution equality on the set of observed circumstances is still necessary for the global equality-of- opportunity condition to be satisfied. These results pave the way for using stochastic-dominance tools (see also Andreoli et al. (2014)) to measure the unfairness of the distribution, which we discuss below.

C. The measurement phase

Once a model has been estimated, the question of how to proceed to use the estimations obtained in the econometric phase remains open. Various choices have been proposed concerning three issues: the type versus tranche approach, the direct unfairness versus the fairness gap, and the inequality index. We will deal with these three approaches in turn.

C (i). Types versus tranches

In a discrete setting, we can construct a matrix whose rows correspond to types whose columns to effort levels. An element m_{ij} of the matrix is the outcome for type i at effort level j. It is important to emphasize that this way of proceeding is correct if and only if the knowledge of circumstances and effort is sufficient to determine the outcome level. It means that, with respect to the decomposition of the process allowed by the regression, the residual is assigned to either effort or circumstances, unless the outcome is replaced by the predicted outcome. In this setting, two principles of compensation can be stated.

The *tranche-compensation principle* (which corresponds to the usual compensation principle stated in section 3) states that the closer each column is to a constant vector, the better. If for some effort level (column), the inequality of outcome across types is reduced, and everything else remains unchanged, equality of opportunity has improved.

The *type-compensation principle* states that it is always good to transfer resources from an advantaged type to a disadvantaged type, provided that the ranking of types is respected. Suppose that between two types, one is unambiguously better off than the other, that is, the outcomes can be ranked unambiguously according to first-order

stochastic dominance. Then a transfer from the dominant type to the dominated type for some effort level, ceteris paribus, is EOp enhancing. This principle can be extended further to a second-order stochastic dominance test (Lefranc et al (2009)). Indeed if two types have the same average outcome but the first one has a larger variance, any risk-averse individual would prefer to belong to the second type, and consequently one cannot declare that the two types have the same opportunities in terms of risk prospects. The need to take into account the risk dimension echoes the treatment of heteroscedasticity of the residuals in the parametric case by Björklund et al (2012). This extension leads to a weak criterion of equality of opportunity, which corresponds to a situation of absence of second-order stochastic dominance across types.

These two compensation principles are associated with two approaches to measuring inequality of opportunity that Fleurbaey and Peragine (2013) have dubbed 'ex post' and 'ex ante.' The ex post approach measures inequality of opportunity by the size of the variation in outcomes, across types, at each effort level. To the extent that, at any given effort level, outcomes differ across types, inequality of opportunity exists. This is the implicit approach in Roemer's program (3.1), which focuses upon how well the worst-off type is doing, at each effort level. In contrast, the ex ante approach views inequality of opportunity as reflected in the degree to which average outcomes of different types differ: this approach is clearly represented by Van de gaer's program (3.2). Fleurbaey and Peragine (2013) show by the means of an example that the two principles clash. There is no complete ordering of the full domain of (positive) matrices, which respects both principles. If we connect this to the results obtained by Lefranc et al (2009), it is as if we said that *equal-luck opportunity* conflicts with *conditional-distribution equality*.[26] They claim that one must choose between the two. Logically this is correct. Empirically, it seems to us, that the conflict is not deep, because the principles are useful in different informational contexts.[27] Either one trusts the information about effort, and

[26] The comparison is not artificial because to some extent, both principles can be viewed as a ranking adaptation of (6.8) and (6.9).

[27] This standpoint is reminiscent of the informational basis of social choice (D'Aspremont and Gevers (1977)) which connects the choice of the social welfare

the tranche-compensation principle is appropriate, or one lacks information about effort, or believes it is insufficiently reliable because of the omitted variable problem, and then the type-compensation principle remains available[28].

We conclude with an insight borrowed from Ramos and Van de gaer (2013), who remark that if we retain the Roemerian effort, annihilating inequality within the columns of the matrix implies equalizing the prospects for each type, since by construction the distribution of Roemerian effort is the same for every type.

C (ii). Direct unfairness and the fairness gap

There is a variety of ways to measure the departure of a distribution of an outcome from one displaying full equality of opportunity, given the typology. Here we present a version of what are called 'direct unfairness (DU)' and the 'fairness gap (FG).' These measures are dual to each other. (See Van de gaer (1993), Fleurbaey and Schokkaert (2009) and Pistolesi (2009) and Checchi and Peragine (2010).)

