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Empirical explorations of the limitations of the Equality of Opportunity framework

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Abstract

This thesis reflects on how to assess unfair inequality in health. Its main arguments are that the Equality of Opportunity framework may be more adequate for this task compared to the framework of socioeconomic health inequalities, but that there are several limitations regarding how the Equality of Opportunity framework has been implemented. The thesis features a systematic literature review and five empirical applications, including three questionnaire-experimental studies. The literature review in Chapter 2 explores how the framework of Equality of Opportunity has been used to assess health inequalities. The third chapter looks at socioeconomic health inequalities in Chile and it shows for the first time that socioeconomic differences in life expectancy have increased in the last two decades. Four limitations of the theory of Equality of Opportunity are explored. Chapter 4 argues that the 'control approach' has failed to provide an operational definition of effort. In this respect, it was found that the requirements needed to provide a definition of effort according to such an approach are not satisfied empirically. Chapter 5 shows that there are several challenges to compensate for the indirect effect of circumstances. It was found that an alternative compensation criteria has moderate acceptance among Chilean members of the public. Chapter 6 uses the theory of Equivalent Income to provide a basis to reduce inequalities among individuals who face the same constraints. This idea finds some support among a representative sample of Chilean adults. Chapter 7 suggests that the 'preference approach' may be a better strategy to operationalise effort and circumstances. In this chapter, an empirical study assesses Equality of Opportunity according to this approach. The thesis concludes with the proposition that the 'preference approach' and the theory of equivalent income may offer a better alternative to assess unfair inequalities.

A mis Lucías.

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Statement of Authorship

I am the sole author of Chapters 1, 2, 5, 7 and 8. Chapters 3, 4, and 6, are papers written with co-authors:

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Chapter 1: Introduction

> —*Si acaso doblares la vara de la justicia, no sea con el peso de la dádiva, sino con el de la misericordia.*
>
> – Miguel de Cervantes, *Don Quijote de la Mancha*

This thesis aims to reflect on how unfair inequality in health can be measured. It focuses on two different frameworks to assess unfair inequalities, the framework of socioeconomic health inequalities and the framework of Equality of Opportunity (EO). The thesis provides new evidence of socioeconomic inequality in health in Chile and it addresses several limitations of the EO framework.

The most common approach to assessing unfair health inequalities has been to analyse inequalities by socioeconomic groups. There is a large literature on inequality in income, which differs with the literature on inequality in health in many ways. The study of socioeconomic inequalities, which first studies date from 1960s [1], has always been concerned with the measurement of unjust health differences. As it has been suggested by Gakidou et al. (1999, 2000), the traditional approach to health inequalities focuses on health differences between groups and it does not addresses 'total' health inequalities at the individual level. In contrast, the study of income inequality has been mainly concerned with the unequal distribution of income between 'individuals', and the shift from focusing on income

[1] Cash-Gibson et al. (2018) provide a bibliometric analysis of studies on socioeconomic health inequalities from 1966 to 2015. The study shows that the publications before 1970 were scarce and that it was not until the beginning of 1970's that the frequency of publications is equal or higher than one per year. I know of one study on health inequalities published before 1966 (Behm, 1962).

inequality as such to the measurement of Inequality of Opportunity (IO) has been relatively recent (the first publications in this field appeared in the early 1990s (Fleurbaey, 1994; Roemer, 1993; Van de gaer, 1993)).

In a very influential paper, Whitehead (1992) introduced the distinction between (health) inequality and inequity. While inequalities include both fair and unfair health differences, inequities correspond to health differences that are, systematic, socially produced and unfair. According to this definition, health inequalities that are distributed randomly and factors that cannot be modified (such as the biological effect of sex and age on health) should not be considered unjust. Among the modifiable differences in health, the line between what is considered fair and not revolves around whether choices could be considered to be under the individuals' control. In this regard, Whitehead argues that choices that are unfairly constrained, such as choices over health-related lifestyles that are influenced by income or social customs, should be distinguished from choices that account for legitimate health differences, such as choices over risky sport. However, this distinction seems arbitrary and is not clear under what conditions choices constitute a legitimate or illegitimate source of inequality.

The theory of EO comprises several approaches that have been developed mainly in the area of economics, and have their roots in a set of philosophical ideas that have been referred to as luck-egalitarianism or responsibility-sensitive egalitarianism (Knight, 2009). Responsibility-sensitive egalitarianism brought to the egalitarian tradition a more conservative idea about holding individuals responsible for their actions. It claims that we should distinguish between factors that are beyond or within the individuals' responsibility and that inequalities due to the former kind of factors are illegitimate. The theory of EO has translated these ideas to the analysis of inequality in income and other outcomes. According to EO, a given distribution of outcomes can be characterised as a function of two sets of factors, those which the individuals should and should not be held accountable for, referred to as effort and circumstances, respectively.

Among other aspects, the approaches to EO differ regarding where to locate the 're-

sponsibility cut' (Schokkaert and Devooght, 2003) or the partition between effort and circumstances. There are two main traditions. The preference approach, which could be tracked back to the works of Rawls (1971) and Dworkin (1981a,b), holds that individuals should be responsible for their preferences since preferences define our identity and it would be disrespectful to interfere in it. The so-called control approach emerged as a critique of the preference approach and it has been developed most notably by Cohen (1989), Arneson (1989) and Roemer (1996). According to the control approach, individuals should be held accountable in proportion to how responsible they are for their choices. In this sense, individuals should not be held accountable for factors that are beyond their control.

The theoretical literature have translated these philosophical ideas into a set of principles that embody the idea of EO, namely the principles of compensation and reward. Compensation principles are about how to reduce inequalities between individuals with different circumstances, whereas reward principles are about how to deal with inequalities due to effort among individuals with the same circumstances. There are different versions of these principles and there are many incompatibilities between them (Ramos and Van de gaer, 2016; Bosmans and Öztürk, 2021). The most prominent frameworks of EO, those developed by Roemer (1993, 1996, 1998) and Fleurbaey (1994, 1995a,b, 2008), are motivated by the control and preferences approaches, respectively.

In my view, there are three main characteristics that make EO more attractive compared to the normative perspective adopted by the research on socioeconomic health inequalities. First, EO offers more sound normative arguments regarding what constitutes illegitimate inequality. It could be argued that Whitehead's normative position is very similar to relational egalitarianism. Relational egalitarianism is rooted in a contractualist perspective, where moral claims should follow a second-person interpersonal justification (Anderson, 2014). In this regard, an inequality that cannot be attributed to the actions of others (such as random factors) or that cannot be modified by the actions of others (such as innate talent or genetic make up) should not be considered unfair. By contrast, luck-egalitarianism can be understood as a consequentialist and communitarian perspective, according to which justice is an ideal situation in which moral desirability does not

depend on whether or not this state of affairs is feasible and where duties derive from our responsibility for the fate of every other member of the community. Second, it seems that EO is better equipped to specify under which conditions individuals' choices can be considered to be legitimate sources of inequality. Third, the methods used by the theory of EO are better equipped to formalise the concepts of fair and unfair inequalities. Compared to the literature on socioeconomic health inequalities, the literature on EO has developed a strong theoretical basis, in the form of principles of compensation and reward, that guide the empirical analysis [2].

To understand how the framework of EO could be used to analyse unfair inequalities in health, the third chapter reports on a systematic literature review of empirical studies aimed to assess IO in health outcomes in adults. Compared to other literature reviews (Fleurbaey and Schokkaert, 2011; Jusot and Tubeuf, 2019), this work covers in greater detail the normative justifications used to define the partition between circumstances and effort and how the econometric models have been specified. More importantly, this review critically examines the estimators that have been used to assess IO and proposes a novel categorization of these estimators.

The third chapter analysed inequalities in life expectancy in Chile according to the framework of socioeconomic inequalities. This chapter uses information from censuses and data from death certificates to compare the life expectancy and lifespan variation of individuals according to their rank in the distribution of years of education within their own birth cohort. The study focuses on three periods of time (1991, 2002 and 2017) and two educational groups (first quintile, tenth decile). The changes in life expectancy over time in each socioeconomic group are decomposed according to the leading causes of death.

The literature review identified several limitations of the EO framework. The canonical model proposed by Roemer fails to provide an explicit account of what effort 'is' in

[2] Although the empirical literature on health inequalities is vast and has grown rapidly since the late 1980's (Cash-Gibson et al., 2018), the literature on social welfare foundations for the measurement of health inequalities is scarce and recent (the first work on this field date from 2006 (Bleichrodt and van Doorslaer, 2006)).

reality. In Roemer's model, effort is conceived as an ordered set of inputs with respect to a given outcome. The model assumes that effort is not observable but that it can be identified based on information about the joint distribution of outcomes and circumstances. However, as Roemer has admitted, this strategy fails once it is acknowledge that the distribution of outcomes can also be shaped by luck (Roemer, 2012). Lefranc and Trannoy (2017) have proposed an alternative strategy that may help to identify effort in the presence of luck. This assumes that the order of inputs can be defined with respect to how costly is for the individuals, in terms of their own utility functions, to engage in each combination of inputs. The fourth chapter aims to understand to what extent the assumptions behind this notion of effort hold among members of the public. With this purpose, a questionnaire-experimental study was conducted in Chile. Adapted to the health context, Lefranc and Trannoy's approach implies that people agree unanimously regarding an ordinal ranking of lifestyles determined by how costly the effort is to engage in each. The survey explores if the preferences of members of the public satisfy this requirement.

Chapter 5 focuses on how to compensate for the indirect effect of circumstances. As it has been acknowledged in the literature, circumstances can have a direct and an indirect effect on outcomes (Bourguignon et al., 2007; Jones, 2019). The direct effect corresponds to the return to effort, conditional on circumstances, whereas the indirect effect corresponds to the influence of circumstances on the distribution of effort. It could be said that the core of the EO theory is about the direct effect, namely that conditional on a given effort, individuals should not face different outcomes due to circumstances. However, different normative positions have been proposed regarding the indirect effect of circumstances. Roemer's framework assumes that the influence of circumstances on the distribution of effort is illegitimate, whereas Fleurbaey's framework assumes the opposite. This chapter explores how the normative principles that embody the idea of EO can be interpreted depending on whether the indirect effect of circumstances is considered legitimate or not. Additionally, the chapter discuss some limitations that arise when trying to compensate for the indirect effect of circumstances and proposes an alternative compensation criteria. A questionnaire-experimental study is conducted to elicit the preferences of members of

the public regarding different compensation strategies.

The remaining chapters explore the preference approach. Chapter 6 focuses on the liberal reward principle, which suggests that a redistributive policy should be neutral with respect to inequalities that arise due to legitimate factors (Fleurbaey, 2008). Applied to the preference approach, this principle would suggest that when individuals with different preferences choose from the same choice set, the inequalities resulting from those choices are legitimate. In this chapter it is argued that since the shape of the choice set is beyond the individuals' responsibility, a reduction of inequalities among individuals with the same circumstances could be justified if the menu of alternatives is more favourable to individuals with certain kinds of preferences. The chapter proposes to measure how favourable a choice set is to each kind of preference using a measure analogous to equivalent income. These concepts are applied to the interplay between lifestyles and health. A questionnaire-experimental design is used to understand the extent to which these normative position finds support among a representative sample of Chilean adults.

Chapter 7 is inspired by an argument proposed by Fleurbaey and Schokkaert (2009). They suggest that there are factors that influence outcomes through different pathways or mechanisms, some of which may be considered legitimate while others may be judged illegitimate sources of inequality. For this reason they point out that empirical researchers should build structural models that distinguish between the different mechanism of actions of the variables included in the analysis. Based on this idea, this chapter argues that for the partition between legitimate and illegitimate factors to be intelligible, empirical researchers should provide an operational definition of effort and circumstances. The chapter discusses why the control approach fails to provide such a definition. In contrast, it is suggested that the preference approach allows to provide an operational definition of effort and circumstances. An empirical application aimed to assess IO according to this approach is provided.

The next chapter covers the systematic review of studies about EO applied to health. Chapter 3 presents a study that analyses trends in socioeconomic inequality in life ex-

pectancy in Chile. The other chapters feature four studies including three questionnaire experiments with general public samples that explore the limitations of the EO framework. Across these chapters, four aspects of the EO theory are challenged. First, it is argued that Roemer's model lacks an operational definition of effort and that the requirements behind the alternative notion of effort proposed by Lefranc and Trannoy (2017) are not satisfied empirically. Second, it is shown that the compensation of the indirect effect of circumstances clashes with basic notions of neutrality and that Roemer's framework fails to identify this due to the restrictive assumptions of that model. In this regard, an alternative approach to compensation is proposed. Third, the thesis makes the case that the liberal reward principle can be challenged in favour of a reduction of inequalities if the choice set faced by individuals of the same type is more favourable to certain kinds of preferences than others. Fourth, the thesis argues that the control approach fails to provide an operational definition of effort and circumstances, and suggests that circumstances and effort can be operationalised according to the preference approach, although there are several challenges to translating these definitions into the empirical analysis.

The thesis claims that the framework of socioeconomic health inequalities has several limitations to define what constitutes unfair inequalities. In this regard I would argue that the framework of EO several challenges of the EO and that has not necessarily provided good answers to these shortcomings of the socioeconomic health inequality framework. The thesis argues that the control approach has failed to provide operational definitions of effort and circumstances and that without such definitions it is not possible to provide an intelligible notion of unfair inequality. In contrast, the preference approach and the theory of equivalent income may offer a better alternative to assess IO. In this regard, the thesis suggests alternative proposals to move the debate forward.

