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measures of well-being

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Equality of Opportunity in Four Measures of Well-being[*]

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Abstract

A growing literature has tried to measure the extent to which individuals have equal opportunities to acquire income. At the same time, policymakers have doubled down on efforts to go beyond income when designing policies to enhance well-being. We attempt to bridge these two areas by measuring the extent to which individuals have equal opportunities to achieve a high level of well-being. We use the German Socio-Economic Panel to measure well-being in four different ways including incomes. This makes it possible to determine if the way well-being is measured matters for identifying who the opportunity-deprived are and for tracking inequality of opportunity over time. We find that, regardless of how well-being is measured, the same people are opportunity-deprived and equality of opportunity has improved over the past 10 years. This suggests that going beyond income has little relevance if the objective is to provide equal opportunities.

JEL codes: D3, D63, I31

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1   Introduction

The notion that individuals ought to have equal opportunities in life is popular among politicians, the general public, and philosophers alike. A sizable number of empirical studies have analyzed the extent to which individuals have equal opportunities for income acquisition (see Ramos and Van de gaer (2016), Roemer and Trannoy (2015), and Ferreira and Peragine (2016) for recent reviews). These studies are based on the idea that when evaluating the progress of societies, looking at the level and distribution of incomes provides an incomplete picture. A distinction has to be made between income differences arising from factors individuals ought to be held personally responsible for and income differences arising from factors outside the realm of personal responsibility. Whereas the former income differences are considered fair, the latter are considered unfair, and ought to be minimized.

In recent years, there has been a growing interest in going beyond income to measure individual well-being (Fitoussi *et al.*, 2010). Well-being (or welfare, we use the two interchangeably) is inherently multidimensional, and growth and income statistics fail to capture this multiplicity. Given the growing interest in going beyond income, it seems pertinent to apply this discussion to the equality of opportunity framework. If individuals ought to have equal opportunities for well-being, then using income as the acquisition variable in equality of opportunity studies could be problematic. Incomes ignore the disutility of effort, the well-being individuals receive from other dimensions of life, and the differences in preferences over income and these other dimensions. Indeed, the philosophers who advocate for equality of opportunity do not advocate for equality of opportunity for income acquisition, but rather something broader than income such as welfare or advantage (Arneson, 1989; Cohen, 1990).

Once it is acknowledged that incomes are not sufficient for measuring well-being, the door opens for many alternatives. Which other well-being dimensions are necessary? Should we measure these dimensions separately or somehow aggregate them into a single number? How can we incorporate the fact that individuals have different preferences over these various dimensions? Should we try to measure well-being directly by alluding to self-reported happiness levels?

We use 25 years of data from the German Socio-Economic Panel (SOEP) to measure welfare in four ways; with incomes, life satisfaction, a multidimensional index, and equivalent incomes. We use incomes to facilitate comparisons with the generic way of measuring equality of opportunity. The other three measures have roots in different philosophical theories about well-being (Parfit, 1984; Griffin, 1986). Life satisfaction explicitly tries to measure mental states, the multidimensional index

defines and aggregates an objective list of dimensions of importance for well-being, and equivalent incomes incorporate preference heterogeneity.

We will investigate if the measure of welfare matters for 1) characterizing the opportunity-deprived and 2) tracking inequality of opportunity over time. In both cases, we first regress the welfare measures on circumstance and effort variables or equivalently, variables we hold individuals responsible for and variables we do not hold individuals responsible for. In order to answer our first research question, whether the measure of welfare matters for characterizing the opportunity-deprived, we assign each individual an "opportunity" rank. The opportunity ranks order individuals according to how much their circumstances contribute to their welfare. They can be interpreted as an ordinal measure of individuals' opportunities, where the highest ranked possesses the best combination of circumstances and vice versa. We compare the determinants of the opportunity ranks across the four well-being measures. Broadly speaking, if individuals have similar opportunity ranks across the four well-being measures, then a characterization of the opportunity-deprived will not depend on how we measure welfare.

In order to answer our second research question, whether the measure of welfare matters for tracking inequality of opportunity over time, we use the norm-based approach. Upon regressing the welfare measures on circumstance and effort variables, this entails assigning a fair welfare level to each individual, which only depends on the individual's effort variables. Next, norm-based inequality metrics that calculate the divergence between the actual welfare levels and these fair welfare levels are computed. The more the two vectors diverge, the more circumstances rather than effort are determining welfare levels, and the more inequality of opportunity there is. See Ramos and Van de gaer (2016) for more information on the norm-based approach.

Since the four welfare measures follow different distributions, we are not able to compare the *extent* of inequality of opportunity across the different measures. This is little different from the fact that it is not possible to compare the level of welfare or inequality of welfare across the different measures. We will deal with this problem by indexing the extent of equality opportunity and tracking the development over time. The development over time is comparable across the different measures.

We find that the measure of well-being matters little, both with regards to characterizing the opportunity-deprived and with regards to tracking inequality of opportunity over time. In particular, we find that regardless of how welfare is measured, inequality of opportunity in Germany has decreased in the last 10 years. These results are robust to using different divergence measures and, for the most part, to

changing what we hold individuals responsible for. This is encouraging news for policymakers interested in providing equal opportunities while going beyond income, as they may broadly get things right if they proxy well-being with income.

To our knowledge, this is the first paper to explicitly address the Beyond GDP agenda in a Roemerian equality of opportunity framework. We are certainly not the first, however, to relate notions of fairness with welfare measurement. Fleurbaey and Maniquet (2011) summarize extensive work on this topic. This prior work generally incorporates concerns about fairness directly into the well-being measure. Our approach, in contrast, first computes measures of welfare and then analyzes the extent to which factors beyond individual control are driving the welfare differences. A particularly relevant paper for our approach is Ravallion (2017), which incorporates the disutility of effort into estimates of inequality of opportunity. We go in a different direction by analyzing whether the concept of welfare matters for estimates of inequality of opportunity. In previous studies, the measurement of welfare has been shown to matter for assessments of how average welfare has developed over time (Blanchflower and Oswald, 2004), for how inequality in welfare has developed over time (Stevenson and Wolfers, 2008), and for identifying the most welfare-deprived (Decancq and Neumann, 2016).

Roemer (2012) explicitly argues against using welfare as the outcome variable in equality of opportunity estimations. He does on two grounds. Firstly, because policymakers are interested in dimensions of well-being separately, such as health, income, or education, rather than well-being itself. This may certainly be the case, but if the ultimate objective is to equalize opportunities for well-being, then equalizing opportunities for only one dimension of well-being might actually bring about the opposite result (Calsamiglia, 2009). To see this, consider a policy that targets people born in a certain region of a country because they have fewer opportunities to acquire a high income. If these people simultaneously have better health, more leisure, or different preferences over the importance of income, they need not have fewer opportunities to acquire a high level of well-being. Our framework helps clarify if such examples have empirical leverage. The second reason why Roemer argues against using welfare as the outcome variable is grounded in the difficulty of measuring well-being in a cardinal way. Although this certainly complicates the exercise, we believe useful lessons can still be drawn.

The rest of the paper is organized as follows. Section 2 explains both the philosophical and axiomatic theory behind measuring equality of opportunity for well-being. Section 3 details our data and measurement approach. Section 4 outlines the results and provides several robustness checks. Section 5 concludes.

2 Theory

2.1 Well-Being

Three overarching theories of well-being exist in the philosophical literature; objective list theory, preference satisfaction theory, and mental state theory (Parfit, 1984; Griffin, 1986). *Preference satisfaction theory* is the most commonly assumed in economics. It claims that an individual's welfare depends on the degree to which his preferences are satisfied. Often preference orderings are assumed to be revealed through choice behavior. The underlying tenet behind these revealed preferences is that if an agent chooses bundle A over bundle B, then the agent must prefer A over B, and the agent must be better off with A rather than B. *Mental state theory* takes its starting point in what goes on inside the mind of individuals rather than their observed choices. According to this theory, well-being is the degree to which individuals are happy or the extent to which they experience pleasure over pain. *Objective list theory* argues that individuals' lives go well to the degree that they are in possession of certain items on a list, which could be income, education, health, safety, etc.

In short, mental state theory cares about what individuals feel, (revealed) preferences about what individuals choose, and objective list theory about external factors, which could be independent of the choices and feelings of individuals. Each theory has its advantages and shortcomings. Preference satisfaction theory, at least in the revealed form, can be criticized when individuals' decision-making is subject to imperfect knowledge or behavioral biases. If individuals have mistaken beliefs about what is best for themselves or lack willpower to choose what is best for themselves, then there is little reason to believe that their choices are a good manifestation of their well-being. Mental state theory can be criticized for its "physical condition neglect" (Sen, 1985), whereby individuals might feel well only because they have adapted to horrible conditions. Objective list theory can be criticized for being elitist in the sense that a set of indicators and weights are chosen somewhat independent of the preferences of individuals. All of these critiques can of course be counteracted, but doing so would be outside the scope of this paper.

This three-part division of well-being concepts is still very much in use today in both theoretical and empirical literature about well-being (see for example the chapter division in the Oxford Handbook of Well-Being and Public Policy (Adler and Fleurbaey, 2016) and the Stanford Encyclopedia of Philosophy on Well-Being (Crisp, 2016)). We will operationalize a measure of well-being with roots in each of these theories and see if they lead to different conclusions about equality of opportunity.

We are not attempting to argue in favor of one of these welfare concepts. Rather, we will take some of the operationalizations of these concepts at face value and investigate if equality of opportunity estimations depend on which measure is used.

2.2 Distributive Justice

Until Rawls published his Theory of Justice (Rawls, 1971), the predominant view of justice was defined in utilitarian terms. Under this view, the just outcome maximizes total welfare or, equivalently, equalizes marginal utilities. This view is welfarist in the sense that if all individuals' welfare levels are known, then no additional information is needed to decide whether one scenario is more desirable than another. Rawls argued against this welfarist view, emphasizing that we should not seek to equalize marginal utilities, but rather primary goods, which is a broader notion that also encompasses rights and liberties.

A number of subsequent scholars proposed variations of what the right equalizandum ought to be, building on the work of Rawls. Sen (1980) argued that neither utilities nor primary goods were enough to judge outcomes. He concluded that we need to look at what individuals are capable of achieving with these goods, thus advocating for basic capability equality. Dworkin (1981) contended that resources are the right equalizandum, while Arneson (1989) and Cohen (1990) argued that we ought to pursue equality of opportunity for welfare and equal access to advantage (see Roemer and Trannoy (2016) for a more complete account on the developments in distributive justice since Rawls).