For the sake of specificity, suppose there is an income distribution F with mean μ for a population with two types; the type-distributions of income are F^1 and F^2 with means μ^1 and μ^2. Denote the inverses of these functions – their quantile functions – by v^1 and v^2, as in section 3. The frequencies of the two types in the population are f^1 and $f^2 = 1 - f^1$. Of course, we have $F = f^1 F^1 + f^2 F^2$. Define the counterfactual

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function to the informational setting of the social decision marker (for instance, utility levels for maximin, utility differences for utilitarianism).

[28] The terminology 'ex ante' and 'ex post' for describing these two approaches to conceptualizing inequality of opportunity is unfortunate, because the data of the problem, $\{\mathbf{T}, G^t_\varphi, f^t, u, \Phi\}$ make no distinctions with respect to *time.* We would prefer to say that one may focus either upon the injustice of 'unequal rewards to equal efforts' (ex post approach) or the injustice of 'unequal rewards to unequal circumstances' (ex ante). The distinction is also reminiscent of the difference between the 'compensating outcomes' approach (ex post), and the 'equalizing opportunity sets' approach (ex ante) introduced by Ooghe et al. (2007).

distribution Φ as one in which all members of each type receive the mean income of their type. The graph of Φ is a step function with two steps. The mean of Φ is equal to the mean of *F*. If Φ were the true income distribution, it would be the case that all inequality was due to circumstances, since by construction there is no variation of effort within either type. Therefore the inequality present in Φ can be viewed as that part of the inequality in *F* that is entirely due to circumstances. Now let *I* be any measure of inequality in distributions. We can say that $I(\Phi)$ is the extent to which *F* departs from full equality of opportunity. $I(\Phi)$ is called 'direct unfairness.'

Next we take the dual approach. Let's suppose there are 100 degrees of effort, $\pi = 1,2,...,100$. At each degree of effort π, there is a two-point distribution of income: fraction f^1 receive income $v^1(\pi)$ and fraction f^2 receive $v^2(\pi)$. Denote these two-point distribution functions by Q^π. Of course we have $F = \frac{1}{100}\sum_{\pi=1}^{100} Q^\pi$. Now consider the counterfactual distribution – call it Ψ -- where at each π, all individuals receive the average value of those at that tranche of effort, that is, $f^1 v^1(\pi) + f^2 v^2(\pi)$. The mean of Ψ equals μ. If Ψ were the true income distribution, we would say that all inequality is due to effort – there is no longer a distinction between the incomes of different types. Therefore $I(\Psi)$ is a measure of the inequality in *F* due to effort, and so we may define $I(F) - I(\Psi)$ as the inequality due to circumstances, and hence a measure of the departure of the distribution *F* from full equality of opportunity. This is called the 'fairness gap.'

For example, let *I* be the 'mean logarithm deviation.' One may compute that:

$$DU = MLD(\Phi) = \log \frac{\mu}{(\mu^1)^{f_1}(\mu^2)^{f_2}}$$

and $$FG = MLD(F) - MLD(\Phi) = \frac{1}{100}\sum_{\pi=1}^{100} \log \frac{f^1 v^1(\pi) + f^2 v^2(\pi)}{(v^1(\pi))^{f^1}(v^2(\pi))^{f^2}} .$$

Notice that if $\mu^1 = \mu^2$ then $DU = 0$ and that $FG = 0$ if $v(\cdot)^1 = v^2(\cdot)$. Thus, the DU measure is less demanding than the *FG* measure in the sense that the former only requires the means of the type distributions to be equal to declare that equal opportunity is complete, while the latter requires the type-distribution functions to be identical. It

follows that *DU* is a measure of inequality of opportunity associated with Van de gaer's objective (3.2) and the *FG* is associated with Roemer's objective (3.1). In like manner, *DU* is associated with Fleurbaey-Maniquet's conditional equality (4.1) and *FG* with their egalitarian-equivalent approach (4.2).

Both *DU* and *FG* define real-valued mappings on the domain of income distributions (where the typology is specified). It is pretty clear from the above formulas that they will not order distributions in the same manner. We believe both measures are of use, and there is no strong reason to prefer one over the other. Several variations of these measures appear in the literature.