Formatting

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Chapter 2: Inequality of opportunity in health: a review and critique of the literature

Abstract

Equality of Opportunity has become a widely used framework to assess health inequalities. This paper offers a review and critique of the studies that have measured inequality of opportunity in health. A literature review search was conducted using EconLit, Embase, MEDLINE, Web of Science and Google Scholar. The review included only empirical studies aimed to assess inequality of opportunity in health outcomes in adults. The data extraction and analysis focused on: how circumstances and effort have been defined and how inequality of opportunity has been measured. After the screening process, 29 articles were included. The following factors were considered as circumstances among the studies: parental factors, childhood and adolescence circumstances, health endowments, ability, religion, and ethnicity. Studies disagree on the normative interpretation of inequalities due to adult socioeconomic position. Sex and age were considered as 'neutral' variables in several articles, which is not a category that figures in the canonical framework of inequality of opportunity. Most studies define effort in relation to health-related lifestyles. Four normative approaches to defining effort were found. We will refer to them as i) a choice approach, ii) a genuine control approach, iii) an authentic preference approach, and iv) a family's effort approach. The normative interpretation of the unexplained variability was typically missing. Two broad categories of estimators were found. Most studies focus on estimators which aim to measure inequality of opportunity. These estimators can be further classified depending on whether they aim to explicitly reflect the normative principles of compensation and reward. The second category includes estimators that assess

what would be the counterfactual distribution of outcomes if inequality of opportunity would be suppressed. We reflect on the normative justifications to categorize the variables as circumstances or effort, offer some considerations about the role of sex and age on health inequalities, and discuss the implications of labelling variables as normatively 'neutral'. Compared to the assessment of income-inequality of opportunity where effort is usually assumed to be unobservable, many of the reviewed studies include some effort variables. We argue that, even though health-related lifestyles are attractive variables widely available in population surveys, its use as a measure of effort is challenging and perhaps dubious. We examine the normative foundations of some of the inequality of opportunity estimators and argue against a popular strategy among the reviewed studies, which is the use of relative inequality of opportunity estimators (inequality of opportunity as a fraction of total inequality) of categorical health outcomes.

2.1. Introduction

Inspired by luck-egalitarianism, Equality of Opportunity (EO) has become a widely used framework to assess health inequalities. The canonical framework of EO acknowledges that the distribution of outcomes among a society is driven by factors of two kinds: those for which individuals should be held accountable (referred to as effort) and those which are beyond the individuals' responsibility (referred to as circumstances). As stated by Fleurbaey, "equal opportunity ethics wants to eliminate inequalities due to circumstances and not inequalities due to effort" (Fleurbaey, 2012, p. 202). Besides effort and circumstances, it has been suggested that 'luck' should be considered as a third category of factors (Lefranc et al., 2009; Lefranc and Trannoy, 2017). Different normative positions have been proposed regarding whether society should aim to reduce inequalities due to luck.

The aim of our study is to survey the empirical literature to see how the framework of EO has been applied to assess health inequalities. Since our review is focused on normative as well as methodological concepts, we will first provide a brief summary of some key theoretical aspects.

A word should be said regarding the way we summarise these theoretical aspects. We will cover the operationalization of EO as the intersection of three separate topics: i) the partition between circumstances, effort and luck, ii) the normative principles that guide the analysis, and iii) the outcomes over which EO is assessed. Nevertheless, each of the frameworks that have been developed in the literature of EO should be better understood as a single unit, rather than as an *ad-hoc* collection of these three components.

2.1.1. The partition between circumstances, effort and luck

Following the categorization provided by Lefranc et al. (2009), three factors are usually labeled as circumstances: genetic endowments, social background and social connections, and characteristics of the individuals acquired during childhood and adolescence. The

notion of effort is perhaps more elusive. We follow Fleurbaey and Schokkaert (2011), where two main normative positions are distinguished [1]. The first links effort with the notion of controlled-choices (referred to as the 'genuine control' approach in Fleurbaey and Schokkaert (2011)), whereas the second links effort with the individuals' endorsed preferences when facing the same constraints or choice sets (referred to as 'authentic preference' approach in Fleurbaey and Schokkaert (2011)). We cover the notion of luck in less detail, but a brief summary of its normative implications is offered after looking at circumstances and effort.

Vallentyne (2002) referred to genetic endowments and social background as the 'initial opportunities' of individuals. These factors are usually conceived as circumstances since they are not the results of agents' choices. However, it also has been argued that innate ability is a legitimate source of inequality because is part of the individuals' identity and -in contrast to social background- the allocation of genetic endowments in the birth lottery cannot be changed by social policy [2] [3].

Arguably, up to some point in the individuals' life, there are several characteristics (e.g. education and lifestyles) that are chosen by someone else (e.g. legal guardians) on behalf of them. In addition, there are other characteristics that are chosen by the individuals while their decision-making ability is still immature. Arneson (1990) coined the term 'canonical moment' to define a transition period when individuals start becoming accountable for their preferences and choices. In this regard, the inequalities that emerged before the canonical moment are good candidates to be considered to be beyond the indi-

[1] Roemer (2012) and Lefranc and Trannoy (2017) have proposed an alternative definition of effort as a parameter in the subjective utility function of individuals that could represent the psychic cost associated with different activities. We do not cover such definition here.

[2] It could be argued that the distribution of innate ability on a given cohort may be the result of assortative mating of the parents of that cohort. In that sense, to the extent that social policy could have an impact on assortative mating, it could also impact the distribution of innate ability of future generations. However, it is hard to think on how such a public policy could be feasible (or desirable).

[3] The distinction between aspects that can (or cannot) be shaped by social policy or by how the society is organized resembles the definitions of natural and moral inequality provided by Russeau in his famous *Discourse on the Origin of Inequality*. The former account for inequality due to a different distribution of endowments (among which Russeau includes age, health and bodily strength, and we could perhaps add innate ability). By contrast, moral inequalities are created and reproduced by the society. Russeau focus on the latter arguing that society is not responsible for the inequalities that arise from nature. The notion that inequalities do to innate ability should be respected is one of the core arguments of the libertarian theory developed by Nozick (1974).

viduals' responsibility. Moreover, another aspect to examine is to what extent the role of the family in the pursuit of their children's future wellbeing could be a legitimate source of inequality (see for example Swift (2005); Brighouse and Swift (2014)).

Are individuals responsible for the choices they make after the canonical moment? Some scholars have argued that individuals should be held accountable for their decisions to the extent that they have genuine control over their choices (see for example Arneson (1989), Cohen (1989), and Roemer (1998)). Moreover, several factors that shape the individuals' choices are beyond their control. Preferences may be the result of the interaction between the individual and its environment. Think for example of the influence of parents and other experiences during childhood, job experiences, as well as the impact of mass media and shocks, among many other determinants. Choices also depend on the individuals' innate decision-making ability, which allow people to make more or less accurate judgements regarding the consequences of their actions. However, once we start taking into account all the factors that shape our decisions we may end up concluding that these are the result of a deterministic process and that we lack control of our choices (Fleurbaey and Schokkaert, 2009, 2011). As argued by Phillips (2006), in such a case the notion of individuals as autonomous beings is undermined, and is hard to make them responsible for their decisions. These considerations cannot be solved without a coherent theory of free will.

As it has been advanced by Frankfurt (1971), one may define that having free will depends on whether individuals identify themselves with their actions. Hence, there is free will provided that the individuals have the capacity to weigh and approve their preferences and then act according to those preferences [4]. A similar notion can be found in Korsgaard (1996) concept of 'reflective endorsement'. Koorsgard asserts that individuals are moral agents if they are capable of calling their beliefs into question and, after re-

[4]Both Frankfurt and Dworkin recognizes that there are some situations where individuals do not identify themselves with their revealed preferences. In such cases there may be a claim to override individuals' choices and still pursuit their own benefit. One example is the case of individuals who suffer from addictions that they wish they do not have, but who lack enough will capacity to change their behaviour. Also, individuals may not be considered as endorsing their preferences when they lack the capacity to reflect about acts, such in the case of severe mental impairments or dementia.

flection, endorse some actions over another. However, as stated by Robinson (2014), one may consider that if such underlying disposition or capacity is a random factor which is beyond the individuals' control, they should not be responsible for it either [5].

A way out of the free will problem may be to argue that individuals should be held accountable for their endorsed preferences, irrespective of how these were acquired, since these are constitutive of the individuals' conception of the good life and ultimately define their identity. Nevertheless, besides preferences, choices are also a function of the choice set available to each person. Then, a distinction should be made between authentic preferences (the preferences of individuals' with respect to different choice sets or under different constraints) and revealed preferences (the choices made when facing a particular choice set or constraint). Therefore, as it has been asserted by Le Grand (1991) and Fleurbaey (2008), we should hold individuals accountable for their endorsed preferences, but not for the influence of circumstances on the constraints faced by them.

Besides circumstances and effort, Lefranc et al. (2009) and Lefranc and Trannoy (2017) have proposed to include luck as a third component of the EO framework. To better understand the normative implications of luck, we consider useful to distinguish between choices, events and consequences. Consider a two period process in which there is a decision in period one and a probabilistic event with uncertain consequences in period two. The distribution of consequences depends only on the informed choices that individuals make in the first period, which are of two kinds: i) those that influence the probability of occurrence of the event, and ii) those that shape the consequences of the event if it occurs. Assume that there is a group of individuals who have the same characteristics (e.g. innate ability, skills, income, education, etc). In such a case, we may consider that the (ex-ante) inequality in the probability of occurrence of the event can be attributed to the individuals' responsibility since is caused by their (controlled) choices. However, whether the event occurs or not is beyond the individuals' control and can be attributed to luck.

[5] The compatibilist notion of free will in Frankfurt is similar to one of the arguments advanced Fleurbaey (2008) according to which we may retain a non-deterministic notion of preferences if we assume that there is an underlying non-causally determined disposition in every agent that allows them to react differently to the same external *stimuli*.

This gives rise to two conflicting normative positions. On one hand, the consequences of the event depends on the choices of the second kind made in the first period and it could then be considered under the responsibility of the individuals. On the other hand, among individuals who face the same probability of occurrence of the event, consequences-inequalities could be considered unfair, since consequences are attached to luck. Different normative arguments have been suggested, which are either closer to the former or to the latter aforementioned positions (see for example Le Grand (1991); Fleurbaey (2008); Lefranc and Trannoy (2017)).

2.1.2. The normative principles that guide the analysis

We now cover several aspects regarding the normative principles that guide the assessment of EO, assuming that the partition between circumstances and effort has been defined [6]. EO is realized with respect to some achievement when two principles are fulfilled: compensation and reward (Fleurbaey and Schokkaert, 2011). Reward principles offer considerations regarding the achievements of individuals who are of the same type (type being defined as a given combination of circumstances), but who exert different effort. Compensation principles are about reducing inequalities between individuals of different types. Following Fleurbaey and Schokkaert (2011), two variants of these principles have been proposed: the utilitarian and the liberal perspective. According to the utilitarian perspective, compensation is realized when individuals who exert the same level of effort have the same achievements, irrespective of their type [7]. By contrast, according to the liberal perspective, compensation is assessed with respect to a reference type (i.e. a type that is judged to be a normatively relevant standard). Hence, compensation is realized when for each level of effort and for any type, individuals that exert a given level of effort experience the same achievements as individuals who exert that same level of effort, but who belong to a reference type. Utilitarian reward says that there should be no inequality

[6] How to account for the effect of luck has usually been neglected and is not covered here. A proposal about how to incorporate luck to the normative principles of compensation and reward has been proposed by Lefranc and Trannoy (2017).

[7] More generally, utilitarian compensation seeks to achieve that all the individuals at the same level of effort share the same equally distributed equivalent (EDE) (see Fleurbaey and Schokkaert (2011)). EDE is the value of outcome to be achieved equally by all the individuals and that could be considered as good as the current distribution from the point of view of social welfare.

aversion with respect to the distribution of achievements among individuals of the same type (or that the achievements of a type can be assessed by the sum of outcomes). Liberal reward is focused on the transfers between individuals and it aims to achieve neutrality, in the sense that the redistributive policy should be neutral with respect to those factors for which the individuals are responsible. Hence, liberal reward is realized when all the individuals of the same type are subject to the same transfers.

Within each perspective, the compensation and reward principles are usually not compatible, which means that either compensation or reward should be prioritized. Moreover, the utilitarian and the liberal perspective are not compatible either. For instance, if it were possible to fully redistribute the achievements between individuals of different types, compensation in the utilitarian approach may entail that individuals of the same type receive different transfers, which would violate liberal reward. In contrast, the compensation principle in its liberal version satisfies that at least for individuals at the reference level of circumstances, liberal reward holds. The incompatibility between both perspectives can also be found with respect to the reward principles. Think for example what would these perspectives suggest if there were a single type among the society. In such a case, since utilitarian reward assesses the value of opportunity states as the sum of outcomes, it will allow transfers between individuals provided that the sum of outcomes increases. However, this would violate liberal reward, since according to such principle there should be a '*laissez-faire*' policy and no transfers should be made.

The assessment of IO translates these distributive principles into the measurement of inequality. The purpose of IO assessment is to obtain a measure that captures all the inequality accounted for by circumstances excluding inequality due to effort. This can be translated into two conditions (Fleurbaey and Schokkaert, 2009) [8]. The first condition mirrors the reward principles and states that a measure of unfair inequality should not measure legitimate inequality. The second condition mirrors the compensation principles,

[8]The framework advanced by Fleurbaey and Schokkaert is more general and propose to partition the variables into fair and unfair sources of inequality. In this regard IO will be one of many normative positions that could be adopted to guide that partition. In the IO framework fair variables are referred to as effort while unfair variables are referred to as circumstances.

and entails that when a measure of IO is zero, no illegitimate inequalities should be left unmeasured. As it happens with the compensation and reward principles, these two conditions cannot generally be satisfied at the same time (Fleurbaey and Schokkaert, 2009).

2.1.3. The outcomes over which EO is assessed

A key aspect of the EO framework is to define what outcome distribution requires assessment. Two main alternatives can be found in the literature. The work that has been developed by Roemer and other scholars (Roemer, 1996, 1998, 2012; Roemer and Trannoy, 2015) has mainly been focused on the assessment of EO on single outcomes or achievements, such as education, income or health. Alternatively, the framework advanced by Fleurbaey and others (Fleurbaey, 2008; Fleurbaey and Schokkaert, 2009, 2011; Fleurbaey, 2012) have been conceived as a vehicle to assess EO on individuals' well being, understood as a representation of individuals' preferences over different achievements [9].

We are aware of two previous literature reviews about IO in health (Fleurbaey and Schokkaert, 2011; Jusot and Tubeuf, 2019). Our review is more recent than both of them and therefore includes more articles. It is also different in scope compared to the review by Jusot and Tubeuf (2019), mainly because we only include studies that focus on adults and we exclude studies that did not provide a measure of IO (see inclusion and exclusion criteria in Section 2.2.1). Furthermore, compared to both reviews, our work covers in greater detail the normative justifications to define the partition between circumstances and effort and how the econometric models have been specified. This is particularly relevant for the study of IO in health, in contrast to the study of IO of income, since in the former many studies included effort explicitly, whereas in the latter effort is usually assumed to be unobservable. More importantly, this review focuses on the estimators that have been used to assess IO and propose a novel categorization of these estimators.

[9] Kobus et al. (2020) proposed how to measure IO when outcomes are represented by a multidimensional variable. In the discussion section we come back to the implications of using single vs multiple outcomes to assess IO.