Although these philosophers differ in their preferred equalizandum, they all adhere to the point of view that knowing all individuals' welfare levels is not sufficient. We need to know how that welfare came about, whether it came from fortunate backgrounds or from factors we can hold individuals accountable for. As such, they agree on the need to go beyond welfarism and accept some degree of individual responsibility, and thereby some degree of just inequalities. Notably, none of the philosophers defined the equalizandum in terms of income. Rather, they considered broader notions than income such as welfare, advantage, or functionings. Our approach attempts to get a bit closer to these frameworks. In particular, our approach is closely related to that of Arneson (1989), who precisely argued for equalization of opportunities for welfare.[1]

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[1]That being said, Arneson (1989) considered welfare to be preference satisfaction, thus differing from our take, where we will look at different theories of welfare.

2.3 Equality of Opportunity with the Norm-Based Approach

The philosophical theories of distributive justice have been operationalized in economics through the works of Roemer (1993), Van de gaer (1993), and Fleurbaey (1994) amongst others. The starting point in many of these operationalizations is to consider a population, $\mathcal{N} = \{1, 2, \ldots, n\}$, and a distribution of an outcome variable for this population, $\boldsymbol{y} = (y_1, y_2, \ldots, y_n)$. Often $\boldsymbol{y}$ is considered to be income, but here we will take welfare/well-being as the outcome, such that y_i is the welfare of individual $i \in \mathcal{N}$. An individual's outcome is assumed to be a product of two sets of variables: circumstances, $\boldsymbol{a^C}$, and effort, $\boldsymbol{a^E}$. Circumstances are the factors outside the realm of control for the individual, the factors one ought not to hold an individual responsible for. These are often taken to be gender, region of birth, parental education, parental income etc. Effort variables are the factors one ought to hold an individual responsible for. The well-being of individual i is thus assumed to be given by $y_i = f(\boldsymbol{a_i^C}, \boldsymbol{a_i^E})$. We consider the well-being levels to be cardinal and interpersonally comparable, but our setting also works in an ordinal framework where we convert the welfare levels into welfare ranks.

Based on this set-up, the literature proceeds with measuring the extent to which the outcome variable is driven by circumstance or effort variables. To do so we will rely on the norm-based approach (Ramos and Van de gaer, 2016), also called the *fairness gap* in Fleurbaey and Schokkaert (2009). This approach uses fair allocation rules to assign each individual a fair outcome, which only depends on his or her effort level, and calculates inequality of opportunity as the divergence between the actual outcomes and the fair outcomes. The more the two distributions diverge, the less individuals' effort are associated with their well-being and the more circumstances are shaping individuals' outcomes.

The axiomatic literature on fair allocations has put forward two criteria that fair allocation rules ideally ought to satisfy, these being the compensation principle and the reward principle. The *compensation principle* states that differences in well-being due to differences in circumstances should be eliminated. The *reward principle* is concerned with the proper reward of effort for individuals with the same circumstances. Unfortunately, these two criteria are mutually incompatible (Bossert, 1995; Fleurbaey, 1995). The literature has proposed allocation rules that weaken these two principles in order to make them compatible. Two such rules are the Egalitarian Equivalent principle (Bossert and Fleurbaey, 1996) and the Generalized Proportionality principle (Cappelen and Tungodden, 2017).

Both principles start by defining a norm vector of circumstance variables, $\tilde{\boldsymbol{a}}^C$ and calculate the well-being individuals would have had, if they had this norm level

of circumstances, $f(\boldsymbol{a_i^E}, \tilde{\boldsymbol{a}}^C)$. This neutralizes the effect of circumstances on well-being and the differences in $f(\boldsymbol{a_i^E}, \tilde{\boldsymbol{a}}^C)$ can therefore be thought of as expressing fair advantage. As the mean of $f(\boldsymbol{a_i^E}, \tilde{\boldsymbol{a}}^C)$ may differ from the mean of the actual outcomes, and since resources should not be wasted and cannot come out of nothing, some adjustment is necessary. The two fair allocation rules deal with this in different ways. To estimate the distribution of fair outcomes, call this $\boldsymbol{z}$, the Egalitarian Equivalent (EE) principle, distributes the difference between the size of the two distributions equally across individuals:

$$z_i^{EE} = f(\boldsymbol{a_i^E}, \tilde{\boldsymbol{a}}^C) + \left(\mu(\boldsymbol{y}) - \frac{\sum_{j \in \mathcal{N}} f(\boldsymbol{a_j^E}, \tilde{\boldsymbol{a}}^C)}{n} \right), \tag{1}$$

where $\mu(\boldsymbol{y}) = \frac{1}{n} \sum_{j \in \mathcal{N}} y_j$. This principle has the advantage that if the well-being function is linearly separable in circumstances and effort, such that $y_i = g(\boldsymbol{a_i^E}) + h(\boldsymbol{a_i^C})$, then the fair well-being levels do not depend on which norm vector of circumstances is chosen and the expression boils down to

$$z_i^{EE} = g(\boldsymbol{a_i^E}) + \frac{\sum_{j \in \mathcal{N}} h(\boldsymbol{a_j^C})}{n}. \tag{2}$$

The Generalized Proportionality (GP) principle, instead, respects the well-being shares of the fair well-being allocation $f(\boldsymbol{a_i^E}, \tilde{\boldsymbol{a}}^C)$ by scaling them by the same factor:

$$z_i^{GP} = f(\boldsymbol{a_i^E}, \tilde{\boldsymbol{a}}^C) \frac{\mu(\boldsymbol{y})}{\sum_{j \in \mathcal{N}} f(\boldsymbol{a_j^E}, \tilde{\boldsymbol{a}}^C)/n}. \tag{3}$$

An individual's fair outcome only depends on his/her effort variables and reflects how much the individual ideally is entitled to under the given allocation principles.[2] The more aligned the fair outcomes and the actual outcomes are, the lower inequality of opportunity. Conversely, the more they diverge, the greater inequality of opportunity. We can measure the extent to which the two distributions diverge from each other by employing a divergence measure, $D(\boldsymbol{y}\|\boldsymbol{z})$, which evaluates the divergence between the two distributions, $\boldsymbol{y}$ and $\boldsymbol{z}$.

Magdalou and Nock (2011) (MN) provide a framework for axiomatically grounded divergence measures.[3] They put forth a class of divergence measures between an

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[2]Here we neglect the minor impact each individual's circumstances have on the mean welfare level.

[3]We are heavily indebted for comments and advice from Brice Magdalou on the use and interpretation of appropriate divergence measures.

outcome distribution, $\boldsymbol{y}$, and a reference distribution, $\boldsymbol{z}$:

$$D_{MN}(\boldsymbol{y}\|\boldsymbol{z}) = \frac{1}{n} \sum_{i \in \mathcal{N}} \left[\phi(y_i) - \phi(z_i) - (y_i - z_i)\phi'(z_i) \right], \qquad (4)$$

where for all $c \in \mathbb{R}_{++}$, the function $\phi(c)$ is given by:

$$\phi(c) \coloneqq \begin{cases} \frac{1}{s(s-1)} c^s, & \text{if} \quad s \neq 0,1, \\ c \ln c, & \text{if} \quad s = 1, \\ -\ln c, & \text{if} \quad s = 0. \end{cases} \qquad (5)$$

s is a sensitivity parameter, similar to the one we find in standard inequality measurement. This class boils down to the generalized entropy class of standard inequality measures if $\boldsymbol{z}$ is assumed to be the mean of the actual distribution. The class $D_{MN}(\boldsymbol{y}\|\boldsymbol{z})$ satisfies partial symmetry (i.e. it is invariant to permutations of (y_i, z_i) pairs) along with other relevant properties. By using the function ϕ from (5) in (4), one obtains

$$D_{MN}(\boldsymbol{y}\|\boldsymbol{z}) = \begin{cases} \frac{1}{n}\frac{1}{s(s-1)} \sum_{i \in \mathcal{N}} \left[y_i^s + (s-1)z_i^s - s\, y_i\, z_i^{s-1} \right], & \text{if} \quad s \neq 0,1, \\ \frac{1}{n} \sum_{i \in \mathcal{N}} \left[y_i \ln\left(y_i/z_i\right) + z_i - y_i \right], & \text{if} \quad s = 1, \\ \frac{1}{n} \sum_{i \in \mathcal{N}} \left[y_i/z_i - \ln\left(y_i/z_i\right) - 1 \right], & \text{if} \quad s = 0. \end{cases} \qquad (6)$$

Cowell (1985) suggests a different class of divergence measures, which he calls measures of distributional change, that satisfies different properties.[4] The measure equivalent to (4) is:

$$D_C(\boldsymbol{y}\|\boldsymbol{z}) = \frac{1}{n} \sum_{i \in \mathcal{N}} \left[z_i\, \phi(y_i/z_i) \right]. \qquad (7)$$

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[4]The measures proposed by Magdalou and Nock (2011) and Cowell (1985) differ in two important aspects. Both divergence measures generalize the principle of transfers, a cornerstone to inequality measurement, but Magdalou and Nock (2011) impose a weaker generalization of the principle of transfers than Cowell (1985). In addition, and unlike Cowell (1985), Magdalou and Nock (2011) impose judgement separability, which allows measures to be additively decomposed into two components when the reference distribution is egalitarian, but the mean of the reference distribution differs from the mean of the actual distribution. The first component evaluates the divergence between the actual distribution and a hypothetical distribution where everyone has mean income, while the second one evaluates the efficiency loss brought about by the divergence between the hypothetical distribution where everyone has mean income and the egalitarian reference distribution.

By using the function ϕ from (5) in (7), $D_C(\boldsymbol{y}\|\boldsymbol{z})$ can be written as

$$D_C(\boldsymbol{y}\|\boldsymbol{z}) = \begin{cases} \frac{1}{n}\frac{1}{s(s-1)}\sum_{i\in\mathcal{N}}(y_i^s z_i^{1-s} - 1), & \text{if} \quad s \neq 0, 1, \\ \frac{1}{n}\sum_{i\in\mathcal{N}} y_i \ln(y_i/z_i), & \text{if} \quad s = 1, \\ \frac{1}{n}\sum_{i\in\mathcal{N}} z_i \ln(z_i/y_i), & \text{if} \quad s = 0, \end{cases} \qquad (8)$$

where "-1" is added when $s \neq 0, 1$ to obtain a proper generalization of the generalized class of inequality indices. Devooght (2008) provides an empirical application of this class to equality of opportunity in Belgium.