The above definitions of DU and FG above are applicable with poor data sets, in which we have no explicit information on effort variables, and use only the information in the type-distributions of the outcome . For a rich data set, where we have information on the levels of effort variables, we may use regression analysis to define parametric versions of DU and FG. We refer readers to Roemer and Trannoy (2015) for details.

Classical measures of inequality in distributions (Gini, Lorenz curve) may be viewed as measuring the distance between the actual distribution of an outcome from the equal distribution of that outcome. The fairness gap is a generalization of this approach, where the counterfactual distribution, instead of being the equal one, is taken to be one which is deemed fair according the opportunity-egalitarian view. Another variant, proposed by Fleurbaey and Schokkaert (2009), is to measure the 'inequality gap' between a distribution and the counterfactual (e.g., $I(F-\Psi)$) instead of the gap of inequalities ($I(F)-I(\Psi)$). Almås et al (2011) introduce an "unfairness Gini index" (see Devooght (2008) for the "unfairness" General Entropy class) and an "unfairness Lorenz curve."

C (iii). The choice of an inequality index

The entire spectrum of inequality indices has been used by researchers in EOp, perhaps with the exception of Atkinson's indices. One can speculate that the absence of the Atkinson indices is due to EOp's not being a welfarist theory. Lefranc et al (2008) and Almås et al (2011) have used the Gini index, and Aaberge et al (2011) have used the Gini and rank-independent measures. Elements of the entropy family have been used by Bourguignon et al (2007) who pick the Theil index, Checchi and Peragine (2010), and

Roemer (2014). Ferreira and Gignoux (2011) and Lefranc et al. (2011) use the mean logarithmic deviation (MLD). Pistolesi (2009) and Björklund et al (2012) are eclectic and use a range of measures. These examples are when the outcome is income attainment, and they are relative measures, invariant to scale.

When the outcome is health status (self-assessed health or mortality), it makes sense to use an absolute measure such as the variance, which satisfies translation invariance. (It makes sense to say that inequality of life expectancies does not change when all individuals gain one year of life expectancy.) .See Fleurbaey and Schokkaert (2009). Jusot et al (2013) and Bricard et al (2013).

Returning to the income case, there is no first-best choice. The connection with stochastic dominance, which is the advantage of rank-dependent measures, among them the Gini index, is counterbalanced by the decomposability properties of the entropy family.

The indices in the entropy family are decomposable in the following way. For the general entropy measure of degree θ , we have:

$$GE^{\theta}(F) = \sum_{t=1}^{T} f^{t} \left(\frac{\mu^{t}}{\mu} \right)^{\theta} GE^{\theta}(F^{t}) + GE^{\theta}(\Phi) \ ,$$

where the notation is as in section C(ii). In particular, GE^{0} is the mean log deviation, and we see that for this index, the inequality in F is precisely the sum of the inequality in Φ plus the weighted sum of the inequalities in the type distributions. It is therefore appealing to define $\frac{GE^{0}(\Phi)}{GE^{0}(F)}$ as the share of inequality due to circumstances. A number of studies use this 'relative measure' on inequality of opportunity (for example, Checchi and Peragine (2010), Ferreira and Gignoux (2011)) because, on top of additive decomposability across subpopulations, it satisfies path independence (Foster and Shneyerov (2000)). In the present context, this property means that two ways of computing between-type inequality lead to the same evaluation. In addition to decomposing inequality of a distribution in this manner, if we have a rich data set, we can use regression analysis to decompose inequality into the inequality of its sources (circumstances and kinds of effort). The natural decomposition of the variance given by the covariance of a source (see Shorrocks (1982)) has a nice interpretation in the

framework of inequality of opportunity (See Ferreira, et al (2011), Jusot et al (2013) and Roemer and Trannoy (2015).) That said, for any inequality index, we may define a cooperative game whose characteristic function assigns each group (or 'coalition') of sources of inequality a 'value,' the amount of inequality that its members generate. The Shapley value of this game is a nice way of assigning roles to sources in generating outcome inequality. The method is explained in Chantreuil and Trannoy (2013) and Shorrocks (2013) and is applied in Björklund et al (2012) to compute the role of various circumstances and effort in generating income inequality in Sweden.

We conclude that in the health realm variance may be a better choice, while MLD is prominent for income achievement. Of course, these inequality indices embody a specific degree of inequality aversion which may not reflect the redistributive preferences of the social decision-maker.