2.2. Methods

2.2.1. Search strategy

During February of 2022, a literature review was conducted in EconLit, Embase, MEDLINE and Web of Science. Additionally, a search for grey literature was performed in Google Scholar. The references of each of the selected studies were also used to find additional articles. The key terms used in the search strategy were: luck egalitarianism, responsibility-sensitive egalitarianism, equality of opportunity, inequality of opportunity and variations of these terms. An example of the search strategy in MEDLINE is provided below.

Search strategy in MEDLINE trough OVID:

1. responsibility sensitive.mp.
2. ((equit* adj2 opportunit*) or (inequit* adj2 opportunit*)).mp.
3. egalit* opportunit*.mp.
4. ((equal* adj2 opportunit*) or (unequal adj2 opportunit*) or (inequalit* adj2 opportunit*)).mp.
5. opportunit* adj2 egalitarian*.mp.
6. luck egalit*.mp.
7. health.ti,ab.
8. 1 or 2 or 3 or 4 or 5 or 6
9. 7 and 8
10. limit 9 to (English language and humans)

Exclusion and inclusion criteria

Only studies that used some measure of health status as the outcome of interest were included, which exclude studies focusing on inequalities in access to health care or health

care financing. Only studies about health inequalities in adults were included. We excluded studies that assessed inequalities in children because, as discussed by Kanbur and Wagstaff (2016), inequalities among children could be considered to be beyond their responsibility and therefore all inequalities at that age could be deemed unjust. To be included in the review, studies should have measured IO in health, which excludes studies that test for EO [10], or that analyze the association between circumstances, effort and outcomes without providing a measure of IO. Papers published in peer-review journals, working papers and reports were included. The language was restricted to English.

2.2.2. Screening and selection of articles

The screening and selection process was performed in three steps. In the first step, irrelevant articles were discarded based solely on the title information, if in doubt, studies were retained for the next step. In the second step, titles were reviewed and based on the following sequential criteria. Articles were excluded if they: i) were not about EO, ii) were not not about health, iii) were not empirical analysis, iv) were not about adult population, v) did not assess inequality of health outcomes, vi) were not written in English. In the third step, abstracts were reviewed and discarded based on the same set of criteria. At this stage, if there were doubts about the inclusion of some studies, the full text was assessed. The screening and selection of articles was performed by two authors independently (NS and PS). At each stage disagreements were resolved by discussion between the two review authors.

2.2.3. Data extraction and synthesis

The information that was extracted from each article was: country of analysis, health outcome used, which normative justifications were provided to define the partition between circumstances, effort and unexplained variability, and how inequality of opportunity was measured (estimators that were used and how they were estimated). An ad-hoc matrix

[10] We distinguish between studies that test whether there exists EO in a given population from studies that aim to measure the amount of IO in a given population. The latter was the focus of this review.

of data extraction was designed for this purpose.

A narrative synthesis was performed and a categorization of the estimators used as well as the methods used to obtain those estimators was proposed. The data extraction and synthesis was performed by one author (NS) and validated by another author (RC).

2.3. Results

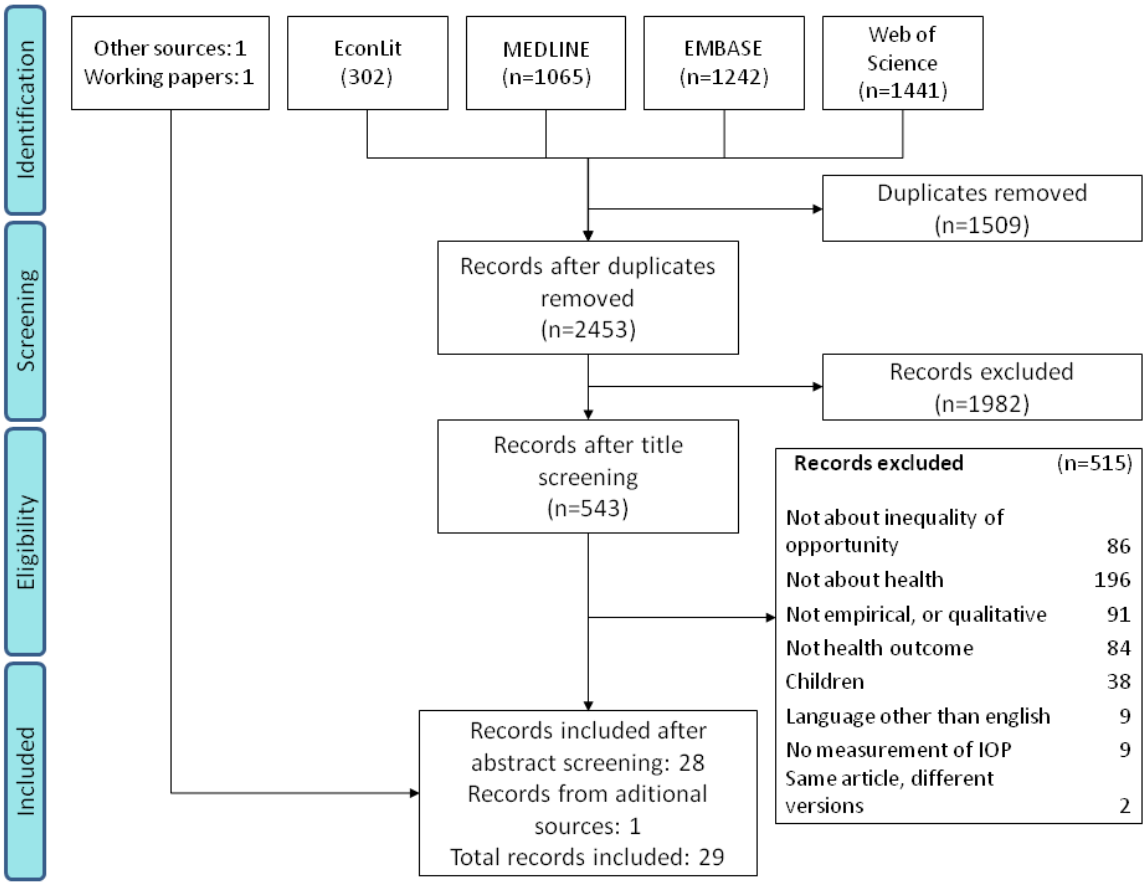
After the screening and selection, 29 articles which correspond to 26 studies were included in the analysis (see Figure 2.1) [11]. These studies analysed health inequalities in the UK (n=6), Colombia (n=2), China (2), France (n=2), Canada (n=2), Chile (n=1), Luxembourg (n=1), Indonesia (n=1), Israel (n=1), The Netherlands (n=1), United States of America (n=3) or compared several countries in Europe (n=4).

2.3.1. Health outcomes

Most studies (n=18) used ordinal measures of self-assessed health (SAH) as outcomes (Rosa Dias, 2009; Jusot et al., 2010; Trannoy et al., 2010; Bricard et al., 2013; Lazar, 2013; Jusot et al., 2013; Donni et al., 2014; Jones et al., 2014; Jusot et al., 2014; Carranza and Hojman, 2015; Chen, 2015; Øvrum and Rickertsen, 2015; Fajardo-Gonzalez, 2016; Pasqualini et al., 2017; Deutsch et al., 2018; Chen et al., 2020; Yan et al., 2020; Brunori et al., 2021), three studies used an index of physical or mental health (Jones et al., 2014; Chen, 2015; Asada et al., 2018; Chen et al., 2020; Yan et al., 2020), four studies used physical measurements (e.g body mass index, blood pressure) (Øvrum and Rickertsen, 2015; Pasqualini et al., 2017; Davillas and Jones, 2020; Ding et al., 2021), two used preference-based measures of health status (Asada et al., 2014, 2015, 2018), two used the prevalence of chronic diseases or long-standing illness (Jones et al., 2014; Pasqualini et al., 2017), four studies used bio-markers (Carrieri and Jones, 2018; Carrieri et al., 2020; Davillas and Jones, 2020; Ding et al., 2021), two studies used mortality (García-Gómez et al., 2013, 2015; Chen et al., 2020), one study used median survival and lifespan

[11] The articles of García-Gómez et al. (2013, 2015) and were counted as one study, as well as the articles by Asada et al. (2014, 2015) and Chen et al. (2020; 2020)). For this reason hereafter the number of studies and the number of citations quoted may not coincide.

Figure 2.1: *PRISMA diagram*



(Balia and Jones, 2011), one used a cardinal SAH measure (Rivera, 2017) and one used lifestyles (Øvrum and Rickertsen, 2015). There were no studies using life-course metrics that integrated both health status and mortality (e.g. quality-adjusted life expectancy or healthy life expectancy). See Table A.3.1 in the Appendix for more details.

2.3.2. Normative definitions and its econometric implementation

Partition of variables

According to the theory of EO, variables should be partitioned into circumstances and efforts (and perhaps, luck). Nevertheless, several studies included an additional category of factors that were used as control variables, which play a neutral normative role in the analysis (i.e. there were considered neither effort nor circumstances).

The following variables were categorized differently by several studies, either as circumstances, effort or 'neutral' variables: demographic variables (age and sex), characteristics linked to adult socioeconomic position (e.g. educational attainment, income quintile, occupation, employment status), geographical region and urbanization of the area of residence, household size and marital status.

Some considerations regarding the categorization of age and sex are worth-mentioning. A few studies categorized age and (or) sex as circumstances (Lazar, 2013; Asada et al., 2018; Carrieri and Jones, 2018; Davillas and Jones, 2020; Carrieri et al., 2020; Ding et al., 2021; Brunori et al., 2021). Most studies included demographic variables among neutral factors (Rosa Dias, 2009; Jusot et al., 2010; Trannoy et al., 2010; Balia and Jones, 2011; Bricard et al., 2013; Jusot et al., 2013; Lazar, 2013; Donni et al., 2014; Jusot et al., 2014; Carranza and Hojman, 2015; Øvrum and Rickertsen, 2015; Fajardo-Gonzalez, 2016; Rivera, 2017; Deutsch et al., 2018; Chen et al., 2020). There were three studies that explored alternative normative positions in which sex and age were considered either as legitimate or as illegitimate sources of health inequalities (Asada et al., 2014, 2015; García-Gómez et al., 2013, 2015; Davillas and Jones, 2020).

On one hand, sex and age could be considered circumstances since are factors which are not chosen by the individuals. On the other hand, there are reasons to argue that these are legitimate sources of inequality, which make them similar to effort. One reason offered by some studies in favour of considering these factors as legitimate, is that there is a biological effect of age and sex on health that cannot be modified by policy (Jusot et al., 2013; García-Gómez et al., 2015). Similarly, Jusot et al. (2013) argue that in cross sectional studies age captures the medical and technological progress available to different birth-cohorts (e.g. the technology available to individuals in their 30's is different from the technology that was available to older individuals when they were in their 30's.), which is a factor that cannot be modified by policy. By contrast, it was also highlighted that demographic factors may shape health outcomes through socially-mediated processes (García-Gómez et al., 2015; Øvrum and Rickertsen, 2015; Davillas and Jones, 2020)[12]. Therefore, even if it is not feasible to change the distribution of age and sex in the population or eliminate its genetic impact, it is possible to change the impact of those variables on socially-mediated processes that have an impact on health [13]. Another reason argued to consider age as a legitimate source of inequality is that aging is a process that universally affects all people (provided that they survive up to a given age) (Jusot et al., 2013; Asada et al., 2018).

The following are the factors (or proxies of these factors) that were defined as circumstances among all the studies (see Table A.3.1 in the Appendix for further details):

- Parental factors: socioeconomic characteristics, place of birth, longevity, health status, health-related behaviours, health-related behaviour of the mother during pregnancy;
- Childhood and adolescence circumstances: social conditions, place of birth, whether the child was breastfed, quality of the primary and secondary school attended, lifestyles during childhood, access to health care during childhood, friendship in

[12]For example, sex-related health inequalities could be the result of gender differences regarding lifestyles or occupations, among many other factors. Similarly, the effect of age on health could reflect the prioritization of health care to the young or less opportunities to engage in health-enhancing activities among the elderly.

[13]Moreover, different normative perspectives may be adopted regarding each specific socially-mediated process.

childhood;

- Health endowments: congenital health endowments, morbidity during childhood;
- Ability: cognitive and non-cognitive ability during childhood, numeracy skills in adulthood; and
- Other: religion, language, ethnicity, born during a period of financial crisis or war and experiencing an accident.

There were six studies that defined 'types' which correspond to mutually exclusive combination of circumstances (Donni et al., 2014; Jones et al., 2014; Chen, 2015; Carrieri and Jones, 2018; Carrieri et al., 2020; Brunori et al., 2021), whereas the rest of studies implemented econometric models were circumstances were used as independent variables. Among the former, only Carrieri et al. (2020) and Brunori et al. (2021) used a data-driven latent class approach to define types, whereas the other studies defined types in an *ad-hoc* manner.

Most studies defined effort in relation to adult socioeconomic position (e.g. education and occupation) and lifestyles choices (e.g. cigarette smoking, alcohol consumption, diet, physical activity and obesity[14]). Following the review of normative positions introduced in Section 2.1, we distinguish four approaches to define effort: the choice approach, the genuine control approach, the authentic preference approach and the family's effort approach. Several studies adopted more than one approach.

The choice approach considered that individuals' choices regarding lifestyles, education, or occupation were a legitimate source of health inequality. This strategy was implemented by 10 studies (Rosa Dias, 2009; Bricard et al., 2013; García-Gómez et al., 2013; Jusot et al., 2013; Asada et al., 2014; Jones et al., 2014; Asada et al., 2015; Chen, 2015; García-Gómez et al., 2015; Øvrum and Rickertsen, 2015; Rivera, 2017; Asada et al., 2018).

[14]Obesity can be considered as an intermediate outcome between lifestyles and health status and mortality. Nevertheless, many studies used it as a proxy for health-related lifestyles.

The genuine control approach distinguishes between effort and 'accountable' or 'cleaned' (from circumstances) effort. Efforts are mostly defined as individuals' choices, whereas accountable effort corresponds to the individuals' choices once the effect of circumstances on those choices have been removed [15] [16]. These studies modeled the impact of circumstances on health as the consequences of two effects: a direct and a mediated effect through individuals' choices. The genuine control approach considered that both effects were illegitimate sources of health inequalities. This approach was implemented by 22 studies (Jusot et al., 2010; Trannoy et al., 2010; Balia and Jones, 2011; Bricard et al., 2013; García-Gómez et al., 2013; Jusot et al., 2013; Lazar, 2013; Donni et al., 2014; Jones et al., 2014; Jusot et al., 2014; Carranza and Hojman, 2015; Chen, 2015; García-Gómez et al., 2015; Fajardo-Gonzalez, 2016; Rivera, 2017; Pasqualini et al., 2017; Deutsch et al., 2018; Carrieri and Jones, 2018; Carrieri et al., 2020; Chen et al., 2020; Davillas and Jones, 2020; Ding et al., 2021; Brunori et al., 2021).