The two different classes of divergence measures, $D_{MN}(\boldsymbol{y}\|\boldsymbol{z})$ and $D_C(\boldsymbol{y}\|\boldsymbol{z})$, coincide when $s = 1$ (the last two terms in $D_{MN}(\boldsymbol{y}\|\boldsymbol{z})$ when $s = 1$ cancel each other out in our case). For this reason we are going to use $s = 1$ as our main specification. Parameters $s = 0$ and $s = 2$ with $D_{MN}(\boldsymbol{y}\|\boldsymbol{z})$ will be used as robustness checks. One of the features of D_{MN} is that a progressive transfer in the actual distribution, $\boldsymbol{y}$, reduces the divergence between $\boldsymbol{y}$ and $\boldsymbol{z}$ as long as the individuals involved in the transfer have the same reference, $\boldsymbol{z}$. It is a kind of priority given to the worse-off individuals when the individuals involved in the transfer share the same $\boldsymbol{z}$. Moreover, if (and only if) $s < 2$, the further down the distribution of $\boldsymbol{y}$ such a transfer takes place, the more the divergence between $\boldsymbol{z}$ and $\boldsymbol{y}$ is reduced. This property resembles the principle of diminishing transfers in the context of inequality measurement, which holds for the class of entropy indices when $s < 2$. When $s = 2$ the measure is ordinally equivalent to the Euclidian distance, and it is thus insensitive to the position on the distribution where the progressive transfer (among individuals with the same reference) takes place. Thus, the parameter value $s = 2$ can be seen as a threshold. Contrary to this, the parameter value $s = 0$ yields a measure that is more sensitive to transfers lower down the distribution than our baseline measure with $s = 1$.

As another robustness check we will use a divergence measure which is a generalization of the standard Gini coefficient developed by Almås $et\ al.$ (2011), called the Unfairness Gini, $D_{Gini}(\boldsymbol{y}\|\boldsymbol{z})$:

$$D_{Gini}(\boldsymbol{y}\|\boldsymbol{z}) = \frac{1}{2n(n-1)\mu(\boldsymbol{y})}\sum_{i\in\mathcal{N}}\sum_{j\in\mathcal{N}}|(y_i - z_i) - (y_j - z_j)|. \qquad (9)$$

As a final robustness check we will use a very simple measure of measure of the divergence; the rank correlation between welfare levels and $\boldsymbol{h}(\boldsymbol{a^C})$. A large correlation suggests a high degree of inequality of opportunity, since individuals with the best circumstances also have the highest welfare levels. A correlation of 0, in turn, reflects that the quality of individuals' circumstances is not correlated with

their welfare. If we use income as the outcome variable and consider parental income as the only circumstance variable, then this measure boils down to a frequently used measure of immobility; Spearman's correlation between parents' and children's income level (see for example Chetty *et al.* (2014)).

3   Data & Measurement

We use data from the German Socio-Economic Panel (SOEP), which is a yearly panel that started in 1984. The panel contains detailed questions on household income, life satisfaction, other well-being dimensions, as well as biographical and historical data that we use to construct circumstance variables. We use data from 1992, the first year where East Germany can be included in our sample, to 2016, and include all working and unemployed individuals but drop individuals outside the labor market and observations with missing values. In total, we have 170,142 person-year observations meeting our baseline specification. These are spread around 21,838 individuals in 15,452 different households.

Our baseline analysis will use the following circumstance variables: gender, father's education (3 categories), mother's education (3 categories), father's occupation (6 categories), polynomial of age, height, place of birth (West Germany, East Germany, abroad), degree of urbanization at place of birth (4 categories), and number of siblings. As baseline effort variables we use years of education, work hours, a dummy for whether the respondent is self-employed, and a dummy for whether the respondent works in the public sector. Effort may be a slightly misleading term here, the point of these four variables is that they plausibly lie within individual control and hence constitute factors that we may hold individuals accountable for. One could easily argue that, say, number of hours worked does not lie within individual control. For this reason, we will provide robustness checks where we move these four variables to the other side of the responsibility cut. Summary statistics of the circumstance and effort variables are given in Table 1.

3.1   Constructing Welfare Variables

We use four different welfare variables in the analysis. First, we use log incomes. This is the most frequently used outcome variable in equality of opportunity studies. We use it as a baseline for comparison to the other well-being measures. We use annual net household income expressed in 2010 constant EUR adjusted for family size using the OECD equivalence scales. The other three welfare variables are rooted in the three concepts of well-being that Parfit (1984) and Griffin (1986) put forward.

Table 1: Summary Statistics

	mean	sd	min	max
Circumstance Variables				
Father's education: Lower secondary or less	0.65	0.48	0	1
Father's education: Upper secondary	0.21	0.41	0	1
Father's education: Tertiary	0.14	0.34	0	1
Mother's education: Lower secondary or less	0.68	0.47	0	1
Mother's education: Upper secondary	0.25	0.43	0	1
Mother's education: Tertiary	0.08	0.26	0	1
Father's occupation: Blue-collar (untrained)	0.13	0.34	0	1
Father's occupation: Blue-collar (trained)	0.33	0.47	0	1
Father's occupation: Not employed	0.07	0.26	0	1
Father's occupation: White-collar	0.27	0.44	0	1
Father's occupation: Self-employed	0.11	0.32	0	1
Father's occupation: Civil servant	0.08	0.28	0	1
Place of upbringing: Large city	0.22	0.41	0	1
Place of upbringing: Medium city	0.18	0.39	0	1
Place of upbringing: Small city	0.23	0.42	0	1
Place of upbringing: Countryside	0.37	0.48	0	1
Place of birth: West Germany	0.64	0.48	0	1
Place of birth: East Germany	0.29	0.45	0	1
Place of birth: Abroad	0.07	0.26	0	1
Height	172.96	9.22	80	220
Female	0.47	0.50	0	1
Number of siblings	1.92	1.65	0	17
Age	42.39	12.25	17	91
Effort Variables				
Years of education	12.64	2.73	7	18
Weekly work hours	35.54	15.96	0	80
Self-employed	0.09	0.29	0	1
Works in public sector	0.18	0.39	0	1

Notes: Summary statistics of circumstance and effort variables. n = 170,142.

The second welfare measure we use is life satisfaction, which has roots in mental state theory. Life satisfaction is the answer to the question, "How satisfied are you with your life, all things considered?" The answer categories range from 0 (completely dissatisfied) to 10 (completely satisfied). For the purpose of this study, we consider the answers interpersonally comparable. This is not meant as an endorsement of this particular account of well-being but rather as an inquiry into how inequality of opportunity estimates would look if one accepted these assumptions.

The third welfare measure we use is a multidimensional welfare measure, which has roots in objective list theory. To construct the measure of multidimensional welfare we partly follow Decancq and Neumann (2016). We consider four dimensions;

income, health, leisure, and employment.[5] Income is measured the same way as above. Employment is a binary variable taking the value of 1 if the respondent had a job at the time of the survey. Leisure is measured as the amount of daily hours spent on leisure (capped at 6 hours). Health is itself a composite index composed of 1) an indicator for whether the individual is disabled, 2) the number of doctor appointments the respondent had last year and 3) the number of inpatient nights in hospitals the respondent had last year. To aggregate these sub-dimensions into one health dimension we regress a health satisfaction question on the three variables and use the coefficients as weights. The health satisfaction variable is composed of answers to how satisfied individuals are with their health on a scale from 0 (not at all satisfied) to 10 (completely satisfied). For the income, leisure, and health dimension, we standardize the values such that the highest observed level is 1 and the lowest observed level is 0. Now we have four dimensions each bounded between 0 and 1. To arrive at the final multidimensional index, we simply add these four together.

The fourth welfare measure, equivalent incomes, is based on preference satisfaction theory. In short, equivalent incomes are the incomes individuals need together with a reference bundle, to make them indifferent with their actual bundle. Although preferences are often estimated from choice behavior, this is difficult when the arguments cover a wide array of dimensions of well-being. An alternative method to recover preferences used by Decancq *et al.* (2015), is to regress life satisfaction on the dimensions of well-being and interpret the weights as marginal rates of substitution. The resulting utility functions seem to be highly correlated with the utility functions one would recover from choice behavior (Akay *et al.*, 2017). This approach easily accommodates preference heterogeneity by allowing for interactions between sociodemographic characteristics, w, and the various dimensions, dim. We follow this approach and use the following subset of the circumstance and effort variables as preference heterogeneity parameters, w: birth location, sex, age, work hours, self-employed, and public sector worker. As the non-income dimensions, dim, we consider health, employment, and leisure, like in the multidimensional index. Our life satisfaction regression looks as follows:

$$lifesat_{it} = [\beta^{inc} + \gamma^{inc} w_{it}]ln(inc_{it}) + [\beta^{dim} + \gamma^{dim} w_{it}]dim_{it} + w_{it} + \mu_t + \alpha_i + \varepsilon_{it} \quad (10)$$

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[5]Although we would like to include more dimensions, such as education, we run into estimation problems since this also is considered an effort variable. As we will regress the welfare variable on circumstance and effort variables, and since we do not want to have the same variables on each side of the regression, we omit this dimension.

Output from this regression is shown in Table A.1 in the Appendix. In order to calculate the equivalent incomes, we first select a reference vector, $\tilde{dim}$, of all other dimensions than income. Here we choose the mean outcome (mode for categorical variables), since this avoids favoring any extreme marginal rates of substitution.[6] Then we calculate the income needed together with $\tilde{dim}$ for this joint bundle to make individuals indifferent with their actual bundle. That is, we isolate $ln(inc_{it}^{eq})$ below:

$$
\begin{aligned}
lifesat\big(ln(inc_{it}), dim_{it}\big) &= lifesat\big(ln(inc_{it}^{eq}), \tilde{dim}\big) \\
\Leftrightarrow ln(inc_{it}^{eq}) &= ln(inc_{it}) + \frac{\beta^{dim} + \gamma^{dim} w_{it}}{\beta^{inc} + \gamma^{inc} w_{it}}(dim_{it} - \tilde{dim})
\end{aligned}
\tag{11}
$$