D. Results

The estimates of inequality of opportunity (as the inequality due to circumstances) are a lower bound to the true figure in all cases reviewed below, except for the upper-bound estimates of Niehues and Peichl (2014) ; the magnitude of the underestimation is greater the poorer the dataset. Consequently, the importance of the empirical results has to be gauged by considering the typology that can be defined with the dataset. We are interested in these questions: What is the extent of equality of opportunity with respect to overall inequality? What is the contribution of effort to inequality? Is the indirect contribution of circumstances through its impact on the distribution of effort sizeable? Does it make much difference to follow Roemer's approach in measuring effort as the residual, or will using absolute measures of effort give similar results? Among circumstances, what are the most significant? Is there a common pattern among inequalities of opportunity with respect to the outcomes of health, education and income? Is there a difference of magnitude in inequality of opportunity between the developed countries and the developing countries? Does the ranking of countries differ when we look at inequality of opportunities versus inequality of outcomes? Do taxes and benefits or other instruments make a large difference in measuring inequality of opportunity?

Starting from a very coarse definition of types, (three levels for father's education, five levels for income), Lefranc et al. (2009b) found that Sweden and Norway almost achieve full equality of opportunity for income, while at the other extreme in the group of western countries lie Italy and the US, with other European countries in between. The qualitative results are similar to those of Roemer et al (2003). We will take a closer look at the Nordic countries before reporting the results obtained for Germany, Italy and the US. We will then contrast these results with those obtained for Latin America, Africa and Turkey.

Three thorough empirical studies have studied EOp for income in Scandinavia: Aaberge et al (2011) and Almås et al (2011) for Norway, and Björklund et al (2012) for Sweden. In the last one, the authors define a fine-grained typology (1152 types), which partitions the sample into types based upon parental income quartile group (four groups), parental education group (three groups), family structure/type (two groups), number of siblings (three groups), IQ quartile groups (four groups), and body mass index (BMI) quartile group at age 18 (four groups).[29] The random sample consists of 35% of Swedish men born between 1955 and 1967 and the outcome is an average of pre-fisc income over seven years (age group: 32-38). Looking at the graphs of stochastic dominance reveals something that was already present in Lefranc et al (2008): the income CDFs of the different educational or parental-income types are quite close. The differences are more pronounced for IQ-types. Parametric results reveal that the three most important contributors to inequality of opportunity are parental income, IQ, and the type heterogeneity of the disturbance (which may be due to effort, luck or unobserved type heterogeneity, because the parental-income and education group are still large). Looking at the Gini coefficient (the results are a bit sensitive to the measure, as usual), putting IQ aside, the other 'social' circumstances account for between 15.3% and 18.7% of the overall Gini. That means that in the counterfactual situation where the only factors of inequality would be these social circumstances, the Gini coefficient would attain a modest value of 0.043 for the oldest cohort. The contribution of IQ represents about 12%

[29] BMI is measured at a young age. It would be far more controversial to put BMI on the circumstance side for older people. Of course, there are genetic roots of obesity among some subjects, but the main determinant is lifestyle (see the discussion in Bricard et al. (2013)).

of the overall Gini. So far, these results are very impressive and confirm that Sweden is close to reaching a situation of equal opportunity. Still, it remains to be seen if introducing parental income in a continuous way and perhaps education of both mother and father separately, thus refining the typology, would alter the results significantly.

The results for Norway obtained by Aaberge et al (2011) are built upon a coarser typology (three educational parental levels, to grow up in a large family or not, to be born in a main city or not, and birth cohort). Tranches are defined by relying upon the Roemer identification axiom. The data come from a rich longitudinal set containing records for every Norwegian from 1967 to 2006, enabling one to construct a permanent income measure. The authors measure inequality for permanent income in Norway, using both an ex ante and ex post approach. In the former, they calculate the Gini coefficient of the distribution of permanent income across types; in the latter, they compute the Gini coefficients of the distributions of permanent income across types *at each effort level*, and then average these. The two approaches give similar results. The Gini coefficient in permanent income is as low as 0.17, and the authors graph Pen's parade (the inverses of the permanent income CDFs) for the three educational groups. These inverse CDFs are quite close. The Gini coefficient corresponding to inequality of opportunity is about 0.05 suggesting that opportunity inequality accounts for about 28 percent of income inequality when the analysis is based on permanent income. Since the typology is coarser than in Björklund et al (2012) for Sweden, the results so far are compatible with a higher inequality of opportunity and likely a higher contribution of inequality of opportunity to overall inequality. Almås et al (2011) use a different methodology and the results cannot be easily compared. Nevertheless, their results can be interpreted as providing an upper bound for the impact of effort. They compute the fairness gap with the Gini index when circumstances have been removed. If we consider the usual candidates for effort variables such as years of education, hours of work (for those who work), working in the public sector, county of residence, and choice of university major, then effort's raw contribution to the Gini in Norway in 1986 is about 25.5% in the pre-tax income when we do not sterilize effort variables of the impact of circumstances. However, the impact of parental background on effort variables is quite small. It represents one Gini point over a Gini of 0.26. Interestingly, they find an increase of the unfairness gap from 1986 to 2005, while the standard Gini remains more or less constant.