The authentic preference approach was implemented only by García-Gómez et al. (2013, 2015). The study argues that lifestyles' choices are a function of the individuals' preferences and environmental factors such as the budget constraints of individuals. In addition, it is argued that choices are not necessarily legitimate sources of inequality if the individuals' preferences are based on biased information, due to heterogeneity in cognitive abilities about the outcomes that result from adopting different lifestyles.

The family's effort approach was explored only by Jusot et al. (2013). That study focuses on the normative interpretation of the influence of parents on the choices made by their offspring and it compared three approaches: the choice approach, the genuine control approach and the family's effort approach[17]. The latter considered that the influence of parents on their offspring's choices should be fully respected.

[15] The choice and genuine control approaches were labeled by several studies as the 'Barry' and the 'Roemer' approaches respectively, since it would translate the normative positions on this matter by Bryan Barry and John Roemer (see Roemer (1998)).

[16] Recall that the definition of circumstances varies between studies. In this regard, each partition of variables entails a different normative approach.

[17] Referred to as the 'Swift' approach by (Jusot et al., 2013), since it was linked to the normative views by Adam Swift (see Swift (2005)).

Models' specification

Different modeling strategies were implemented depending on the normative position adopted. A more detailed description of the models' specification and estimation strategies is provided in Table A.3.1 in the Appendix .

Choice approach The models' specification used by the studies that adopted this approach consists of modelling circumstances and effort (individuals' choices) in one equation, without accounting for the effect of circumstances on effort.

Genuine control approach approach The studies that adopted this approach assume that circumstances have a direct and an indirect or mediated effect on health outcomes, where the indirect effect results from the influence of circumstances on the distribution of effort. Among the studies that adopted this normative perspective, seven studies used reduced-form equations where health outcomes are a function of circumstances only (Rosa Dias, 2009; Jusot et al., 2010, 2014; Pasqualini et al., 2017; Davillas and Jones, 2020; Ding et al., 2021; Brunori et al., 2021). The specification of reduced-form models aims to to capture both the direct and the indirect effect of circumstances on health outcomes.

The rest of the studies included at least some effort variables and tried to distinguish between the direct and indirect effect of circumstances. To account for the effect of circumstances on effort, three strategies were identified. Carrieri and Jones (2018) and Carrieri et al. (2020) split the sample according to types. For each type, they specify a separate model where outcomes are a function of effort (lifestyles). This strategy allows the decomposition of the direct from the mediated effect of circumstances on health outcomes.

Jones et al. (2014) and Chen (2015) model health outcomes as a function of circumstances and effort, where efforts consist of lifestyles, educational attainment and so-

cioeconomic position [18]. They used a non-parametric approach to assess the influence of circumstances on health by decomposing the cumulative distribution of health outcomes in three components: i) the proportion of individuals of a given type who attain a given educational level, ii) the proportion of individuals of a given type and a given educational level who have a given combination of lifestyle-socioeconomic position and iii) the cumulative distribution of health of individuals of a given type, who have a given lifestyle and a given socioeconomic position.

The third strategy implemented by the remaining studies consisted on specifying a system of equations. In this system of equations the health outcome is a function of individuals' efforts (mostly lifestyles), circumstances and neutral variables, while efforts are a function of circumstances and neutral variables (and in some cases, of other legitimate factors). Among these studies, two used a simultaneous equation approach (Balia and Jones, 2011; García-Gómez et al., 2013, 2015) which allow for correlation between the error terms of the different equations. The rest of studies estimated one equation at a time. First, a regression of individuals' efforts on circumstances and neutral variables was implemented. In a second step, the predicted residuals of the first step were used as a cleaned measure of effort in the equation of health outcomes.

Authentic preference approach The study by García-Gómez et al. (2013, 2015) implemmented and contrasted several normative approaches. The study used a system of equations where mortality was a function of health events (hospitalizations), health-related lifestyles and a set of additional factors (age, gender, home ownership, marital status, being married, having children and home ownership); health events were a function of lifestyles and the set of additional factors; whereas lifestyles were a function of the set of additional factors and a set of variables referred to as 'preferences shifters' (religion, region of residence and urbanization of the area of residence) since these factors were supposed to influence only lifestyles with no effect on health events and mortality.

[18] The two models are is slightly different. See Table A.3.1 in the Appendix for details.

Among the normative positions implemented by this study, there is a distinction between what the authors called a 'preferences' and an 'authentic preference' approach. In the preference approach, it is assumed that lifestyles are a legitimate source of inequality with respect to health events and mortality, whereas all the other factors are considered illegitimate sources of inequality in relation to health events and mortality. In contrast, the authentic preference approach assumes that the influence of education on lifestyles is illegitimate, since it is a proxy for budget constraints beyond and for heterogeneity of cognitive abilities, both of which are unfair drivers of individuals' choices.

Family's effort approach Among the normative positions explored by Jusot et al. (2013) the family's effort approach is based on the notion that the influence of parents' choices on their children should be respected. The study modeled health outcomes as a function of health-related lifestyles and 'cleaned' circumstances. Since the influence of parents' on children's lifestyles is considered legitimate, circumstances should be cleaned from its effect on children's choices. To do this, each circumstance was modeled as a function of children's lifestyles. The predicted residuals from these equations were interpreted as circumstances cleaned from its effect on children's efforts.

Normative interpretation of unexplained variability

As it has been discussed elsewhere (Fleurbaey and Schokkaert, 2009; Ramos and Van de gaer, 2016), the unexplained variability in the econometric models also requires a normative interpretation.

The estimation of unexplained variability is different when modeling continuous or categorical outcomes. This has implications in the way of decomposing total inequality. When modeling continuous outcomes computing the residuals of the model is straightforward, which allows to obtain a measure of unexplained variability. By contrast, when modeling binary outcomes the computation of residuals is challenging. Among those studies that decompose inequality of continuous outcomes, total inequality is the aggregation

of inequality attributed to observed circumstances, unexplained variability, and in some cases, effort (there were studies that did not include effort variables) (Asada et al., 2014, 2015, 2018; Carrieri and Jones, 2018; Carrieri et al., 2020; Davillas and Jones, 2020; Ding et al., 2021).

Those studies that decompose inequality of categorical outcomes used two approaches. Some studies used a linear probability model which allow them to decompose inequality in terms of observed circumstances, observed effort and unexplained variability, as if the outcome was continuous (Bricard et al., 2013; Jusot et al., 2014; Carranza and Hojman, 2015). In contrast, other studies used non-linear models in which case total inequality is the collection of inequality due to observed circumstances and observed effort and it does not include inequality due to unexplained variability (Rosa Dias, 2009; Trannoy et al., 2010; Balia and Jones, 2011; Jusot et al., 2013; Lazar, 2013; Donni et al., 2014; Øvrum and Rickertsen, 2015; Fajardo-Gonzalez, 2016; Deutsch et al., 2018).

Only three studies referred to the normative interpretation of the unexplained variability. Two studies provided estimates that allow to assess how the estimates of IO change if unexplained variability is considered a fair or an unfair source of inequality (Asada et al., 2014, 2015, 2018). One study looks at the correlation between higher moments of the type-specific residuals and both circumstances and effort (Carrieri and Jones, 2018). Since low correlation was found, the authors suggest that this may entail that unexplained variability can be "mostly regarded as random noise" (Carrieri and Jones, 2018, p. 12).

As it was mentioned in the previous section, several studies regress individuals' choices (such as lifestyles or other variables) on circumstances and demographic factors and then use the residuals of those equations as a measure of effort. In all these cases the variables used to capture individuals' choices were categorical. Two strategies were used to retrieve the residuals. Four studies estimated generalized (probit) residuals (Trannoy et al., 2010; Jusot et al., 2013; Lazar, 2013; Donni et al., 2014; Carranza and Hojman, 2015) whereas three studies used linear probability models (Bricard et al., 2013; Rivera, 2017;

Fajardo-Gonzalez, 2016) [19]. Among these studies, only two acknowledged that the residuals of those estimations also contain the effect of luck as well as unobserved circumstances (Trannoy et al., 2010; Fajardo-Gonzalez, 2016).

2.3.3. Estimators

Two categories of estimators were identified across studies. The first are estimators which aim to measure IO. Among these studies, we propose to distinguish two sub-categories: studies that use measures of IO that explicitly ascribe to the reward and compensation principles, and those for which the normative implications remain implicit. The second category are estimators that, instead of assessing IO, provide information about what would be the counterfactual distribution of outcomes if IO is suppressed.

Assessment of IO

Explicit normative strategy We refer to this strategy as 'explicit' since its aim is to compute a measure of IO which embodies specific normative principles. As it has been described elsewhere (Ferreira and Peragine, 2016; Ramos and Van de gaer, 2016), this strategy consists in obtaining a counterfactual distribution of outcomes $\widehat{H}'$ where all the inequality is due to IO. In these studies the econometric model is used to compute $\widehat{H}'$ according to the compensation or the reward principles, in its utilitarian or liberal versions (see Ramos and Van de gaer (2016) for a survey of how to obtain $\widehat{H}'$). Table A.3.1 in the Appendix describes the method used by each study to obtain $\widehat{H}'$. Only two studies (Carrieri and Jones, 2018; Carrieri et al., 2020) did not rely on this strategy. These studies used a model specification that allows to decompose total inequality into inequality due circumstances, effort and unexplained variability and at the same time to embody both kinds of principles.

Once $\widehat{H}'$ is estimated, IO is simply obtained by applying an inequality index I over $\widehat{H}'$. This will be denoted as an absolute measure of IO (θ_a^{IO}):

[19] Fajardo uses years of education and a linear model.

$$\theta_a^{IO} = I(\widehat{H}') \quad . \tag{2.1}$$

An alternative consists of obtaining a measure of relative IO (θ_r^{IO}), which results from dividing θ_a^{IO} over total health inequality [20]. There are two kinds of estimators that can be distinguished depending on whether the denominator is the total 'observed' inequality or the total explained or 'predicted' inequality. The first strategy estimates relative IO as:

$$\theta_{r,o}^{IO} = \frac{I(\widehat{H}')}{I(H)} \quad , \tag{2.2}$$

while the second strategy seeks to estimate IO as:

$$\theta_{r,p}^{IO} = \frac{I(\widehat{H}')}{I(\widehat{H})} \quad , \tag{2.3}$$

where H corresponds to the observed outcomes and $\widehat{H}$ to the predictions of health outcomes obtained by the model. Among studies that estimated relative IO the interpretation of the remaining fraction of inequality that is not due to IO varies between $\theta_{r,o}^{IO}$ and $\theta_{r,p}^{IO}$. In the former, total inequality includes IO (θ_a^{IO}), inequality due to effort and due to unexplained variability (and perhaps neutral variables), whereas $\theta_{r,p}^{IO}$ does not include inequality due to unexplained variability.

There were six studies that only obtained absolute measures of IO (Jusot et al., 2010; García-Gómez et al., 2013; Asada et al., 2014; Jones et al., 2014; Asada et al., 2015; García-Gómez et al., 2015; Asada et al., 2018; Brunori et al., 2021). The measures of inequality used by these studies were the Gini index, the variance and the dissimilarity index.

Amid the studies that obtained relative measures of IO, one study computed a relative measure of IO over explained inequality and did not performed a decomposition

[20] The distinction between absolute and relative measurement of IO is different from the distinction between an absolute and a relative concept of inequality. The latter refers to whether the index of inequality used entails that proportional vs absolute changes in the outcome do not affect inequality.

of inequality (Rosa Dias, 2009). This study measured inequality using the Gini index, the variance, and the dissimilarity index. Among the rest of studies that obtained relative measures of IO, two computed $\theta_{r,o}^{IO}$ and performed a decomposition of total inequality into inequality due to circumstances, effort and unexplained variability (Carrieri and Jones, 2018; Carrieri et al., 2020), whereas two compute $\theta_{r,p}^{IO}$ and decomposed explained (by the model) inequality into inequality due to circumstances and effort (Lazar, 2013; Donni et al., 2014). The former two studies measure inequality using the Gini index and the variance, and used the decomposition method developed by Jones and López Nicolás (2006). The other two studies measure inequality using the Atkinson index and the Mean Logarithmic Deviation (MLD) and use a path-independent multiplicative decomposition method. Two studies computed $\theta_{r,o}^{IO}$ and estimated the contribution of each circumstances to total inequality Chen et al. (2020); Ding et al. (2021) and one study computed $\theta_{r,o}^{IO}$ and estimated the relative contribution of each circumstance to inequality explained by circumstances Davillas and Jones (2020). In all these cases, the inequality measure used was the MLD and inequality was decomposed using the Shapley decomposition method. Besides Chen et al. (2020), all the studies that measure relative IO also provide estimates of absolute IO.

Implicit normative strategy Several studies adopted an approach in line with the tradition of inequality decomposition. These studies decompose total inequality into a fraction due to circumstances and a fraction due to effort (and usually also a fraction due to neutral variables), the former being interpreted as IO. In contrast to the previous approach, in this case the aim is not to reflect the compensation or reward principles and the normative implications of these measures remain implicit. There were 11 studies that adopted this strategy (Bricard et al., 2013; Jusot et al., 2013, 2014; Øvrum and Rickertsen, 2015; Fajardo-Gonzalez, 2016; Pasqualini et al., 2017; Rivera, 2017; Deutsch et al., 2018; Asada et al., 2014, 2015; Carranza and Hojman, 2015; Asada et al., 2018).

In this case the absolute measure of IO is simply that part of inequality explained by circumstances. Compared to the explicit normative strategy, θ_a^{IO} does not embody

specific normative principles. Similar to the previous strategy, there are two alternatives to estimate relative IO: as a fraction of the total observed variability ($\theta^{IO}_{r,o}$) or as a fraction of the variability explained by the model ($\theta^{IO}_{r,p}$). Besides the study by Jusot et al. (2014) where only relative measures of IO are reported, the other studies reported absolute and relative measures.