The result is an interpersonally comparable measure of individual welfare that takes differences in preferences into account.
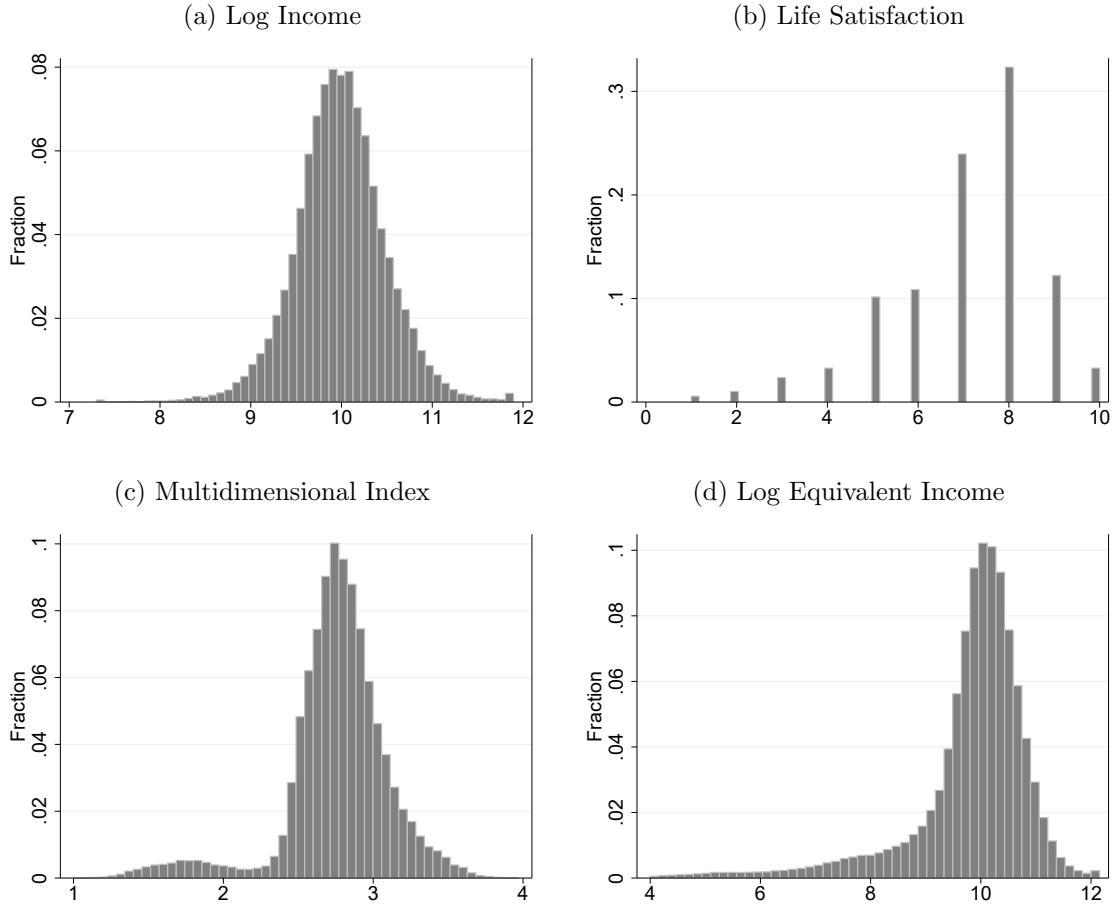
By employing equivalent incomes as a welfare measure in our analysis, we are implicitly taking sides in a rich philosophical debate about whether individuals should be held responsible for their preferences. Our empirical approach implicitly deems differences in well-being arising from preference heterogeneity unfair if they stem from circumstance variables, but fair if they stem from effort variables. This is in contrast to most applications of equivalent incomes, which hold that individuals should be responsible for all their preferences. We can amend our approach such that individuals are held responsible for all their preferences by decomposing the equivalent income measure into a part that is due to preference heterogeneity and a part that does not incorporate preference heterogeneity. We will do so as a robustness check. A detailed discussion of this method along with an illustration is given in Appendix A.2. Still, our usage of equivalent incomes as a welfare measure that is regressed on income and circumstance variables is in contrast to the typical use of equivalent incomes, which incorporate issues of unfairness directly into the measure. We simply interpret equivalent incomes as another measure of well-being to be used in our analysis.[7]

Histograms of the four final welfare measures are presented in Figure 1.

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[6]To see this, suppose we were to choose the maximum value rather than the mean. Then we would give individuals with a high preference for income a relatively high level of well-being, as these individuals need a relatively high income together with this reference bundle to be indifferent to their actual bundle.

[7]A challenge with our use of equivalent incomes is the endogeneity problems generated by having circumstance and effort variables influence the dependent variable as well as entering on the right-hand side of the regressions. Measurement error in one of the variables we use as preference shifters would create a spurious relationship between the fair outcomes and actual outcomes. For the preference shifters we deal with, we conjecture this is a relatively minor concern.

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Figure 1: Histograms of Welfare Measures

(a) Log Income

(b) Life Satisfaction

(c) Multidimensional Index

(d) Log Equivalent Income

Notes: Histograms of the four welfare measures. The income and equivalent income distribution is bottom (top) coded at the 0.1th (99.9th) percentile. Life satisfaction is bottom-coded at 1 since values of 0 do not work with our divergence measure.

3.2 Estimating Equality of Opportunity

For our empirical specification, we consider well-being to be a linearly separable function of effort and circumstance variables:

$$y_{it} = \beta^C a_{it}^C + \beta^E a_{it}^E + \epsilon_{it} \tag{12}$$

Two important issues remain unsettled. First is the issue of how to interpret the error term, ϵ_{it}. The error contains omitted effort variables, omitted circumstance variables, measurement error, and general uncertainty. It is unclear whether this should be considered within individual control. This is an important decision as it accounts for most of the variation in the welfare levels. In our baseline specification,

we follow the inequality of opportunity literature and consider it an effort variable, but as a robustness check we shift it to the other side of the responsibility cut.

The other unsettled issue is what to do with the correlation between the effort and circumstance variables. Individuals' effort levels are partly determined by their own choices and partly by their circumstances. Years of education, for example, is partly influenced by individuals' social background and partly by an individual's own choices. We follow Roemer's approach and consider this correlation to be outside the realm of individual responsibility (Roemer, 1998).[8] In practice, this means that prior to estimating the impact of circumstances and efforts on well-being we perform an auxiliary regression of the following form:

$$a_{it}^E = \gamma a_{it}^C + \eta_{it} \tag{13}$$

We perform such a regression for each effort variable and use the residuals from these regressions as our effort variables in our main regression, which then becomes:

$$y_{it} = (\beta^C + \gamma \beta^E)a_{it}^C + \beta^E \eta_{it} + \epsilon_{it} \tag{14}$$

Due to the Frisch-Waugh-Lowell theorem, the coefficients on the effort variables will be the same in (12) and (14). The coefficients on the circumstance variables will be different as they in (14) also incorporate the indirect effect of circumstances on effort.[9] We will later report specifications where we omit this auxiliary regression.

To compare who the opportunity-deprived are across the four well-being measures, we rank individuals according to their opportunity profile, that is, according to the quality of their circumstances. We calculate each person's yearly opportunity rank as

$$r_{it}^{opportunity} = H_t\big[(\beta^C + \gamma \beta^E)a_{it}^C\big], \tag{15}$$

where H_t is the yearly cumulative distribution of individuals' unfair advantage. This allows us to compare the opportunity-deprived across the four well-being measures.

To estimate equality of opportunity over time using the norm-based approach,

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[8]Jusot *et al.* (2013) likewise call this Roemer's view, while not correcting for this correlation is termed Barry's view (Barry, 2005). A final possibility, where the correlation between effort and circumstances is considered effort, is called Swift's view (Swift, 2005).

[9]This regression obviously suffers from omitted variable bias, which makes the interpretation of the coefficients from the regression problematic. As long as the regression does not overfit the data, an implication of the omitted variables is that the regression provides a lower-bound estimate of the amount if inequality attributable to circumstances (Ferreira and Gignoux, 2011; Brunori *et al.*, 2018).

we first compute each individual's fair outcome, using equation (2):

$$z_{it}^{EE} = g(\boldsymbol{a_{it}^E}) + \frac{\sum_{j \in \mathcal{N}} h(\boldsymbol{a_{jt}^C})}{n_t} = \beta^E \eta_{it} + \epsilon_{it} + \frac{\sum_{j \in \mathcal{N}} (\beta^C + \gamma \beta^E) a_{jt}^C}{n_t} \qquad (16)$$

That is, we compute each individual's fair outcome as the contribution to well-being from the individual's effort and the average contribution coming from circumstances for all individuals in the sample for the year in question. Second, we utilize our battery of divergence measures to compute the divergence between the fair outcomes and the actual outcomes.

4 Results

4.1 Who are the Opportunity-Deprived?

Table A.2 in Appendix A.3 shows the results of the regressions from equation (14). Based on this output and equation (15), we calculate each person's yearly opportunity rank. Table 2 shows the correlations between these opportunity ranks for the four welfare measures. The correlations reveal the extent to which the same people are opportunity-deprived across the four measures. In the table – and throughout the paper – we bootstrap confidence intervals in order to take all derived uncertainty into account, including the uncertainty when constructing the welfare measures. We bootstrap 500 resamples at individual-level clusters.

Table 2: Correlation Between Opportunity Ranks

	Log Inc.	Life Sat.	Multidim. Index	Log Eq. Inc.
Log Income	-	-	-	-
Life Satisfaction	0.53	-	-	-
	(0.47, 0.57)			
Multidim. Index	0.73	0.89	-	-
	(0.70, 0.76)	(0.86, 0.92)		
Log Eq. Inc.	0.89	0.59	0.74	-
	(0.81, 0.93)	(0.50, 0.66)	(0.66, 0.79)	

Notes: Correlations between $\boldsymbol{r^{opportunity}}$ for the four welfare measures. Bootstrapped 95th percentile confidence intervals in parenthesis.

The opportunity ranks display rather high correlations, suggesting that the same people are opportunity-deprived regardless of how we measure welfare. The welfare measures we have constructed are of course partly contained within each other; the

income variable is included in both the multidimensional index and the equivalent income measure, and the latter two use the same four dimensions but aggregate them differently. We can analyze the extent to which this is driving the high rank correlations by comparing them with the rank correlation between the welfare levels, which are shown in Table 3. In all cases, the correlations are higher when we look at $r^{opportunity}$. This indicates that the high opportunity rank correlations are not driven solely by the measures' interrelatedness. This also suggests that the way welfare is measured matters more if we target the welfare-deprived than if we target the opportunity-deprived.