Next, we will review results on the poor achievers of the EOp class among developed countries, the US and Italy. In passing, we will touch upon the comparison between Germany and the US performed by Niehues and Peichl (2014). Pistolesi (2009) uses panel data -- the PSID from 1968 to 2001 -- and he considers age, race, education of both parents, the region of birth and the occupation of the father as circumstances. The two responsibility variables are the years of education and the hours of work. Their conditional distributions are estimated non-parametrically against the vector of circumstances. Pistolesi (2009) then predicts two counterfactual distributions for both educational and working-duration distributions. In the first, the effect of unequal circumstances is removed, whereas each individual is assumed to have exerted the same effort in the second. The circumstances have a weaker impact on hours of work than on education, a finding quite common across empirical studies, and which makes sense. A presentation of the results with the Gini to allow comparisons with previous studies shows that the share of inequality due to circumstances in the direct unfairness sense is about 35% for a five-year average earnings at the mean point of the distribution. Niehues and Peichl (2014) on the same PSID data with a focus on earnings and gender, age, place and country of birth, occupation and education of the father as circumstance variables, find a share of inequality in permanent income due to circumstances quite close to Pistolesi's result (30%). It is indisputably higher than in Sweden but follows a quite remarkable decreasing trend over the period. If the results were confirmed –the Niehues and Peichl (2014) results point in the other direction, but it is not the main focus of their study – it would mean that the increase in inequality that has occurred in the US is not due to an increase in inequality of opportunity. Interestingly, Germany exhibits the same degree of inequality of opportunity (around 30%) on permanent income as the US with earnings data coming from the German Socio-Economic Panel (GSOEP). On annual earnings, the absolute value of inequality of opportunity (unfairness gap with the MLD) is surprisingly similar in the US and Germany. The share of inequality of opportunity is however lower in the former country (16% instead of 28%), because the inequality in snapshot distribution is much higher. It is as if the higher volatility of earnings in the US labor market were not linked to the set of observable circumstances. If this volatility is interpreted as luck, then it will mean that the random factors in the labor markets are not

linked to circumstances, a kind of empirical validation of the requirement formulated about luck by Lefranc et al (2009) (see section 4). Checchi and Peragine (2010) study inequality of opportunity in Italy. There are three circumstances: parents' education (five types), sex, and regions (North, South). What is striking is that with such a coarse typology, they find that inequality of opportunity accounts for about 20% of overall income inequality in Italy -- that is, higher than the 16% in Sweden with a much finer typology.

So far, all the produced estimates were of lower-bound type and the range of the inequality of opportunity as a percentage of total inequality is about 15%-30% without any measure of IQ. The Swedish result jumps to almost 30% when IQ is included. Niehues and Peichl (2014) provide an estimation of the upper bounds according to formula (6.4b) for Germany and the US which is double the lower bounds, that is, at least 60% and even 70% in the US. These figures are close to those put forward by Hugget and al (2011) who calibrate an intertemporal model of human capital accumulation. They find that in the US initial conditions (i.e. differences existing at age 23) are far more important than are shocks received over the rest of the working lifetime. Initial conditions account for 61 percent of the variation in lifetime earnings!