There were three studies that computed $\theta^{IO}_{r,o}$ and decompose total inequality into inequality due to circumstances, effort and unexplained variability (Asada et al., 2014, 2015; Carranza and Hojman, 2015; Asada et al., 2018), one study that obtained $\theta^{IO}_{r,o}$ and decomposed total inequality into inequality due to each circumstance and unexplained variability (Jusot et al., 2014), five that computed $\theta^{IO}_{r,p}$ and decompose explained inequality into inequality due to circumstances and effort (Bricard et al., 2013; Jusot et al., 2013; Øvrum and Rickertsen, 2015; Fajardo-Gonzalez, 2016; Rivera, 2017; Deutsch et al., 2018) and one that obtained $\theta^{IO}_{r,p}$ and decomposed explained inequality into inequality due to each circumstance (Pasqualini et al., 2017).

Four studies use the variance as a measure of inequality and the Shorrocks' decomposition (Asada et al., 2014, 2015; Carranza and Hojman, 2015; Rivera, 2017; Asada et al., 2018). Fajardo-Gonzalez (2016) decompose the dissimilarity index using the Shapley decomposition method whereas Deutsch et al. (2018) decompose the variance using the Shapley decomposition method. Pasqualini et al. (2017) use the R-squared as a measure of explained inequality and the explanatory power of circumstances over total inequality as a decomposition method. Øvrum and Rickertsen (2015) decompose inequality using the Gini index.

Improvements due to IO reduction

This approach does not aim to obtain a measure of IO, it rather uses counterfactual estimations to assess how the distribution of health outcomes would change if IO is eliminated or reduced. Studies use three estimators that we have labeled as: average absolute improvement (AAI), counterfactual absolute inequality (CAI) and relative inequality re-

duction (RIR). AAI estimates the expected value of a given achievement assuming that circumstances are fixed at a reference level. CAI predicts what would be counterfactual amount of total inequality if the individuals' circumstances were fixed at a reference category. RIR computes the relative reduction in health inequality if circumstances were fixed at a reference category.

Let's denote by $\widehat{H}\{\bar{C}\}$ the counterfactual predictions of the model when the values of all the circumstance variables are fixed at a reference level (usually either the average or the 'best' level); and let N be the total number of individuals i in the sample. The estimators are then defined as follows:

$$\text{AAI} = \frac{1}{N}\sum_{i}\widehat{H}_i\{\bar{C}\} \tag{2.4}$$

$$CAI = I(\widehat{H}\{\bar{C}\}) \tag{2.5}$$

$$RIR = 1 - \frac{CAI}{I(\widehat{H})} \ , \ or \ \ 1 - \frac{CAI}{I(H)} \tag{2.6}$$

There were three studies that estimated AAI (Balia and Jones, 2011; Jones et al., 2014; Chen, 2015). Balia and Jones (2011) used a simultaneous hazard model to assess the influence of parental smoking habits on their offspring's smoking behaviour and its impact on life expectancy. The predictions of the model were then used to assess what would be the counterfactual life expectancy if the individuals had the best level of circumstances (with respect to parents' smoking habits). Jones et al. (2014) assess the different pathways by which childhood circumstances may impact health outcomes in the context of different educational policies in the UK. Circumstances were assumed to have a direct effect on lifestyles and socioeconomic status in adulthood as well as a mediated effect on both outcomes through educational attainment. In addition to circumstances, lifestyles

and socioeconomic status were assumed to influence individuals' health status. Three counterfactual estimations were obtained to assess the impact of suppressing the effect of i) circumstances on educational attainment, ii) the direct effect of circumstances on lifestyles and socioeconomic status, and iii) the direct effect of circumstances on health, respectively. Chen (2015) follows a similar approach to assess IO in the US.

Balia and Jones (2011), Trannoy et al. (2010) and Carranza and Hojman (2015) estimated CAI by predicting what would be the total inequality in the hypothetical scenario where individuals had the best level of circumstances. The latter two studies also estimated RIR by predicting what would be the proportion of inequality that would be reduced if all the individuals in the sample had the reference level of circumstances. While Trannoy et al. (2010) uses in the denominator the inequality of the predicted probability of health outcomes $I(\widehat{H})$, Carranza and Hojman (2015) use total health inequality $I(H)$.

2.4. Discussion

We organise the discussion into three topics: the empirical identification of effort, the use of neutral variables, the interpretation of IO estimators and the outcomes used in the analysis.

2.4.1. Effort

As it was mentioned in Section 2.2.1, the definition and identification of factors that can be conceived as being under the responsibility of individuals is a difficult normative task. In a previous survey, Jusot and Tubeuf (2019) emphasize that in comparison to its application to other outcomes such as income, the literature of IO applied to health has contributed by providing measures that account for the influence of effort, since it easier to define and observe effort in relation to health than in relation to other outcomes. We would like to challenge this statement and argue that, even though is true that health-related lifestyles are usually included in several population surveys, its use as a measure of effort is challenging and perhaps dubious.

The majority of studies included in this review followed the genuine control approach. These studies never bring forth an operational definition of effort. By operational definition we mean a mapping from effort to observed or unobserved characteristics of the individuals. Among studies that follow this approach, two modeling strategies were implemented. In most cases, studies aimed to remove the effect of circumstances from individuals' lifestyles. This was done by first estimating an equation of lifestyles as a function of circumstances, and then using the residuals of those estimations as a cleaned measure of effort. However, most studies did not acknowledge that the residuals of those estimations also contain the effect of luck as well as unobserved circumstances. Moreover, since no operational definition of effort is provided, is not clear what dimension of the individuals would constitute effort once the individuals' choices (lifestyles in this case) were cleaned from all the observed and unobserved factors that are beyond the individuals' control. Other studies used reduced-form specifications where health outcomes are a function of circumstances only. In this case, the effect of circumstances aims to capture both its direct and effort-mediated effects. However, these studies do not provide an operational definition of effort either.

Another definition of effort was the authentic preference approach, according to which individuals' are responsible for their endorsed preferences, but not for the impact of circumstances in the choice sets available to (or constraints imposed on) them. There was only one study that attempted to implement that measure (García-Gómez et al., 2013, 2015). In that study there were several variables considered as legitimate drivers of individuals' lifestyles preferences (age–gender, home ownership, marital status, children, religion, region of residence and urbanization). Education was considered an illegitimate explanatory variable of individuals' lifestyles since it was used as a proxy of i) the (illegitimate) economic constraints and ii) biased beliefs about the consequences of lifestyles.

What is not clear in this study is the hypothesized causal pathways by which the legitimate factors (age, gender, home ownership, marital status, being married, having children, home ownership, religion, region of residence and urbanization of the area of residence)

are supposed to influence the individuals' health-related behaviour. Those variables could be correlated with individuals' lifestyles either because they reflect differences in preferences or because they are among the factors that shape individuals' access to choice sets. Nevertheless, only in the former case should those factors be used as a proxy of authentic preferences. In contrast, if characteristics such individuals' religion or neighbourhood are linked to access to food products, access to urban green space or discrimination in the labour market, those variables could be better understood as proxies of the individuals' illegitimate constraints. Moreover, education, is also (at least to some extent) a result of individuals' preferences, so using this characteristic as an illegitimate driver of lifestyles is questionable.

More broadly, we would argue that obtaining a measure of effort that accounts for the authentic preferences of individuals is a very demanding task for the econometrician. Recall that to implement such definition of effort, the following counterfactual should be computed: what would have been the achievements of individuals of a given type, had they the opportunity to exert their preferences over the choice set that was available to those who are from a different type. The problem that arises is that the revealed preferences of individuals are a function of the only choice set (constraints) that was open to them when they made such choices, which is itself a function of circumstances. Therefore, to identify the 'authentic preferences' of individuals the researcher should find variables that are correlated with the individuals' preferences, but which do not capture the effect of circumstances on the individuals' constraints. Finding such instruments seems a very challenging task.

2.4.2. Neutral variables

We consider that it should be relevant to distinguish between two notions of neutral variables. One alternative is to conceive neutral variables as another category distinct from effort and circumstances. If that is the case, those normative considerations should be made explicit, and its relationship with the principles of compensation and reward should be stated. Moreover, if some variables are conceived as neutral, the estimation

of IO should be independent of their distribution. Otherwise, neutral variables will have an impact on the size of IO, which seems counter intuitive. Another alternative is to use neutral variables to denote factors that could not be categorized as circumstances or effort because the researcher finds the task too challenging. In that situation, it could be a better strategy to explore how the estimation of IO varies when those variables are categorized as either circumstances or effort, as it has been suggested by Fleurbaey and Schokkaert (2011).

As it was described in Section 2.3.2, most studies categorised age and sex as neutral factors. The main reason to categorise it as neutral is that even if they can be considered beyond the individuals' responsibility, it seems problematic to consider these factors as circumstances since its biological or genetic influence cannot be shaped by policy. We consider that there are three things to be distinguished. First, not all the effects of sex and age are biological. Both sex and age can influence the individuals' health trough socially-mediated processes that could be intervened. Second, even if the biological effect of age an sex on the onset of some medical condition may not be subject to intervention, it may be possible to ameliorate the consequences of that medical condition. Third, as it has been acknowledged by Tsuchiya and Williams (2005), from the impossibility to avoid or interfere in the effect of a risk factor (e.g. sex) on health, it does not follow that nothing can be done to ameliorate or compensate such disadvantage. In this regard, as it has been emphasised by Fleurbaey and Schokkaert (2009), even if there are some consequences that cannot be compensated in terms of health, society can compensate the individuals in terms of another dimension relevant for the individual well-being (e.g. income). Moreover, we would argue that in this case one should move from the assessment of IO in health to IO in both health and the dimension which is the object of compensation. Otherwise, focusing on IO in health does not allow to distinguish between societies that establish compensation and those which not.

2.4.3. Interpretation of the estimators

Despite the growing number of studies in the field, there has not been much discussion regarding the normative interpretations of the estimators that have been used. We would argue that many of the estimators that were found in this survey are not relevant to assess EO and its interpretation could even lead to misleading conclusions.

First of all, it should be emphasized that IO is primarily understood as a measure of fairness in the distribution of achievements among a society. In this regard, the size of inequality due to effort is not of normative importance. Moreover, if EO is achieved (or if there was only one type within the society), the magnitude of overall inequality is in fact irrelevant. Consequently, the assessment of IO should prioritise absolute rather than relative measures of IO (such as θ_a^{IO}, AAI and AIR). The reason is that, while the former aims to capture only inequality due to circumstances, relative measures of IO also include in the denominator the fraction of inequality that is due to effort. This implies that relative measures of IO depend on the magnitude of legitimate inequality, which is misleading. Moreover, it seems worrisome that most of the studies surveyed rely on relative measures of IO. Consider the following example. Imagine two societies (A and B) of the same size and which have the same sum of achievements. Both societies have the same absolute level of IO, but society A has a lower total inequality, since inequality due to effort is lower. Nevertheless, according to relative measures of IO, society A has a higher IO compared to society B, which is counter intuitive.

There may be different reasons to privilege a relative measure of IO. One could be that relative IO is attractive because it is expressed as a proportion, which is dimensionless and its interpretation does not require specialist knowledge about how inequality is measured. By contrast, absolute IO may be perceived as more difficult to understand since it is expressed in terms of an absolute value of a given inequality index. However, this reasoning misses the point since relative IO and absolute IO are not two ways of expressing the same construct: they measure different things and the choice between them is not down to the ease of interpretation. Another reason may be that the ranking of IO according to

both absolute and relative IO coincide. For instance, it has been shown that there is a positive relationship between relative IO of income and total income inequality (Brunori et al., 2013). Then, countries with higher total inequality will also have higher absolute IO and higher relative IO. In such a case, a ranking based on absolute and another based on relative IO would coincide. However, this is not necessarily true for outcomes different from income. A third reason may be that, conditional on the same absolute IO, a distribution showing lower rather than higher inequality due to effort, is judged as more desirable from a social welfare perspective. Moreover, that requires making explicit such a normative approach, which probably should be derived from social welfare functions.

Moreover, even if the proportion of total inequality explained by circumstances could be of interest, there are additional limitations to highlight. A widely used estimator in the income-related IO literature is $\theta^{IO}_{r,o}$, which estimates IO as the fraction of total inequality. As it has been shown, since circumstances are never fully-observed, such an estimator constitutes a lower bound of the 'true' relative IO (Ferreira and Gignoux, 2011). The assessment of IO in health has followed the same framework. Some studies used continuous health outcomes, which allow them to compute $\theta^{IO}_{r,o}$ in the same way that it is usually done with income (Asada et al., 2014, 2015, 2018; Carrieri and Jones, 2018; Davillas and Jones, 2020; Carrieri et al., 2020; Ding et al., 2021). In contrast, several studies focused on binary outcomes and used non-linear models, in which case is not feasible to compute the magnitude of the unexplained variability. Rather than computing IO as a fraction of total inequality, these studies obtained $\theta^{IO}_{r,p}$ which corresponds to inequality due to circumstances over 'explained' (by the model) inequality. We would argue that, in contrast to $\theta^{IO}_{r,o}$, $\theta^{IO}_{r,p}$ is not a lower bound of IO neither is a meaningful estimator because it is contingent on the size of the denominator. For instance, the inclusion of new effort variables to a given model may decrease the magnitude of $\theta^{IO}_{r,p}$, even if these variables are not correlated with circumstances.

Several studies have computed relative IO estimators of binary outcomes using the linear probability model (LPM) and the Shorrocks approach to variance decomposition (Bricard et al., 2013; Jusot et al., 2014; Carranza and Hojman, 2015). The attractiveness

of the LPM is that it allows to retrieve a distribution of predicted residuals which makes feasible to compute $\theta_{r,o}^{IO}$. However, we would argue that this method is not adequate. Despite the LPM providing unbiased estimates of the probability of an event conditional on a set of covariates, the residuals are misspecified. Being H_i a binary outcome which takes values 0 and 1, $p_i(H)$ the 'true' probability of experiencing the outcome by each individual and $\hat{p_i}(H)$ the predicted probability obtained by some statistical model, what these studies computed as residuals corresponds to $H - \hat{p_i}(H)$. However, this is not a statistically sound measure of unexplained variability since, if total inequality is measured in terms of $p_i(H)$, the residuals should equal $p_i(H) - \hat{p_i}(H)$. Moreover, this quantity cannot be estimated because $p_i(H)$ is unknown. Therefore, the use of LPM does not solve the problem of how to estimate $\theta_{r,o}^{IO}$ for binary outcomes.