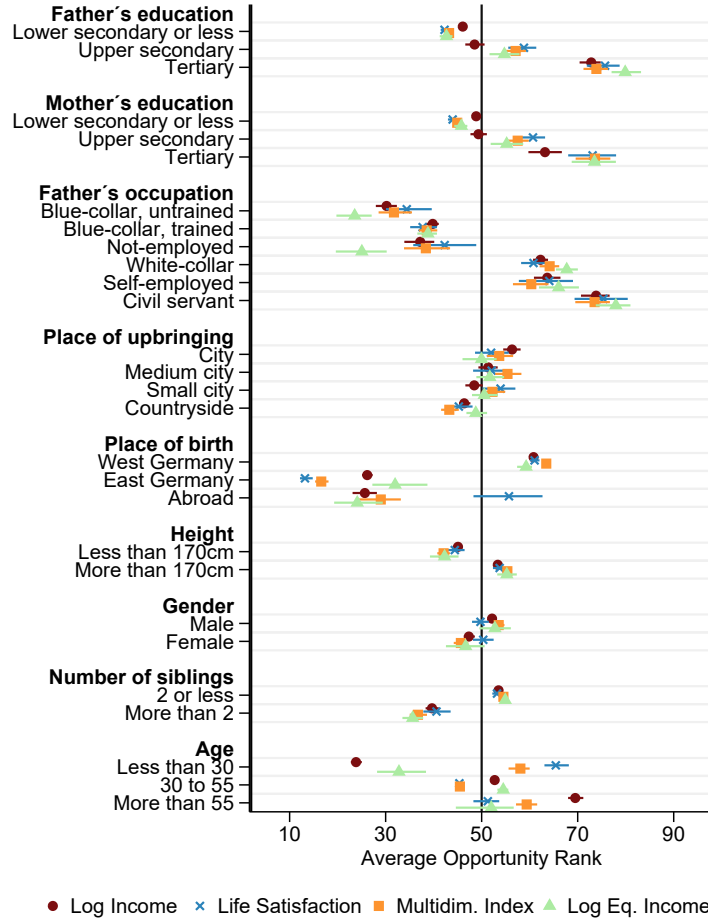Table 3: Spearman Correlation Between Welfare Measures

	Log Inc.	Life Sat.	Multidim. Index	Log Eq. Inc.
Log Income	-	-	-	-
Life Satisfaction	0.20	-	-	-
	(0.18, 0.22)			
Multidim. Index	0.42	0.20	-	-
	(0.41, 0.43)	(0.19, 0.22)		
Log Eq. Inc.	0.68	0.27	0.63	-
	(0.61, 0.73)	(0.25, 0.28)	(0.58, 0.68)	

Notes: Spearman correlation between welfare levels. Bootstrapped 95th percentile confidence intervals in parenthesis.

Since individuals' opportunities are unobservable, policymakers may have to assist the opportunity-deprived indirectly. One way of doing so is by targeting individuals with circumstance profiles that are highly correlated with having low opportunities. We can use the opportunity ranks to test if the characteristics of the opportunity-deprived are similar across the four welfare measures. To do so, we calculate the average opportunity rank for individuals with a given circumstance. Results are shown in Figure 2. The lower the average opportunity rank, the less opportunities individuals with the given circumstance have, and the more this circumstance is a potential factor policymakers can use to target the opportunity-deprived. If the average rank is less than 50, then the particular group has less than average opportunities.

There are many similarities across the welfare measures. Individuals with low educated parents and individuals whose father was a blue-collar worker or not employed have low opportunities. The same applies to individuals who grew up in the countryside, individuals born in East Germany, short individuals, females, and individuals with many siblings.

Figure 2: Who are the Opportunity-deprived?

Notes: The figure shows the average opportunity rank ($r_{it}^{opportunity} = H_t\big[(\beta^C + \gamma\beta^E)a_{it}^C\big]$) for individuals that share a given circumstance. If the points are to the left of the line at 50, then individuals with this circumstance are more than average opportunity-deprived and vice versa. Bars indicate bootstrapped 95th percentile confidence bands.

Meaningful differences emerge only in two places, for people born abroad and for different age groups. People born abroad are more opportunity-deprived in all measures but life satisfaction. A possible explanation for this is that people born abroad understand the life satisfaction scale more optimistically than Germans. Alternatively, it may be because people born abroad tend to have other circumstances, which are particularly good for life satisfaction. We can indirectly check which effect is driving the result by excluding place of birth from the regression, calculating new opportunity ranks, and re-computing the average opportunity rank of individuals born abroad. With this approach, the direct channel from being born abroad on life satisfaction is omitted. Now the average opportunity rank of people born abroad falls below 50 (not shown in figure). This suggests that the previous higher rank was solely driven by the direct positive effect of being born abroad on life satisfaction,

and that individuals born abroad fare worse than people born in Germany with respect to the remaining circumstances. Hence, it may be that the high opportunity rank with respect to life satisfaction for people being born abroad is solely due to scaling effects.

With respect to age, young people are opportunity-deprived in income but not in the multidimensional index. This is hardly surprising as the multidimensional index includes health, and young people on average are healthier. Since young people have a lower preference for health (as shown in Table A.1 in the Appendix), young people are not faring better with equivalent incomes, despite the fact that they are more healthy. With respect to life satisfaction, middle-aged are opportunity deprived while young and people above 55 are doing better. This mimics the well-known u-curved relationship between subjective well-being and age (Blanchflower and Oswald, 2008; Clark *et al.*, 1996).

It is questionable whether resources should be allocated such that individuals have equal opportunities in every part of their life. For this reason, we will later on place age on the other side of the responsibility cut. This may seem counterintuitive but it amounts to saying that individuals should have equal opportunities on expectation over their lifecycle rather than in every point of their life (see Almås *et al.* (2011) for a similar approach).
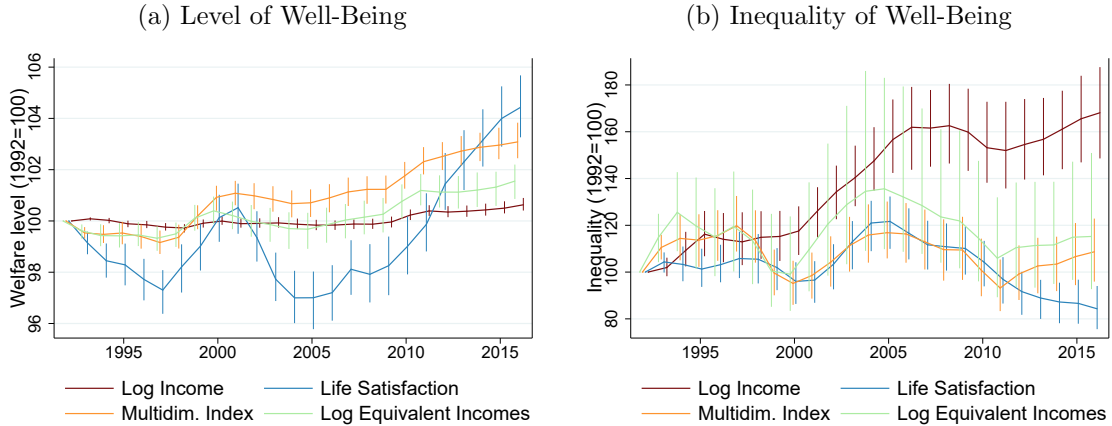
In sum, there is relatively large agreement about whom the opportunity-deprived are across the four measures. Hence, if a policymaker strives to target individuals with low opportunities, it matters relatively little how welfare is measured. Although this suggests that equalizing opportunities does not depend on how welfare is measured, it may very well be the case that the public policies needed to prevent inequality of opportunity from arising in the first place depend on which measure of welfare is used. To study this properly, a causal framework is needed, which goes beyond the scope of this paper.

4.2   Equality of Opportunity over Time

Before analyzing how equality of opportunity has evolved over time, and whether this depends on the well-being measure used, we start with analyzing how the level of well-being has evolved over time and how inequality in well-being has developed over time. Panel (a) of Figure 3 shows the level of well-being in Germany from 1992-2016. In the figure, and in the time-series figures to follow, we use three-year moving averages to smoothen out erratic trends. The level of well-being is normalized to 100 in 1992 to foster comparisons between the different measures.

The figure shows that from around 2005, well-being has increased with all four

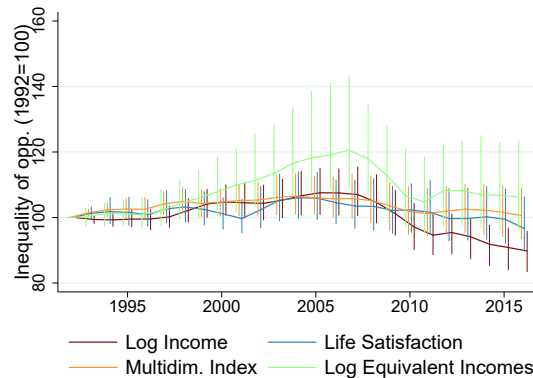Figure 3: Development in Level and Inequality of Well-Being, 1992-2016

(a) Level of Well-Being

(b) Inequality of Well-Being

Notes: Development in the level of well-being and inequality in well-being from 1992-2016. All measures are normalized to equal 100 in 1992 to foster comparisons. Inequality is measured using the Theil index. Bars indicate bootstrapped 95th percentile confidence bands.

measures, but prior to that, life satisfaction and the multidimensional index followed different patterns than the remaining two measures. Panel (b) of Figure 3 shows the development in inequality in the four welfare measures using the Theil index. Inequality in log incomes has increased substantially over most of the period, inequality in life satisfaction has decreased over the past 10 years, while inequality in the other two measures has followed intermediate trends.

Thus, the measure of welfare matters both when we look at the development of welfare and the inequality of welfare over the past 25 years in Germany. How do things look for the development of inequality of opportunity over time? This is displayed in Figure 4.

Figure 4: Inequality of Opportunity over Time

Notes: Development in inequality of opportunity in each well-being variable from 1992-2016 using the Magdalou-Nock divergence measure with $s = 1$ and the Egalitarian Equivalent allocation rule. Bars indicate bootstrapped 95th percentile confidence bands.

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Although confidence bands are quite wide, the measures follow broadly the same pattern. From 1992 to 2005, inequality of opportunity increased, and from then and until 2016, it gradually fell. Some of the welfare measures, particularly equivalent incomes, are noisier, which can be explained by the added uncertainty from the fairly complicated process of constructing this welfare measure.
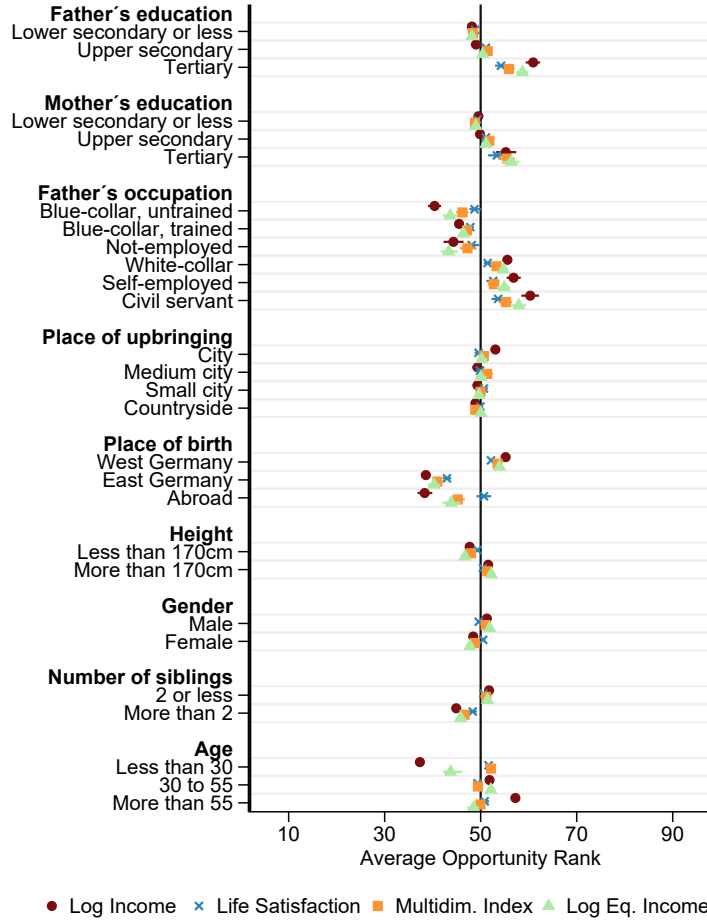
4.3 Altering the Responsibility Cut

The analysis above was based on important normative assumptions regarding what individuals were held responsible for. We assumed that individuals were responsible for four variables (*4var*); their education, work hours, and whether they are self-employed or work in the public sector. We also assumed that individuals should not be held responsible for the part of these variables that could be accounted for by circumstance variables. That is, the correlation (*cor*) between circumstances and effort was itself considered outside the control of individuals. We further assumed that the part of individual well-being that was unaccounted for by circumstance or effort variables (*residual*) was within individual control. Next, we implicitly considered well-being differences across different age groups (*age*) as unfair. Finally, for the equivalent income measure, we assumed that individuals were not responsible for well-being differences due to preference heterogeneity arising from circumstances (*pref*).