Next we turn to less developed countries. The Latin-American study by Ferreira and Gignoux (2011) provides results that can be compared with previous studies. Circumstances are defined as ethnicity, father's and mother's occupation, and birth region, for Brazil, Ecuador, Guatemala, Panama, Colombia and Peru. The number of types is more than one hundred for the first four countries and about fifty for the latter two countries. The contribution of circumstances to inequality is quite high and it varies quite a lot across the six countries. If we look at income, Guatemala and Brazil have in common a high value of the share explained by observed circumstances, about one-third, followed by Panama (30%) and Ecuador (26%). The contribution of inequality of opportunity to total inequality is about 28% in Peru and only 23% in Colombia. However, these two countries have fewer types, which biases the estimates downward with respect to the other countries. The authors also provide estimates of the contribution of non-responsibility characteristics to consumption inequality per capita, which may be more similar to permanent income. The degree to which inequality of opportunity explains

1601 inequality is even higher for some countries, over 50% for Guatemala. Ferreira et al
1602 (2011) study the case of Turkey, which has roughly the same level of development as
1603 Brazil, and find that on a sample of ever-married women aged 30–49, inequality of
1604 opportunity accounts for at least 26% of overall inequality in imputed consumption,
1605 which is by and large a lower value that those found for Latin American countries, except
1606 for Colombia. For African countries we refer to the study of Cogneau and Mesple-Soms
1607 (2008). The surveys that are selected are the only large-sample nationally representative
1608 surveys in Africa that provide information on parental background for adult respondents.
1609 They cover two countries under Britain's former colonial rule, Ghana and Uganda, and
1610 three countries under France's former colonial rule, Ivory Coast, Guinea, and Madagascar.
1611 The typology is defined by a small number of occupational, educational and geographical
1612 circumstances. For the two most developed countries, Ivory Coast and Ghana, the Gini
1613 inequality of opportunity index is about 0.15 (triple of what is found in Sweden) and it
1614 represents about one-third of overall inequality (0.45). The information is poorer for other
1615 countries but, given the results one has on a comparative basis, one can conjecture that
1616 the share of inequality of opportunity is even higher there.
1617 All in all, it seems that inequality of opportunity for income is highly correlated
1618 with inequality of income. This observation is confirmed by the high correlation (0.67)
1619 between these two kinds of inequality, measured by the Gini coefficient for western
1620 countries (Lefranc et al (2008)). Moreover, this strong correlation seems a general pattern
1621 that does not depend on the outcome chosen. Indeed, working on the Retrospective
1622 Survey of SHARELIFE, which focuses on life histories of Europeans aged 50 and over,
1623 Bricard et al (2013) observe a positive correlation of about 0.39 between inequality of
1624 opportunity in health and total health inequality. Furthermore, since lifestyles are
1625 documented in this dataset, the authors are able to show that inequalities of opportunity
1626 for health status in Europe represent on average half of the health inequalities due to both
1627 circumstances and effort (lifestyles). There are, however, large variations across
1628 countries. The health indicator in this study is SAH (self-assessed health) but using
1629 mortality indicators as in Garcia-Gomez et al (2012), the importance of lifestyles also
1630 comes out as a distinctive feature. These authors use a rich dataset for the Netherlands
1631 (1998-2007), linking information about mortality, health events and lifestyles. They

1632 estimate a full structural model that reveals strong educational gradients in healthy
1633 lifestyles which in turn have the expected effect on mortality.
1634 In recent years the field of inequality of opportunity in health status has received
1635 growing attention. Mounting evidence is amassed on both the magnitude and key factors
1636 associated with this kind of inequality. The survey chapter by Fleurbaey and Schokkaert
1637 (2012) provides an excellent discussion of equality-of-opportunity approaches to health
1638 and health care inequity. In particular, the problems in deciding upon the cut between
1639 those factors for which individuals should be held responsible, and those for which they
1640 should not, is carefully dealt with. This issue is particularly sensitive with respect to
1641 health, for some have claimed that holding individuals responsible for behaviors that may
1642 lead to poor health will imply not treating such individuals under a national health service.
1643 Rosa Dias (2009) and Trannoy et al (2010) examine the existence and magnitude
1644 of health status inequality, using data from the UK and France, respectively. Both papers
1645 adopt the stochastic dominance testable conditions proposed by Lefranc et al (2009) to
1646 identify the presence of inequality of opportunity in the data. In both countries, the data
1647 are consistent with the existence of inequality of opportunity in self-reported health status
1648 between individuals of different parental background (types are defined according to the
1649 paternal professional occupation).
1650 The impact of circumstances on life-style choices (effort) has been dealt with in
1651 various ways in these papers. Rosa Dias (2010), using a UK cohort study, concludes that
1652 when unobserved heterogeneity in the set of circumstances is taken into account, the
1653 estimates of the recursive relationship between circumstances, effort, and health
1654 outcomes changes considerably, thereby corroborating the empirical relevance of the
1655 imperfect observability of individual circumstances. Jusot et al (2013), using a French
1656 survey, conclude that adopting fundamentally different approaches to the correlation
1657 between circumstances and effort makes little difference, in practice, for the
1658 measurement of health inequalities. At the aggregate European level, Bricard et al (2013)
1659 find that taking account the correlation between lifestyles and circumstances represents
1660 an increase of 16.8% of inequalities of opportunity relative to the scenario of ignoring the
1661 correlation.