2.4.4. Outcomes

As it has been highlighted by Kobus et al. (2020), the framework of EO has been mainly applied to single outcomes, such as income or health, or it has been jointly applied to multiple outcomes, but treating them as separate identities. Fleurbaey and Schokkaert (2011) have highlighted that focusing on single outcomes do not necessarily provide a good proxy of IO in wellbeing. A given society may have the same levels of IO on single dimensions such as health or income and be more or less equitable in terms of wellbeing depending on the joint distribution of outcomes among individuals. To what extent IO in health can be conceived as a proxy of IO in wellbeing is an important topic that was not discussed among the studies included in this review.

2.5. Conclusion

The framework of EO has been widely used to assess unfair inequalities in health. Despite its many applications, this literature review argues that there are several methodological challenges that have not been properly addressed in the literature: the normative interpretation of the impact of sex and age on health, how to provide an operational definition of effort, the interpretation of relative measures of IO and the assessment of IO on multiple

wellbeing dimensions, among others. Further research on these topics is warranted.

Authorship statement

This paper was written with co-authors. A "CRediT" author statement (Elsevier, 2020) for this paper is as follows:

Rafael Carranza: Validation (validation of data extraction), Writing - Reviewing and Editing. **Mónica Hernández-Alava**: Supervision, Writing - Reviewing and Editing. **Daniel Hojman**: Supervision, Writing - Reviewing and Editing. **Paula Sierralta**: Validation (second reviewer). **Nicolas Silva**: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - Original draft, Project administration. **Aki Tsuchiya**: Supervision, Writing - Reviewing and Editing.

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Chapter 3: Trends in socioeconomic inequalities in life expectancy and lifespan variation in Chile

Abstract

Ample evidence exists of socioeconomic inequalities in life expectancy in Chile, although no studies have analysed trends in inequalities in life expectancy and lifespan variation. This study uses information from censuses and data from death certificates to compare the life expectancy and lifespan variation of individuals according to their rank in the distribution of years of education within their own birth cohort. The study focuses on three periods of time (1991, 2002 and 2017) and two educational groups (first quintile, tenth decile). Changes in life expectancy over time are broken down according to leading causes of death. Consistent with others studies, the results show that less educated groups have a higher lifespan variation and lower life expectancy than their better educated counterparts in society. Moreover, lifespan variation decreased (increased) over time for individuals in the tenth decile (first quintile). Changes in life expectancy show different patterns by sex. Among women the socioeconomic gap has reduced, while it has increased for males. The leading causes of death that explain the increase in life expectancy are cardiovascular, cancer, respiratory and digestive diseases. In the case of males in the first quintile, few gains have been made in life expectancy resulting from cancer and a negative contribution is associated with digestive conditions. The findings of this study underscore the importance of developing methods and finding new sources of information to monitor health inequalities.

3.1. Introduction

Chile has experienced considerable gains in life expectancy in a short period of time relative to the time other high income countries have taken to achieve the same results (Arriaga and Davis, 1969; Organización Panamericana de la Salud., 2017). It is well known that a negative correlation exists in most countries between socioeconomic position and life expectancy (Murtin et al., 2017) [1]. Chile is not exemption in this sense; there is ample evidence of a socioeconomic gradient in life expectancy.

Fuentes-García (2014) researched socioeconomic inequalities in life expectancy among a cohort of elderly people in Santiago. Looking at life expectancy at age 60, the study found that, while the poorest group could expect to live a further 16 years, the corresponding figure was 23 years for the richest group [2]. In a comparative study published by the OECD which analysed life expectancy at age 25 by educational status in 23 countries, Chile ranked 19th for males and 22nd for females, with a gap of 10.9 and 7.6 years respectively between those with tertiary education and those without (Murtin et al., 2017). Using area-level information in Santiago to compare life expectancy at birth between the first and ninth deciles of subcity units in terms of socioeconomic status, Bilal et al. (2019) found a 8.9-year gap for men and a 17.7-year gap for women. Edwards et al. (2021) used administrative data of pensioners and found a three-year gap in life expectancy at age 65 between high and low earners, for both men and women [3]. Moreno et al. (2021) also focus on life expectancy among the elderly. Using information from a population survey linked to vital statistics, the study compared life expectancy at age 60 for individuals with public and private health insurance, finding a gap of 4.9 years for men and 5.6 years for women.

In many countries, socioeconomic inequalities in life expectancy have increased over time in absolute terms. Evidence from the USA and the UK suggests that, as well as wit-

[1] Japan and South Korea are two countries where higher mortality has been documented among upper non-manual workers than among manual workers (Tanaka et al., 2019).

[2] Socioeconomic status was defined based on a multidimensional index that incorporates information about income, education, and home assets and quality of living accommodation.

[3] Top earners are pensioners receiving a monthly pension of more than USD 400, whereas low earners are those who receive less than USD 200

nessing an increasing gap in life expectancy between socioeconomic groups, some groups in society have experienced a stagnation or even reduction in life expectancy in recent years (Bennett et al., 2015; Bor et al., 2017; Bosworth, 2018; Office for National Statistics, 2015) [4]. The phenomenon observed in the US and UK of an increasing gap in life expectancy by socioeconomic groups has also been identified in nations with much lower income inequality levels, such as Denmark, Finland and Sweden (Brønnum-Hansen, 2017; Hederos et al., 2017; Kondo et al., 2014; Tarkiainen et al., 2012; Brønnum-Hansen et al., 2021). Moreover, comparative analyses suggest that Nordic countries have similar or higher absolute and relative inequalities in age-adjusted mortality and life expectancy compared to other countries on the continent (Mackenbach et al., 2017; Mackenbach, 2017; Murtin et al., 2017). Nevertheless, in Spain, which has one of the lowest socioeconomic gaps in age-adjusted mortality in Europe (Mackenbach et al., 2017; Mackenbach, 2017), absolute inequality in life expectancy between educational groups has also increased (Permanyer et al., 2018) over the last 60 years. In summary, notwithstanding their experience of increased life expectancy across the population as a whole, many high income countries have also faced widening socioeconomic inequalities in life expectancy at the same time.

Within mortality research, two main patterns of changes in mortality over time have been identified. A 'shift' to the right in the distribution of death (also referred to as 'mortality delay'), with little change in the shape of the distribution (Kannisto, 2001; Bongaarts, 2005; Canudas-Romo, 2008; Vaupel, 2010), and a 'compression' of mortality, with a higher proportion of deaths occurring in a narrower age interval (Fries, 1980; Bergeron-Boucher et al., 2015). The compression of mortality has been studied using several measures that account for the variability of age at death in a given population, which are usually referred to as 'lifespan variation' (van Raalte et al., 2018). Furthermore, it has been suggested that lifespan variation should be monitored over time to help to detect patterns in mortality changes (Hiam et al., 2021; van Raalte et al., 2018). Increasing lifespan variation indicates that mortality at younger ages is not decreasing as fast as at older ages. Moreover, a growth in lifespan variation may indicate an increase in mortality at

[4]Studies in the US found an increasing in mortality rates among some groups which started around the year 2000, while evidence from a decreasing life expectancy among deprived groups in the UK occurs in the last decade.

younger ages. Evidence shows that socioeconomically disadvantaged groups have higher lifespan variation than economically advantaged groups (Brown et al., 2012; van Raalte et al., 2012; Murtin et al., 2017). Moreover, lifespan variation has been shown to decrease more among higher socioeconomic groups (Permanyer et al., 2018; van Raalte et al., 2014; Sasson, 2016; Brønnum-Hansen et al., 2021).

This study aims to assess, for the first time, trends in socioeconomic inequalities in life expectancy and lifespan variability in Chile, and to understand the contribution of different diseases to changes in life expectancy in different socioeconomic groups over time.

3.2. Methods

3.2.1. Data

The analysis focuses on educational inequalities in life expectancy at age 26 at three time periods: 1991, 2002 and 2017. For each period, data on population at risk and death counts by age, sex and number of years of education were obtained. This information was collected from two different sources. Data relating to population at risk was retrieved from census micro-data (Instituto Nacional de Estadísticas, 2020). Data for death counts were obtained from the mortality database, which is administered jointly by the National Institute of Statistics, the Ministry of Health and the Civil Registry (Departamento de Estadísticas e Información en Salud, 2020).

From each death record, information about education and leading causes of death was obtained. Information regarding the deceased person's education is provided by the next of kin of the deceased person, while the immediate cause of death is taken from death notification documents, prepared by a medical doctor [5]. Data quality and plausibility checks for causes of death are implemented by the above-mentioned public bodies. According to the World Health Organization, the quality of information on causes of death in Chile

[5]There are few deaths certificates (less than 4%) that are not prepared by a medical doctor (Núñez F and Icaza N, 2006). This figure has decreased over time.

is high [6] (World Health Organization, 2010). Causes of death were grouped into seven categories, which are among the leading causes of death (Institute for Health Metrics and Evaluation (IHME), 2021): cancer, cardiovascular, digestive, infectious, mental and behavioural, respiratory and other causes. Details of how diseases were categorised into these groups are reported in the Appendix.

Micro-data is available for the censuses of 1992, 2002 and 2017 [7]. Moreover, information relating to years of education is missing for 1992. In order to make up for this, the estimates for the period 1991 were obtained using data of population at risk from the census of 1992 and information about mortality for 1991.

Information on education contained in both the censuses and the mortality databases includes details of the highest level of education attained and number of years of education within the highest level of education achieved. From this, an ordinal variable taking values from 0 to 20 -'years education'- was built. The Appendix describes the mapping from information on years of education attained in a given educational level to the ordinal variable years of education.

3.2.2. Definition of educational groups

As highlighted in the literature (Bound et al., 2015; Begier et al., 2013; Dowd and Hamoudi, 2014; Goldring et al., 2016; Hendi et al., 2021), as the proportion of individuals in each educational level (e.g. primary school, secondary school, etc.) evolves across birth cohorts, educational categories cannot be used as a ranking measure over time. Following Bound et al. (2015), we define the educational rank of individuals based on the distribution of years of education (from 0 to 20 years) for each birth cohort. Each individual's rank was computed in relation to the distribution of education among individuals aged

[6] Categories are as follows: limited use, low, medium-low, medium-high and high

[7] There was a census in 2012, but due to several problems in its implementation a new census was carried out in 2017

26 to 30 years old[8], when that individual was 26 years old [9]. For instance, the rank of someone who was 90 years old in 2017 was defined in relation to the distribution by years of education among individuals aged 26 to 30 years in 1953.

Distribution by years of education for each year relies on information from censuses (1920, 1930, 1940, 1952, 1960, 1970, 1982, 1992, 2002, and 2017) and a repeated cross-sectional survey (CASEN survey) which is representative of the Chilean population (1990, 1994, 1996, 1998, 2000, 2006, 2009, 2011 and 2015). For years for which no information is available, distribution by years of education was computed using linear interpolation based on the two closer adjacent known values (e.g. the distribution for 2016 was computed based on information for 2015 and 2017 -see Appendix for more details).

Measurement error regarding education reported by the next of kin of the deceased person is a possibility. Moreover, it is less likely for people to err the educational category attained by their deceased relative (e.g. primary or secondary education) than to be mistaken about the years of education attained within a category (e.g. five or six years of primary education). Based on this premise, we choose to compare the life expectancy of individuals in the first quintile against those in the tenth decile, as these educational ranks closely match educational categories over time [10].

Given the educational levels, the distribution of years of schooling is not smooth, and the upper limit (lower limit) of the first quintile (the tenth decile) is unlikely to coincide with the steps in the years-of-schooling distribution. For instance, among women aged 26 to 30 years in 2017, about 15% attained 12 years of education or less, while about 50% attained 13 years of education or less. Therefore, the first quintile includes those with 12yrs, and some, but not all, of those with 13yrs. In order to allocate those with

[8]Information available about the distribution of education by age varies between censuses. In most years it was possible to compute the distribution of education among those aged 26 to 30 years. In other cases information about individuals aged 25 to 29, or 25 to 34 was obtained. See Appendix for more details.

[9]It is assumed that at the age of 26, most individuals have completed their formal education

[10]For instance, the difference between the first and second quintiles in 1920 was whether or not an individual was illiterate; in 1950 it was 1 year vs 2 years of primary school; in 1980 it was completing primary school vs continuing to secondary school; and in 2017 it was completing secondary school vs continuing to further/higher education

13yrs to the first and second quintiles, a composition-adjusted method was used (Bound et al., 2015; Hendi, 2015; Meara et al., 2008; Sanzenbacher et al., 2017), where numbers of deaths and the population at risk in the educational categories with individuals belonging to adjacent ranks was proportionally categorised in each rank. In the example above we assume that a random one out of seven people who attained 13 years of education belong to the first quintile[11].

3.2.3. Estimation

Age-specific mortality rates were estimated for the two educational groups by sex, for each year. Based on this information, four separate period life tables were computed and life expectancy at age 26 (e_{26}) and the modal age at death (M) were estimated for each year. We have chosen life expectancy at age 26, because it can be assumed that most individuals would have completed the majority of their education by that age. Life expectancy was estimated with a maximum age of 100 years, because the mortality database is truncated at that age.

We measure lifespan variability using the life disparity estimator ($e^\dagger$). Life disparity is the population-average of the remaining life expectancy at the age when death occurs (Vaupel et al., 2011):

$$e^\dagger = \int_{x=0}^{w} e_x f_x dx \ , \tag{3.1}$$

where w is the maximum lifespan, and f_x is the life table distribution of deaths, with $\sum f(x) = 1$.

As we have obtained estimates for small sub-populations, mortality rates tend to be unstable. As well as estimates based on the observed mortality rates, we therefore produced life tables based on smoothed mortality rates. For this purpose we used a parametric model, known as the gamma-Gompertz-Makeham model. Like Missov et al. (2016) it was

[11] In the example, about 35% of the population completed 13 years of education. Moreover, the proportion of people who attained 13 years of education and who belong to the first quintile is 5%. Therefore, 5/35 of the individuals who completed 13 years of education should be categorized in the first quintile.

assumed that at each age death counts follow a Poisson distribution:

$$D(x) \sim Poisson\big(E(x)\mu(x)\big) \,, \tag{3.2}$$

where $E(x)$ is the age-specific offset and $\mu(x)$ is the gamma-Gompertz-Makeham mortality hazard at each age:

$$\mu(x) = \frac{ae^{bx}}{1 + \frac{\alpha\gamma}{b}(e^{bx} - 1)} + c \,. \tag{3.3}$$

Equation 3.3 has four parameters. Parameter a captures the base level of mortality, b is related to the age-specific force of mortality, c accounts for an age-independent risk of death from all causes and γ accounts for the effect of frailty. Independent models were fitted for each year, sex and educational group. Models were estimated using maximum likelihood.