Our baseline effort set contained *4var* and *residual*. In this section, we try to shift the responsibility cut by altering what goes into the effort set. First, we look at whether the characteristics of the opportunity-deprived change as we change the effort set. This is analyzed in Figures 5 and 6. Figure 5 uses our most narrow effort set, only *4var*, while Figure 6 uses the widest possible effort set, *4var, residual, cor, age, pref*.

The figures show the same overall pattern as our main results. For the most part, the opportunity-deprived share the same characteristics across all four measures. The only disputes are, once again, for individuals born abroad and for different age groups. The responsibility cut does matter for quantifying the degree to which a particular group is opportunity-deprived. For example, individuals born in East Germany have an average opportunity rank of about 40 with the smallest effort set and 15 with the largest effort set. In other words, East Germans are not doing too poorly if we only hold individuals responsible for four variables (which almost mimics just looking at outcomes), but the more we hold individuals responsible for, the more disadvantaged they are. This suggests that East Germans have relatively high effort levels.

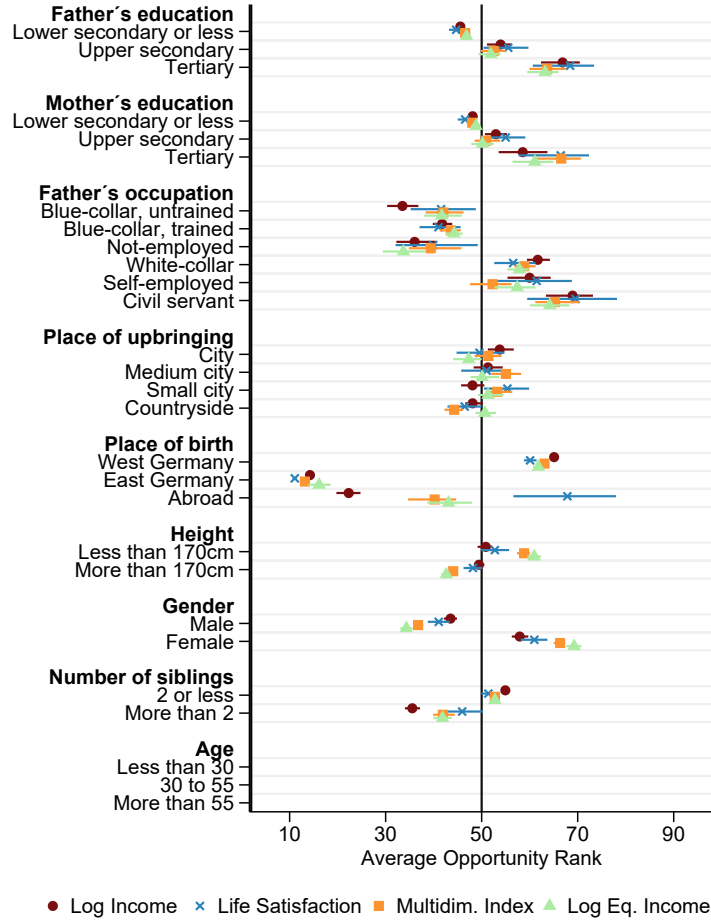Figure 5: Changing the Responsibility Cut: Effort = {4var}

Notes: The figure shows the average opportunity rank for people sharing a particular circumstance using a narrow effort set. Bars indicate boot-strapped 95th percentile confidence bands.

Next, we look at whether the developments over time depend on where we place the responsibility cut. We try six different specifications, which gradually expand the effort set. Results are displayed in Figure 7. Our primary interest is not whether the trends change as we change the responsibility cut, but rather whether the four well-being measures follow similar trends regardless of where we place the cut.

Our baseline results are displayed in panel (c). If we no longer hold individuals responsible for the four variables we had deemed effort (panel (b)), then our main results become more clear; inequality of opportunity increased until about 2005 and then decreased for all four measures. If we only hold individuals responsible for the four variables and shift the residual to the other side of the responsibility cut (panel (a)) then the picture looks very different, particularly for log income. Since the four effort variables only are able to explain very little of the variance, the measure almost boils down to the development in inequality over time, which we already

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Figure 6: Changing the Responsibility Cut: Effort = {4var, residual, cor, age, pref}
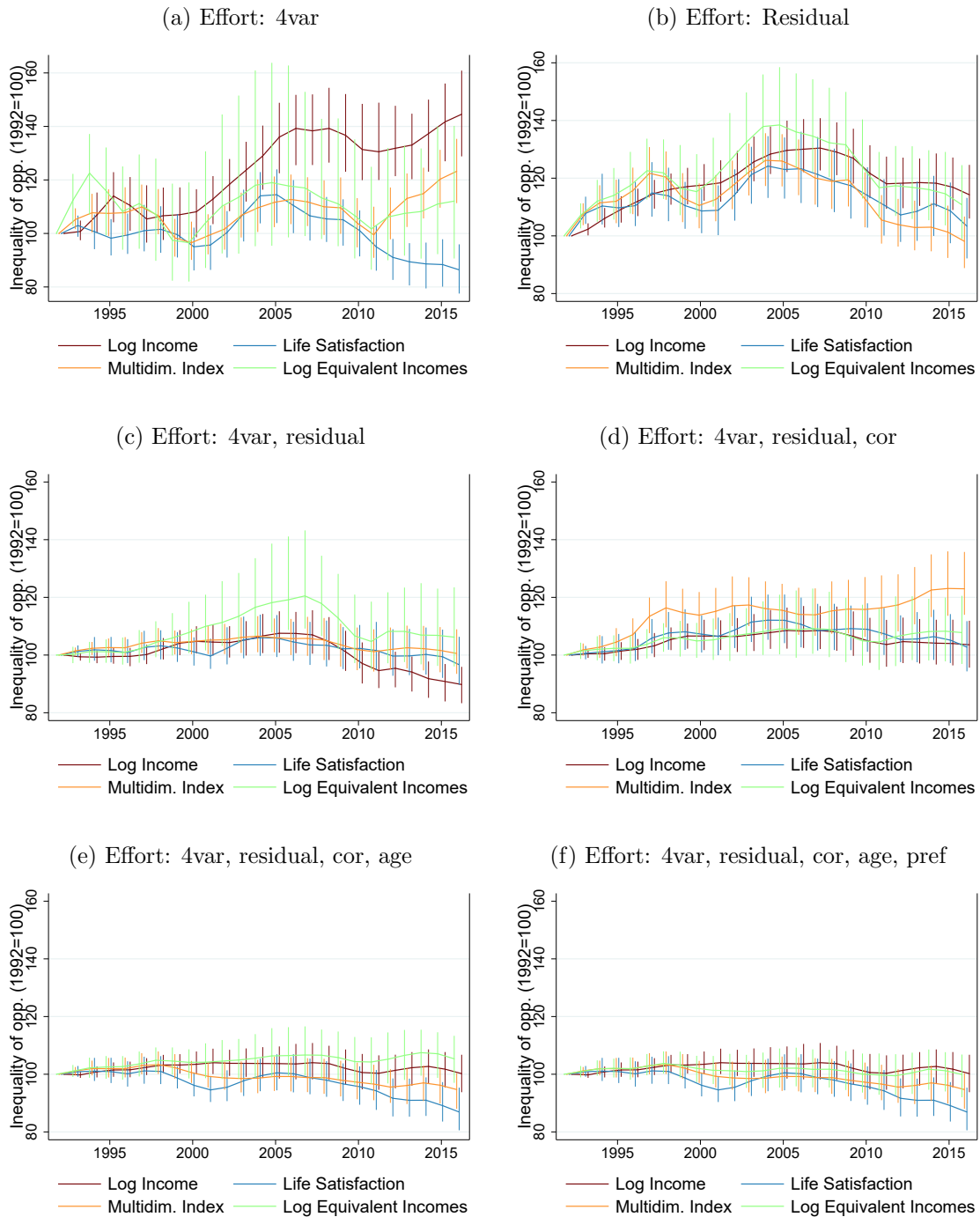

Notes: The figure shows the average opportunity rank for people sharing a particular circumstance using a wide effort set. We no longer report differences in the average opportunity rank by age groups, as age is not considered a circumstance in this specification. Bars indicate bootstrapped 95th percentile confidence bands.

established follows different trends. Other studies that have switched the residual to the other side of the responsibility cut likewise found this to have a great impact on the results (see for example Almås *et al.* (2011) and Devooght (2008)).

If we also hold individuals responsible for the correlation between effort and circumstances (panel (d)), then we still see an increase in inequality of opportunity in all measures from 1992-2005, but from then on the multidimensional index diverges from the rest. In the other cases where we add more to the responsibility cut (panel (e) and (f)), the overall trend changes, but stays broadly similar across the four well-being measures. In these cases, inequality of opportunity has remained rather flat or decreased a little from 1992 to 2016.

In sum, we find that when characterizing the opportunity-deprived, neither the

Figure 7: Altering the Responsibility Cut

(a) Effort: 4var

(b) Effort: Residual

(c) Effort: 4var, residual

(d) Effort: 4var, residual, cor

(e) Effort: 4var, residual, cor, age

(f) Effort: 4var, residual, cor, age, pref

Notes: Development in inequality of opportunity in each well-being variable from 1992-2016 for different responsibility cuts. *4var:* The four variables work hours, education, self-employed, and works in public sector are considered effort. *Residual:* The residuals from the regressions of the well-being variables on circumstance and effort variables are considered effort. *Age:* Age is considered effort (implying we are equalizing lifetime opportunities). *Cor:* The correlation between effort and circumstance variables is not considered a circumstance. *Pref:* Individuals are fully held responsible for their preferences (only applies to the equivalent income measure). Our baseline specification used *4var* and *residual* as effort.

measure of welfare nor the precise location of the responsibility cut is of great importance. When analyzing developments in equality of opportunity over time, where we place the residual matters quite a bit, while enlarging the effort set further has few implications. Although the trend may change depending on what we hold individuals responsible for, for a given responsibility cut, the well-being measures follow broadly the same trend.