We are at the very beginning of solid empirical analyses of inequality of opportunity. Analysis has been hampered so far by the limitations imposed by data sets and the intricacy of the issue. For each recent paper beginning with Bourguignon et al (2007), the same ritual sentence appears in the introduction, to the effect that 'this set of circumstance and effort variables is richer than those used so far in the existing empirical literature on inequality of opportunity.' If this trend continues, we can be optimistic that, in the coming years, data sets will improve, as the stakes become clearer. Because the fraction of inequality due to circumstances is perhaps severely underestimated due to poor data sets, Kanbur and Wagstaff (2014) suggest that the empirical literature may be doing more harm than good, in announcing that the fraction of inequality due to circumstances is 'only' 30% (for example) in a developing country. We demur, because focusing upon the distinction between inequality due to circumstances and effort is ethically sound and politically salient. If the available data sets are unsatisfactory, the remedy is to improve the surveys to produce a better picture of the circumstances that affect outcomes in developing countries. In particular, surveys should attempt to measure the achievements (cognitive and non-cognitive) of children around the 'age of consent,' to be included as a circumstance. And panel data sets, which can be used to compute an upper bound on the degree of inequality due to circumstances, via the method of Niehues and Peichl (2014), will become increasingly available for developing countries.

8. Conclusion

The main contribution of the equality-of-opportunity literature to the vast literature on inequality is to argue that the *source* of inequality matters from an ethical viewpoint. Most would agree that effects of circumstances on persons' well-being that are beyond their control should be rectified, while at least some differential outcomes due to choice are not compensable at the bar of justice. Thus, measures of inequality *as such* are not terribly useful – unless one is a simple outcome-egalitarian, who views all

inequality as unjust. To the extent that economists ignore this ethical principle – and popular view – their measurements of inequality will not persuade people to rectify it[30].

As we said, the theory of equal opportunity involves both an equalizing aspect and a dis-equalizing one. Some philosophers focus – we believe excessively – on the dis-equalizing aspect. We mention the work of Samuel Scheffler (2003) and Anderson (1999), both of whom criticize what they call 'luck egalitarianism' as too focused upon individual choice: to this they oppose a view of 'democratic equality' which involves treating all persons with equal dignity and respect. Indeed, one would surely be sympathetic to their complaint, if the entirety of the equal-opportunity approach were limited to cases of expensive tastes, whether or not society should pay for the hospitalization of the motorcyclist who crashes having chosen not to wear a helmet, or even with the more socially important issue of the responsibility for smoking-related disease. These examples focus upon the dis-equalizing aspect of the equal-opportunity view – that the effects of poor choices are not compensable in a strict interpretation of the view. However, we believe that the main focus of the EOp view is upon its mandate for *equalization* of outcomes that are due to differential circumstances: most urgently, at this juncture in history, for eliminating differences in income, health, and educational achievement that are due to the vastly different socio-economic backgrounds in which children are raised, due in large part to the institutions of our capitalist societies. The bourgeois revolutions, which eliminated feudalism and inequality of opportunity due to arbitrary social status, although not complete (think of caste in India), marked a huge advance in the equalization of opportunities: but they replaced feudal inequality of opportunity with inequality of opportunity due to differential wealth of families. (Of course, ancient forms of inequality of opportunity, due to gender, ethnicity, and race remain as well.) The good news is that the Nordic social democracies have done a great deal in eliminating inequality of opportunity due to income and wealth without paying a cost in terms of economic growth, and countries in general have developed over time, as measured by the elimination of unequal opportunity.

[30] See Roemer and Trannoy (2015) for evidence on popular views of distributive justice.

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