The actuarial method proposed by Pollard (1982) was used to assess the contribution to the changes in mortality rates by age and leading causes of deaths for each educational group. This method enable us to examine changes in life expectancy over two periods of time with relation to age and causes of death. With $y1$ and $y2$ two calendar years, changes in life expectancy at age 26 between both periods ($e^{y2}_{26} - e^{y1}_{26}$) for a given educational rank can be decomposed as follows:

$$e^{y2}_{26} - e^{y1}_{26} = \frac{1}{2}\sum_{i=1}^{k}\sum_{x=0}^{100}({}_{i}m^{y1}_{x} - {}_{i}m^{y2}_{x})({}_{x}p^{y2}_{26}e^{y1}_{x} + {}_{x}p^{y1}_{26}e^{y2}_{x}) \,, \tag{3.4}$$

where i is one out of the seven mutually exclusive causes of death, ${}_{i}m^{y}_{x}$ corresponds to the mortality rate resulting from cause i, at age x during the period y and ${}_{x}p^{y}_{26}$ accounts for the probability of living from age 26 to age x at the period y.

3.3. Results

Table 3.1 shows life expectancy at age 26, life disparity and the modal age at death. For each year, the first row shows the results based on the observed mortality rates, while the data in parentheses represents results obtained from smoothed life tables. Estimates of life expectancy and life disparity differ little between the life tables obtained using observed mortality rates and those built based on smoothed life tables. As it could be expected, modal age at death differs depending on methods as a result of random fluctuation when using the life tables based on observed mortality.

The results for women and men show different patterns. While in 1991 a woman aged 26 in the first quintile could expect to live up to age 76.1, a woman in the tenth decile could expect to live up to age 83.4. In 2017 women aged 26 in the first quintile could expect to live roughly the same number of years as women in the tenth decile in year 1991. Between 1991 and 2017, the increase in life expectancy of women in the first quintile was double that of women in the tenth decile, reducing the gap in life expectancy for both groups (both in absolute and relative terms).

In contrast, in 2017 the life expectancy at age 26 for males in the first quintile was still below the life expectancy observed in 1991 for individuals in the tenth decile. Unlike what is observed among women, the gap in life expectancy between the first quintile and the tenth decile increased over time, both in absolute and relative terms. While in 1991 the gap was 4.4 years, it was 5.6 years in 2017.

We now turn to the analysis of lifespan variability. As expected, for both men and women lower life expectancy among individuals in the first quintile is paired with higher life disparity relative to the tenth decile. Moreover, for both sexes, there is little difference in the modal age-at-death between the first quintile and the tenth decile. Accordingly, lower life expectancy and higher life disparity for those in the first quintile is arguably mainly due to a higher proportion of deaths concentrated in younger ages in the first quintile. This can be seen in Figure 3.1, where for both men and women the modal age

Table 3.1: *Summary of life-table statistics*

	Women						**Men**					
	First quintile			**Tenth decile**			**First quintile**			**Tenth decile**		
	e_{26}	$e^\dagger$	M	e_{26}	$e^\dagger$	M	e_{26}	$e^\dagger$	M	e_{26}	$e^\dagger$	M
1991	50.1	10.9	81	57.4	10.8	80	46.0	12.9	76	51.2	11.3	78
	(50.3)	(11.1)	(80)	(57.5)	(10.7)	(80)	(46.3)	(12.8)	(78)	(51.3)	(11.4)	(78)
2002	55.9	10.8	88	60.2	10.4	88	49.9	13.7	83	55.3	11.4	81
	(56.1)	(10.8)	(87)	(60.2)	(10.3)	(90)	(50.1)	(13.7)	(85)	(55.4)	(11.3)	(83)
2017	57.3	11.6	90	61.0	8.7	92	50.4	14.3	87	56.8	9.3	88
	(57.3)	(11.7)	(92)	(60.0)	(8.8)	(90)	(50.7)	(14.2)	(86)	(56.8)	(9.2)	(86)

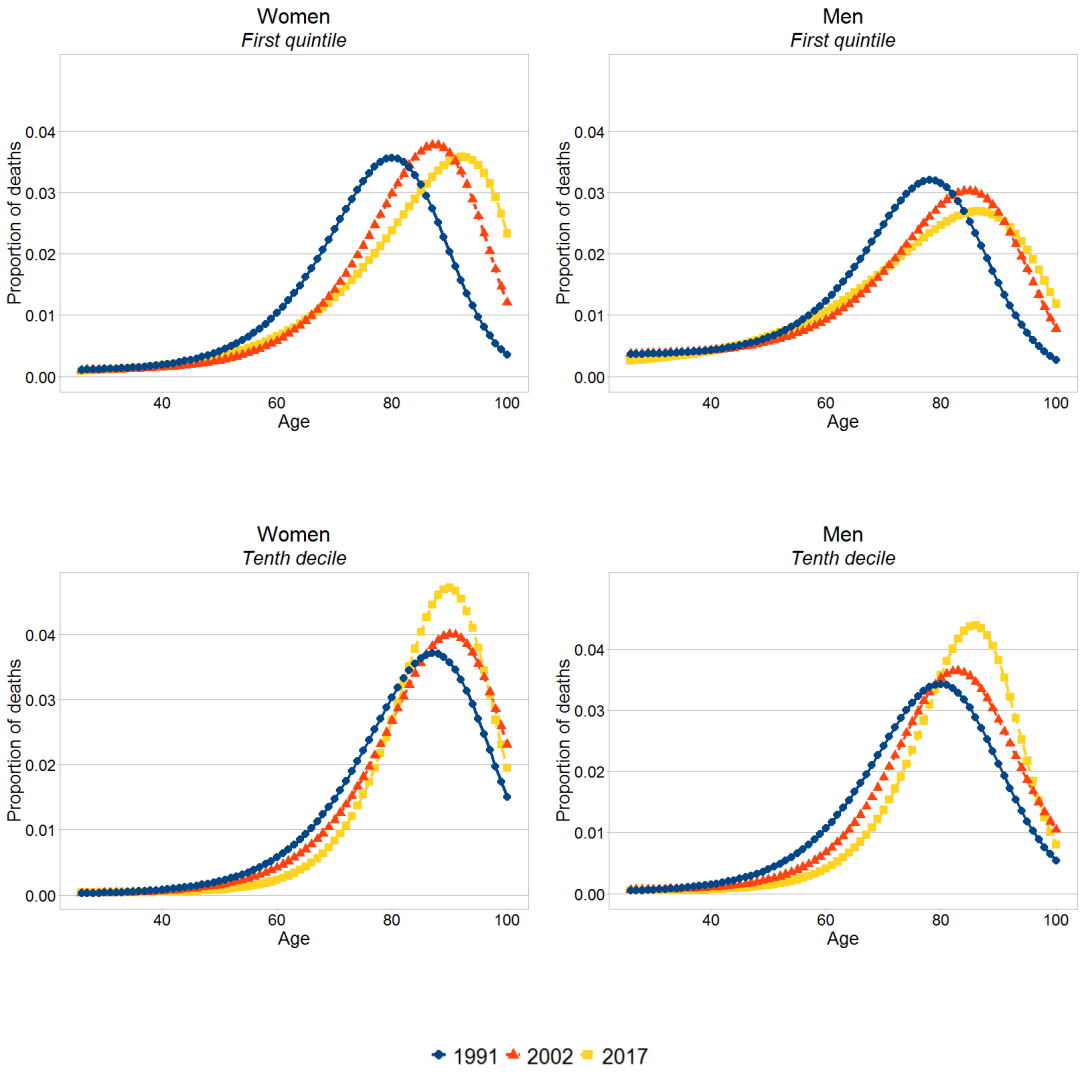
e_{26}: life expectancy at age 26, $e^\dagger$: life disparity, M: modal age at death.

Notes: Data in parentheses represents results obtained from smoothed life tables.

at death (the highest point in the curve) at each year is similar between both educational groups, and at each year the mass of the distribution among the first quintile is more concentrated on the left compared to the tenth decile.

For both sexes and both educational groups, evidence exists of a shift in mortality with the modal age at death increasing. The pattern of compression of mortality differs between the first quintile and the tenth decile. For both men and women in the first quintile life disparity went up over time, demonstrating an increase in variability in the distribution of deaths. Furthermore, between 2002 and 2017 a slight increase in the mortality rates takes place for some age groups (around age 50 years) in the first quintile. In contrast, in the tenth decile there is evidence of compression of mortality. These changes are reflected in Figure 3.1, where there is an increasing proportion of deaths concentrated around the modal age at death in the tenth decile as oppose to the first quintile.

Figure 3.1: *Smoothed age-at-death distributions*

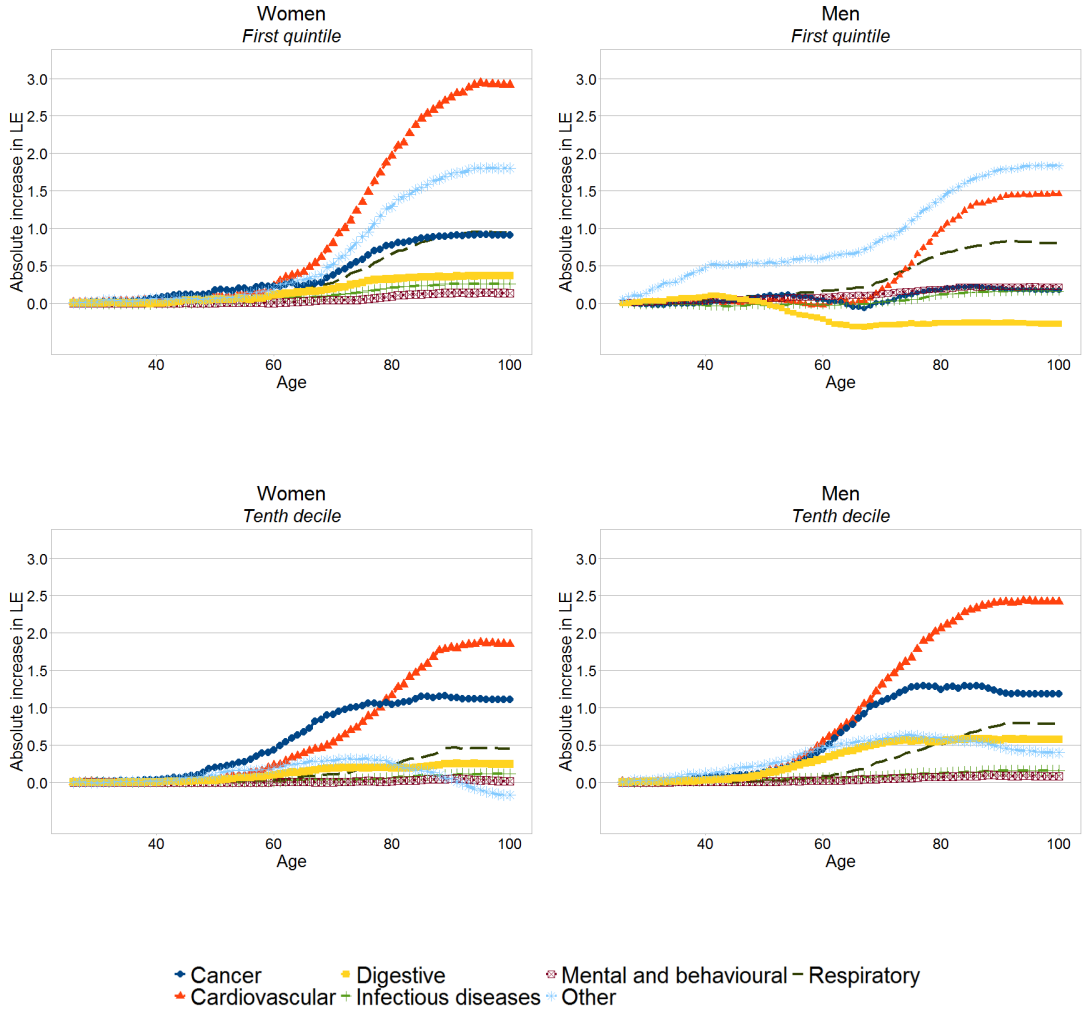


Note: The graphs show the distribution of deaths at each age for the first quintile and tenth decile for each sex and year. The distributions were obtained using the results from the smoothed life tables.

Figure 3.2 shows the results of the analysis of contributions to changes in mortality rates by age and leading causes of deaths for each educational group. The graphs show the accumulated increase in life expectancy due to the reduction of deaths at each age, by the leading cause of death. The total increase in life expectancy due to each group of diseases corresponds to the quantity shown at age 100. For example, the increase in life expectancy as a consequence of a reduction of deaths due to cardiovascular diseases between age 26 and 80 for men in the first quintile was 1 year, and the total increase in life expectancy

due to this cause is nearly 1.5 years. Across the four panels, the reductions of deaths due to cardiovascular diseases, cancer and respiratory diseases are among the leading causes explaining the increase in life expectancy. For both women and men, the gains in life expectancy as a result of other causes were higher among those in the first quintile *vis a vis* those in the tenth decile. Compared to men in the tenth decile, men in the first quintile have experienced a lower increase in life expectancy due to cardiovascular diseases, with roughly no increase below 70 years. Increased life expectancy due to reduction in cancer mortality was negligible among men in the first quintile, while men in the tenth decile have increased their life expectancy by 1.18 years due to this cause. Furthermore, major differences exist in the contribution of mortality resulting from digestive conditions - life expectancy for men in the first quintile reduced by 0.27 years because of this, compared to an increase of 0.57 years among men in the tenth decile. As already mentioned, women in the first quintile experienced a higher life expectancy increase than those in the tenth decile. As it is shown in Figure 3.2 women in the first quintile experienced slightly smaller gains in life expectancy as a result of lower number of cancer deaths and larger gains because of reduction in cardiovascular and respiratory mortality than those in the tenth decile. Furthermore, differences in life expectancy increases because of fewer cancer deaths is consistent with the lower decrease in mortality before age 70 for women in the first quintile.

Figure 3.2: *Contributions to changes in mortality rates by age and leading causes of deaths for each educational group.*



Notes: The graphs show the cumulative increase in life expectancy across age due to groups of diseases, between 1991 and 2017 for the first quintile and tenth decile for each sex and year. The total increase in life expectancy due to each group of diseases corresponds to the quantity shown at age 100.