4.4   Robustness Checks

In this section, we test whether our findings are sensitive to using other divergence measures and fair allocation rules. Our primary interest is not whether the trends change as we change the method, but rather whether the four well-being measures follow similar trends regardless of what method we use. First, we try to use the Generalized Proportional allocation rule rather than the Egalitarian Equivalent allocation rule. Since the results now will depend on which norm vector we use, we show the results using the mode/mean circumstance (for categorical and continuous variables, respectively), as well as the worst and best circumstances, as defined by their bivariate relationship with welfare. Results are shown in Figure A.2 in Appendix A.4. Although large confidence bands prevent us from nailing down the trends with precision, particularly, when the worst circumstances are used as the norm vector, in the other two cases, point estimates suggest that the measures follow broadly the same trend.

Next we try to use the Magdalou-Nock divergence measures with $s = 0$ and $s = 2$ rather than $s = 1$. Results are shown in Figure A.3 in Appendix A.4. Again, we face wide confidence intervals. When $s = 0$, point estimates suggest that inequality of opportunity has decreased over the past 15 years with all measures. Things look a bit different with $s = 2$, where no trend is visible over the last 10 years with life satisfaction and the multidimensional index while inequality of opportunity for income decreased. Since $s = 2$ gives less weight to the bottom of the distribution, this suggest that the improvements in equality of opportunity found in our baseline scenario mostly arose since the most opportunity deprived were given greater chances. At the top of the distribution, the relationship between opportunities and outcomes remains equally strong.

We also try using different divergence measures; the Fairness Gini and the correlation between opportunity ranks and welfare ranks. The latter comes with a number of distinct advantages: 1) The measure is constrained to be between 0 and 1 so there is little need to index the numbers to 1992 = 100, 2) the confidence bands are narrower, 3) it minimizes our reliance on cardinality which is problematic in

the case of life satisfaction, 4) it assures that we are comparing well-being measures that follow the same distributions, 5) it is more intuitive to understand, 6) it allows for zero and negative well-being levels to easily be included in the analysis, 7) it generalizes a frequently used measure of intergenerational mobility, and as such the results can be compared with certain intergenerational mobility studies. Results are displayed in Figure A.4 in Appendix A.4. Both with the Fairness Gini and Spearman correlation, result suggest that inequality of opportunity has improved for all four measures over the past 10-15 years.

5   Conclusion

We have investigated if equality of opportunity estimates depend on what, precisely, we seek to equalize opportunities for. Based on philosophical literature on well-being, we constructed four measures of welfare that are candidates for what we ought to equalize opportunities for. Upon constructing these, we analyzed if the way welfare is measured matters for 1) characterizing the opportunity-deprived and 2) tracking inequality of opportunity over time. We found that, for the most part, neither depend greatly on what measure of well-being we use. These results are robust to most alternative measurement assumptions and changes to the responsibility cut. This is encouraging news for researchers and policymakers interested in going beyond GDP. Whereas previous research has shown that going beyond GDP matters greatly for defining the welfare-deprived and for tracking growth in welfare over time, our findings suggest that going beyond income is less important if the object of interest is to equalize opportunities. Circumstances beyond individual control influence welfare in a similar fashion regardless of how welfare is measured. Hence, for matters of distributive justice, alternative measures of GDP seem to have less importance, and a good picture may be achieved by simply using incomes as a proxy variable for welfare.

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A   Appendix

A.1 Equivalent Income Regression Output

Table A.1: Equivalent Income Regression

	Dep var: Life Satisfaction	
	Coef.	Std. err.
Log income	0.161***	(0.058)
Log income * Place of birth: East Germany	0.190***	(0.036)
Log income * Female	-0.008	(0.032)
Log income * Age	0.001	(0.001)
Log income * Weekly work hours	-0.000	(0.001)
Log income * Self-employed	0.023	(0.037)
Log income * Works in public sector	-0.047*	(0.025)
Employed	1.192***	(0.091)
Employed * Place of birth: East Germany	-0.030	(0.049)
Employed * Female	-0.183***	(0.049)
Employed * Age	-0.010***	(0.002)
Health	0.090***	(0.035)
Health * Place of birth: East Germany	-0.020	(0.017)
Health * Female	-0.007	(0.016)
Health * Age	0.002***	(0.001)
Health * Weekly work hours	0.000	(0.000)
Health * Self-employed	-0.052*	(0.027)
Health * Works in public sector	-0.002	(0.016)
Leisure	-0.026	(0.018)
Leisure * Place of birth: East Germany	-0.014	(0.009)
Leisure * Female	0.006	(0.009)
Leisure * Age	0.001**	(0.000)
Leisure * Weekly work hours	0.000*	(0.000)
Leisure * Self-employed	-0.006	(0.014)
Leisure * Works in public sector	-0.009	(0.008)
Weekly work hours	-0.000	(0.008)
Self-employed	0.141	(0.426)
Works in public sector	0.530*	(0.276)
Observations	170142	
r^2	0.040	

Notes: * p<0.10, ** p<0.05, *** p<0.01. OLS regression with fixed effects and individual-level clustered standard errors. Includes year dummies. The interactions between employment and work hours, private sector work and public sector work are excluded for reasons of multicollinearity. In about 6% of the cases, the coefficient on leisure (when taking the interactions with leisure into account) is negative. In these cases the contribution from leisure is constrained to equal 0.

A.2 Decomposition of Equivalent Incomes

The equivalent incomes are calculated from the following equation:

$$ln(inc_{it}^{eq}) = ln(inc_{it}) + \frac{\beta^{dim} + \gamma^{dim}w_{it}}{\beta^{inc} + \gamma^{inc}w_{it}}(dim_{it} - \tilde{dim}) \tag{17}$$

We want to decompose this into a part that reflects the welfare individuals derive from their specific preferences, and a part that reflects the welfare individuals receive independent of their particular preferences. To do so, we define a set of norm preferences by fixing the preference heterogeneity variables at a given level, $\tilde{w}$, and computing individuals' equivalent incomes with these norm preferences:

$$ln(\tilde{inc}_{it}^{eq}) = ln(inc_{it}) + \frac{\beta^{dim} + \gamma^{dim}\tilde{w}}{\beta^{inc} + \gamma^{inc}\tilde{w}}(dim_{it} - \tilde{dim}) \tag{18}$$
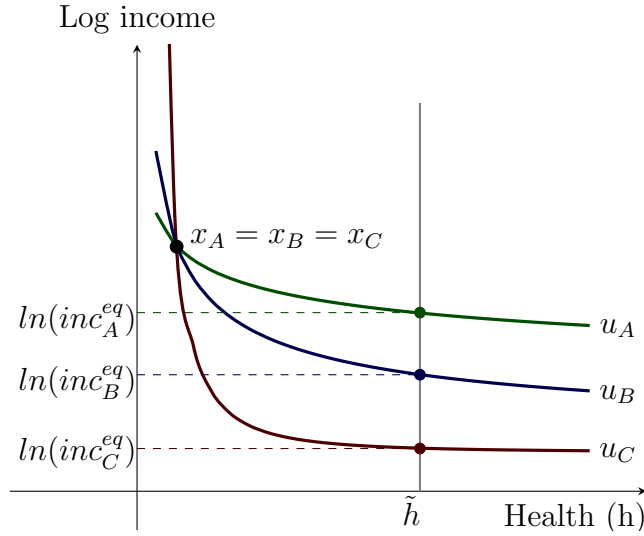
We choose the mean (mode for categorical variables) of the preference heterogeneity variables as the norm preferences. $ln(\tilde{inc}_{it}^{eq})$ does not depend on an individual's preferences, and has thus taken the preference heterogeneity out of the original equivalent incomes. We can now express an individual's equivalent income as,

$$ln(inc_{it}^{eq}) = ln(\tilde{inc}_{it}^{eq}) + \phi_{it}, \tag{19}$$

where ϕ_{it} is the contribution to equivalent incomes individuals receive from the match between their particular bundle and their preferences. An example is given in Figure A.1. We consider three individuals, A, B, and C, and two dimensions of well-being, income and health. A, B, and C consume the same bundle, which contains a lot of income but only little health. They have different preferences, with A putting the largest preference on income relative to health compared to B and C. It seems fitting that A should derive the most welfare from this income-heavy bundle, which also is the case when we calculate the three individuals' equivalent incomes.

Suppose that A, B, and C have different preferences because of variation in a circumstance variable, for example their parents' level of education. If we use equivalent incomes as the welfare variable that is regressed on effort and circumstance variables, which include parental education, then the coefficient on parents' education will eat up the differences in equivalent incomes. As a result, A, B, and C's fair outcomes – which are based on their equivalent incomes after removing the contributions from circumstances – will be equal. The divergence between the fair outcomes and the actual outcomes will be large, which means we consider the three

Figure A.1: Equivalent Income Illustration

individuals to have large unjust differences in well-being. In other words, differences due to preference heterogeneity from circumstances are not considered fair, and individuals are not held fully responsible for their preferences.

Our decomposition can circumvent this problem. In this example, we choose individual B's preferences as the norm preferences. Our decomposition asks what level of equivalent incomes each individual would have had with B's preferences. In this case, all three individuals would have $ln(\tilde{inc}_i^{eq}) = ln(inc_B^{eq})$ for $i = A, B, C$. This means that $\phi_A = inc_A^{eq} - inc_B^{eq} > 0$ and $\phi_C = inc_C^{eq} - inc_B^{eq} < 0$, implying that A gets a positive boost from the match between his bundle of goods and his preferences, while the reverse applies to C.

We want to adapt the regressions such that individuals are held accountable for their ϕ-terms. To this end, we can regress $ln(\tilde{inc}_{it}^{eq})$, instead of $ln(inc_{it}^{eq})$, on circumstance and effort variables. Since the ϕ-terms are not part of these regressions, the circumstance variables can no longer pick up well-being differences due to preference heterogeneity. When calculating individuals' fair outcomes based on this regression, we add back the ϕ-terms, such that individuals are fully held responsible for their preferences. We still use the baseline equivalent incomes, $ln(inc_{it}^{eq})$, for the divergence measures, but the fair outcomes will be based on a regression where the ϕ-terms are fully accounted for.
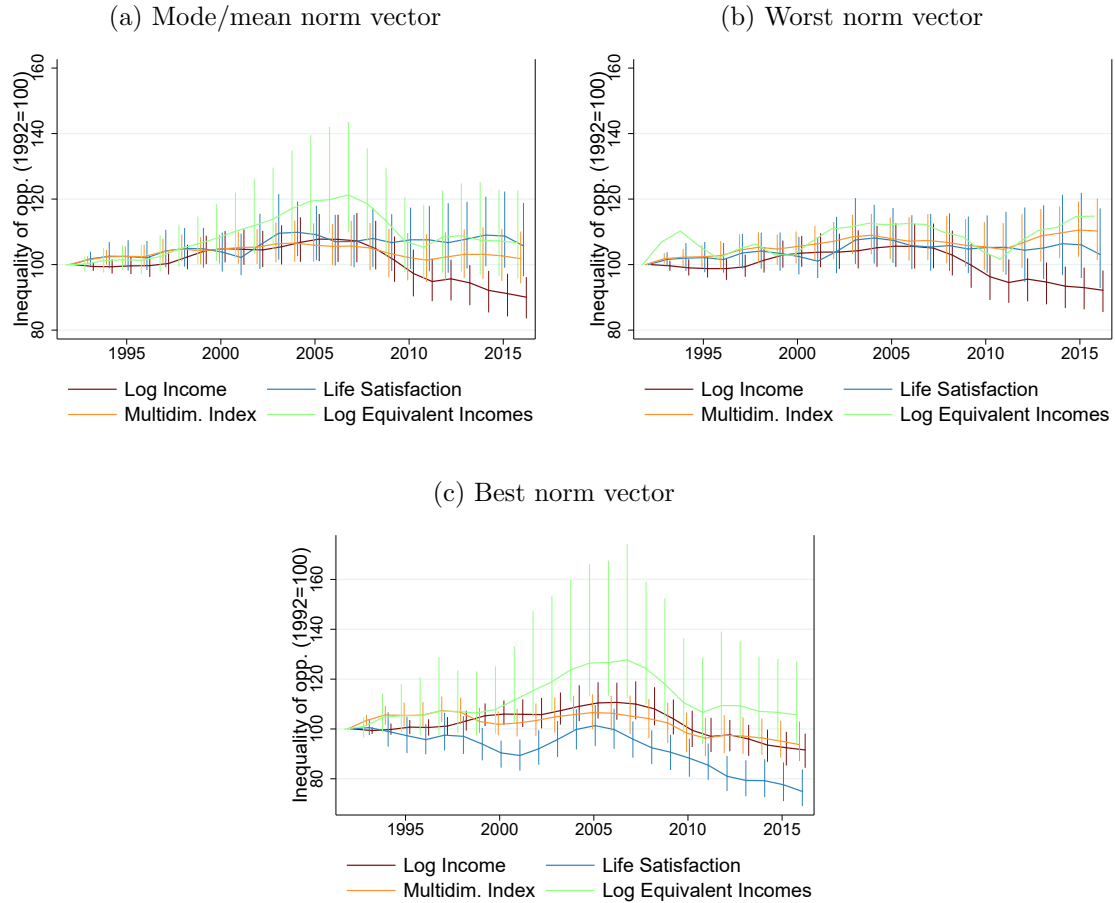
A.3 Regression Output

Table A.2: Regressing Welfare on Circumstances and Effort

	Log Income		Life Satisfaction		Multidim. Index		Log Eq. Income	
	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.	Coef.	Std. err.
Circumstance Variables								
Father's education (ref: lower sec. or less)								
Upper secondary	0.079***	(0.008)	0.110***	(0.028)	0.037***	(0.005)	0.131***	(0.015)
Tertiary	0.141***	(0.011)	0.181***	(0.036)	0.042***	(0.007)	0.229***	(0.021)
Mother's education (ref: lower sec. or less)								
Upper secondary	0.054***	(0.007)	0.094***	(0.027)	0.026***	(0.005)	0.080***	(0.015)
Tertiary	0.070***	(0.013)	0.138***	(0.043)	0.054***	(0.008)	0.134***	(0.024)
Father's occupation (ref: blue collar, untrained)								
Blue-collar, trained	0.065***	(0.008)	0.074**	(0.034)	0.021***	(0.006)	0.124***	(0.020)
Not employed	0.030***	(0.011)	0.029	(0.046)	-0.001	(0.009)	-0.022	(0.028)
White-collar	0.151***	(0.009)	0.169***	(0.036)	0.054***	(0.007)	0.268***	(0.021)
Self-employed	0.136***	(0.011)	0.160***	(0.041)	0.034***	(0.008)	0.248***	(0.024)
Civil servant	0.149***	(0.013)	0.193***	(0.047)	0.046***	(0.008)	0.269***	(0.027)
Place of upbringing (ref: large city)								
Medium city	-0.000	(0.009)	0.024	(0.031)	0.017***	(0.006)	0.060***	(0.018)
Small city	-0.004	(0.008)	0.068**	(0.028)	0.014***	(0.005)	0.077***	(0.017)
Countryside	0.002	(0.007)	0.024	(0.027)	-0.001	(0.005)	0.107***	(0.016)
Place of birth (ref: West Germany)								
East Germany	-0.247***	(0.006)	-0.565***	(0.024)	-0.146***	(0.004)	-0.266***	(0.011)
Abroad	-0.211***	(0.010)	0.001	(0.037)	-0.085***	(0.007)	-0.273***	(0.025)
Height	0.005***	(0.000)	0.011***	(0.001)	0.002***	(0.000)	0.009***	(0.001)
Female	0.037***	(0.007)	0.157***	(0.027)	0.008	(0.005)	0.066***	(0.016)
Number of siblings	-0.032***	(0.002)	-0.021***	(0.007)	-0.011***	(0.001)	-0.048***	(0.004)
Age	0.025***	(0.001)	-0.040***	(0.004)	-0.011***	(0.001)	0.046***	(0.003)
Age squared	-0.000***	(0.000)	0.000***	(0.000)	0.000***	(0.000)	-0.000***	(0.000)
Effort variables								
Years of education	0.047***	(0.001)	0.046***	(0.004)	0.007***	(0.001)	0.057***	(0.002)
Weekly work hours	0.008***	(0.000)	0.013***	(0.001)	0.010***	(0.000)	0.035***	(0.000)
Self-employed	0.113***	(0.011)	-0.013	(0.031)	-0.003	(0.006)	0.114***	(0.017)
Works in public sector	0.012**	(0.005)	0.148***	(0.019)	0.043***	(0.003)	0.042***	(0.012)
r^2	0.323		0.061		0.242		0.310	

Notes: * $p< 0.10$, ** $p< 0.05$, *** $p< 0.01$. Pooled OLS regression with individual level clustered standard errors. n = 170,142.
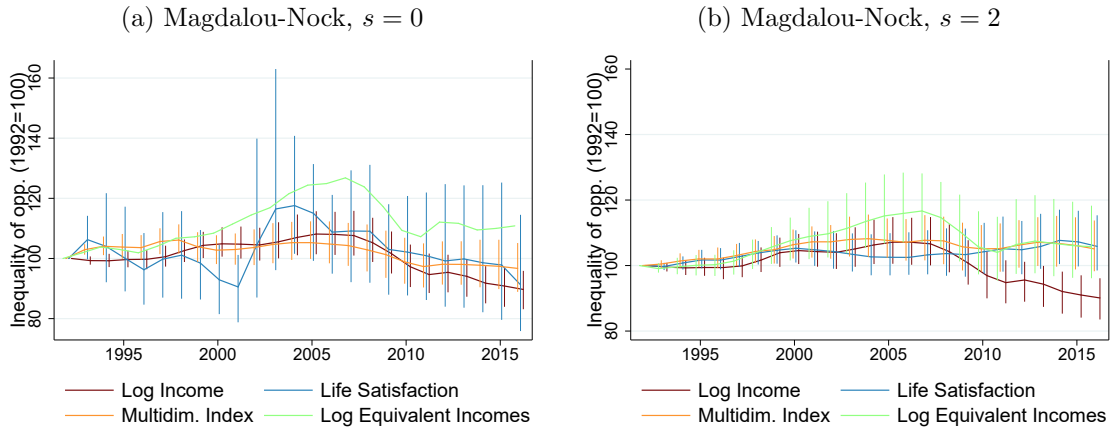
A.4   Robustness Checks

Figure A.2: Changing the Allocation Rule: Generalized Proportionality Principle

(a) Mode/mean norm vector

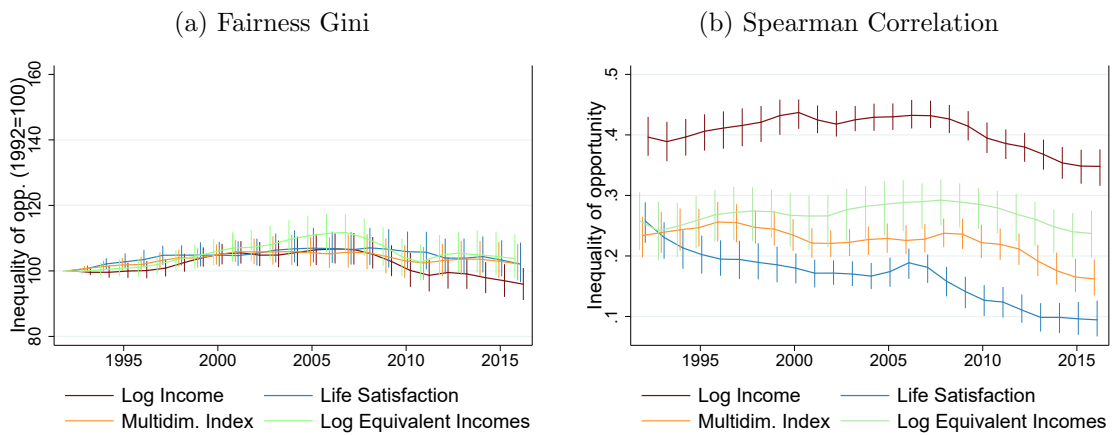(b) Worst norm vector

(c) Best norm vector

Notes: Development in inequality of opportunity in each well-being variable from 1992-2016 using the Generalized Proportionality principle instead of the Egalitarian Equivalence principle. In all cases we use the Magdalou-Nock Divergence measure with $s = 1$. In panel (b) the confidence interval of the equivalent income measure is so wide that it is excluded.

Figure A.3: Changing the Parameter of the Magdalou-Nock Divergence Measure

(a) Magdalou-Nock, $s = 0$ (b) Magdalou-Nock, $s = 2$

Notes: Development in inequality of opportunity in each well-being variable from 1992-2016 using different specifications of the Magdalou-Nock class, combined with the Egalitarian Equivalent principle.

Figure A.4: Changing the Divergence Measure

(a) Fairness Gini   (b) Spearman Correlation

Notes: Development in inequality of opportunity in each well-being variable from 1992-2016 using different divergence measures.

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