3.4. Discussion

The findings of this study shows that in Chile for both sexes there is a gap in life expectancy by education at each point in time. Furthermore, we were able to conclude that between 1991 and 2017, while absolute and relative inequality in life expectancy at age 26 by education have decreased over time among women, they have increased for males. At each year, for both sexes the modal age at death is similar between the first quintile and

the tenth decile, with differences in life expectancy explained mostly by higher mortality at younger ages among the less educated. In addition, this paper has shown that, while life disparity has decreased for the tenth decile, it has increased for the first quintile, particularly among males. This calls for close monitoring of patterns of mortality among disadvantaged groups.

Increases in life expectancy as a result of changes in specific causes of death can mainly be attributed to cardiovascular diseases, cancer, respiratory and digestive disease, the main causes of death in Chile (Institute for Health Metrics and Evaluation (IHME), 2021). There are some similarities and many differences in the pattern of changes between men and women. In both cases there is a bigger increase in life expectancy due to 'other diseases' among men and women in the first quintile *vis a vis* those in the tenth decile. Amongst women the gain in life years due to cardiovascular diseases has contributed to reduce socioeconomic inequalities, whereas the opposite has been observed amongst men. The increase in life expectancy due to cancer and digestive diseases has been relatively similar in women from the first quintile and those in the the tenth decile. In contrast, deaths due to cancer and digestive diseases are in part responsible of an increase in the life expectancy inequality between men in the first quintile and those in the tenth decile. A more detailed analysis looking into specific causes of deaths may shed light regarding the causes behind these patterns. In particular, it would be informative to understand to what extent the differences observed in terms of disease-specific mortality rates by sex and between socioeconomic groups are due to inequalities in terms of disease incidence or net survival (or cause-specific survival). It is paramount therefore to produce this kind of evidence to inform policy oriented recommendations aimed to reduce health inequalities.

This study has several limitations. As described in the methodology, the information about the distribution of education between the ages of 26 to 30 years was only available for some years. For years for which no information was available distribution by years of education was computed using linear interpolation based on the two closest adjacent known values. Moreover, as explained in the appendix, there is a gap in the available data for the period between 1920 and 1940. A number of assumptions were therefore made

to identify educational distributions before 1940 based on the information available until that year. This could introduce bias to the estimations, particularly if many changes in the educational policy took place during that period. However, overall we consider this to be unlikely, as the first educational policies with a significant possibility of shaping educational distributions were implemented in 1920 and 1929 [12]. This will begin to be reflected in the educational distribution of 26-year-old individuals in 1933 and 1946, respectively.

Research into socioeconomic inequalities in life expectancy and mortality relies on two kinds of sources of information, usually referred to as 'linked' and 'unlinked' data (Valkonen, 1993). Studies based on linked data use information on education from sources such as population surveys, censuses and administrative records, alongside vital statistics records at the individual level. In contrast, unlinked data studies obtain information on death counts by education from death certificates, whereas data related to population at risk by education is obtained from other sources, such as population surveys and censuses. Although the use of unlinked data is common in the literature (see for example Olshansky et al. 2012; Meara et al. 2008; Bound et al. 2015; Case and Deaton 2021), it is considered more prone to bias than studies based on linked data (Murtin et al., 2017) as data from death certificates have been shown to provide biased information on educational distribution (Jasilionis and Leinsalu, 2020; Sorlie and Johnson, 1996; Kunst et al., 1998; Rey et al., 2013; Shkolnikov et al., 2007).

The data used in this study rely on information provided by the next of kin of the deceased person relating to the highest attained educational category and the number of years attained within that category. As mentioned in Section 3.2, we choose to compare two educational groups (first quintile and tenth decile) because, over time, both ranks tend to match with educational categories. Arguably, this could reduce the impact of bias regarding the information on years of education within a given educational category. Moreover, is not possible to reduce the risk of bias relating to information on educational categories.

[12] In 1920 it was established that all children must go to the school for four years before they are 13 years old, and in 1929 it became mandatory for children aged between 7 and 15 years old to complete six years of education.

This study does not report on the precision of the life expectancy estimations. Although methods to compute standard errors and confidence intervals of life expectancy estimations are available (Hanley, 2022), most of the times these are not reported in studies assessing socioeconomic inequalities in life expectancy (See for example (Tarkiainen et al., 2012; Sasson, 2016; Sanzenbacher et al., 2017; Permanyer et al., 2018; Olshansky et al., 2012; Murtin et al., 2017; Hendi et al., 2021; Hederos et al., 2017; Brønnum-Hansen, 2017; Brønnum-Hansen et al., 2021; Case and Deaton, 2021)) and its computation is beyond the scope of this thesis. The characterization of the uncertainty of the estimations reported in this chapter could be useful to understand how precise are these results and whether the differences observed between groups are statistically significant.

Despite these limitations, this investigation provides the first evidence of trends in socioeconomic inequality in life expectancy and lifespan variation in Chile. The findings of this study underscore the importance of developing methods and finding new sources of information to monitor health inequalities.

Authorship statement

A "CRediT" author statement (Elsevier, 2020) for this paper is as follows:

Nicolas Silva: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - Original draft, Reviewing and Editing, Project administration.

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Chapter 4: Effort as deservedness: A questionnaire-experimental study

Abstract

The conceptual definition of effort is typically given in the Equality of Opportunity literature as factors which individuals should be held accountable for. However, there appears to be no appropriate operational definition, which can translate the conceptual definition to more tangible specifics. One approach operationally defines effort as activities that everybody regards as costly, and thus assumes an ordered set of inputs with respect to a given outcome. Moreover, this definition assumes that people agree on how costly it is to engage in any combination of inputs in terms of their own utility functions. The reward principle that follows from this notion of effort suggests that higher effort should be rewarded with better outcomes. This paper adapts this notion of effort to the health context, and explores if respondents prefer less costly but supposedly unhealthy lifestyles over costly but supposedly healthy lifestyles when they are told that neither had any real effect on health. A representative sample of Chilean citizens are surveyed using an online questionnaire. The results show that for a given pair of health-related lifestyles, members of the public do not agree on which is more costly, thereby violating the main assumption of effort as unanimously costly activities. The results point to a potential limitation of this theory since if there is no rule governing how to establish the ordering of certain inputs, the notion of effort as unanimously costly activities is unworkable.

4.1. Introduction

Equality of Opportunity (EO) distinguishes between factors that could be considered legitimate (referred to as effort) and illegitimate (referred to as circumstances) sources of inequalities. The two main notions of effort in the literature can be tracked back to Fleurbaey (1994, 1995a,b, 2008) and Roemer (1993, 1996, 1998) [1]. According to Fleurbaey, effort is a matter of individuals' preferences. In this regard, individuals should be held accountable for their preferences to the extent that they identify themselves with it and that preferences have been formed in an ethically acceptable manner.

Roemer's notion of effort corresponds to a set of ordered inputs where this order is defined by the productivity of each combination of factors in relation to an outcome of interest (e.g. income, health). Importantly, Roemer argues that the influence of circumstances on the distribution of effort is illegitimate, in which case individuals cannot be held accountable for their effort, since the distribution of effort is shaped by circumstances. In this regard, the model distinguishes between 'observed' and 'accountable' effort (Roemer and Trannoy, 2015), the former being the realized effort by each individual and the latter a measure that removes the effect of circumstances on effort and it allows to identify individuals with different circumstances who are at the same level of responsibility.

Moreover, rather than providing an operational definition of effort in terms of what constitutes the inputs with respect to a given outcome, Roemer's strategy consists of identifying accountable effort relying on information about the joint distribution of outcomes and circumstances. According to Roemer's model, the distribution of a given outcome is a function of effort and circumstances. Furthermore, an outcome is a strictly increasing function of effort, so that each effort corresponds to a unique outcome [2]. It is also assumed that the cumulative distribution function (CDF) of the outcome, conditional on circum-

[1] Roemer coined the term 'effort', whereas Fleurbaey initially used the term 'responsibility characteristics'. The concept behind the term 'effort' has since developed so that it can mean things that may not align with the lay usage of the word.

[2] Roemer's model assumes that among individuals with the same circumstances, the outcome function is invertible, from which it follows that there is a one to one correspondence between effort and outcomes, conditional on types.

stances, is invertible. Based on these assumptions, Roemer defines accountable effort as the ranking of individuals in the outcome-CDF among individuals with the same circumstances. This strategy to identify accountable effort has been labeled as the Roemer's Identification Strategy (RIA) (Ramos and Van de gaer, 2016).

However, Roemer et al. (2003) recognise that if luck is considered as another input besides circumstances and effort, such an identification strategy fails. This is because there is no longer a one-to-one correspondence between effort and outcomes, so there may be two individuals with the same effort who have different outcomes due to luck (and therefore have a different ranking in the outcome CDF), in which case is no longer feasible to identify accountable effort using the CDF of outcomes. Therefore, since effort and luck influence the production of a given outcome, the identification of effort requires establishing a ranking of the inputs (other than luck) without relying only on information about the outcome distribution.

Based on this insight, Lefranc et al. (2009) and Lefranc and Trannoy (2017) proposed a framework that aims to provide a strategy that could be used to identify effort in the presence of luck. The notion of effort provided by Lefranc and Trannoy (2017) is similar in spirit to Roemer's since effort is an ordered set of inputs chosen by individuals towards the production of a given outcome. However, in contrast to Roemer's model, where effort is characterized in relation to its productivity (i.e. conditional on circumstances and when luck is absent, an individual exerts more effort than another to the extent that the former achieves higher outcomes), Lefranc and Trannoy define effort in relation to how costly it is for the individual in terms of their own utility function to engage in each combination of inputs. Importantly, Lefranc and Trannoy assume that there exists a unanimous agreement among people regarding this ordering.

The reward principle that follows from this definition of effort (the principle of 'minimal reward') states that conditional on the same circumstances, individuals who exert higher effort should achieve better outcomes (Lefranc and Trannoy, 2017) [3]. Although the

[3]This principle is considered minimal since it only requires that the distribution of outcomes is an

model of EO proposed by Roemer does not define effort as costly activities that should be rewarded, in a later work Roemer has proposed that "I believe that the equal opportunity ethic is predicated upon the view that those who expend (costly) effort deserve to be rewarded; more precisely, they deserve to be rewarded for the effort they voluntarily choose which is not determined by their circumstances" (Roemer, 2012, p. 178), which is very similar to the notion of effort proposed by Lefranc and Trannoy.

In this paper, we aim to understand how the notion of effort as unanimously costly activities could be applied to the relationship between health-related lifestyles and health outcomes and to test whether the assumption behind this definition of effort finds support among members of the public.

4.2. Methods

4.2.1. The model

We start by describing the outline of a structural model used to formalise the definition of effort as costly activities. This is a discrete-time model of decision making where time t equals the age of individuals i. At each point in time, the individual makes choices about allocating their time across different activities including consuming different goods and services. The set of activities achieved by the individual in each period is denoted by $a_{i,t}$. Each individual has a set of endowments or characteristics that are denoted by $X_{i,t}$. These endowments describe the characteristics of the individual and what they have, such as genetic make-up, innate ability, skills, health status, information, durable goods and income.

In this model, there is a dynamic relation between $a_{i,t}$ and $X_{i,t}$. The set of activities that are available to the individuals at each period of time is a function of their endowments, $a_{i,t} \in A(X_{i,t})$. The activities achieved by the individuals at a given point in time will shape their endowments in the next period, given the function x and random variability $\zeta_{i,t}$, which we equate to luck: $X_{i,t+1} = x(a_{i,t}, X_{i,t}, \zeta_{i,t})$. Given this functional re-

increasing function of effort, without further specification.

lationship we can define $p(X_{i,t+1}; X_{i,t}, a_{i,t})$ which corresponds to the subjective probability of achieving a given set of characteristics in the next period of time. The consumption of individuals during a given period of time $C_{i,t}$ corresponds to the sum of the consumption associated with each activity $c(a_{i,t})$. The total time $D_{i,t}$ that is available during a given period of time is the sum of the duration of each activity $d(a_{i,t})$. Hence, $c(a_{i,t})$ and $d(a_{i,t})$ represent the opportunity costs of the activities.

A life project $l \in L$ consists of a sequence of activities from time period $t+1$ up to T, T being the individuals' age at death. Since the individual is uncertain about her future characteristics and given that the set of activities that individuals can achieve in each period of time depends on their characteristics, individuals are uncertain about whether they can achieve a given life project. This uncertainty can be characterized as a subjective probability of achieving a given life project conditional on the individuals' characteristics and activities at time t: $\phi_{i,t}\big(l; X_{i,t}, a_{i,t}\big)$. The vector that describes the subjective probabilities of achieving each life project corresponds to $\boldsymbol{\phi_{i,t}}\big(l; X_{i,t}, a_{i,t}\big)$.

The decision making process of individuals consists of choosing which activities to engage in at the current period of time, from the set of activities available to them according to $A(X_{i,t})$, taking into account that the activities they choose will shape the probability of achieving a given set of characteristics in the next period of time, which in turn will shape the probability of achieving different life projects. Therefore, activities have two aspects: as investment (towards a life project) and as consumption (to be enjoyed in the current period of time). Hence, we will assume that individuals have ordinal preferences R over:

$$(l(a), a) = \big(\boldsymbol{\phi_{i,t}}(l; X_{i,t}, a_{i,t}), a_{i,t}\big)$$

We write $(l(a), a) R_i (l(a'), a')$ if i weakly prefers $(l(a), a)$ to $(l(a'), a')$. Let $(l(a), a) P_i (l(a'), a')$ denote strict preference and let $(l(a), a) I_i (l(a'), a')$ denote indifference.

In this model, health status corresponds to one of the individuals' characteristics $X_{i,t}$.

A given health-related lifestyle corresponds to $a^h_{i,t}$, with $a_{i,t} = \{a^h_{i,t}, a^o_{i,t}\}$ and $a^o_{i,t}$ being other activities or 'complementary activities'. Suppose that there are two health-related lifestyles $a^{h,ph}_{i,t}$ and $a^{h,pu}_{i,t}$, which will be referred to as 'perceived healthy' and 'perceived unhealthy' lifestyles, respectively. Let two different sets of activities be $a^{\alpha}_{i,t} = \{a^{h,ph}_{i,t}, a^o_{i,t}\}$ and $a^{\beta}_{i,t} = \{a^{h,pu}_{i,t}, a^o_{i,t}\}$. It will be assumed that for those individuals who adopt lifestyle $a^{h,ph}_{i,t}$, $(l(a^{\alpha}), a^{\alpha})P_i(l(a^{\beta}), a^{\alpha})$ holds, while for those individuals who adopt lifestyle $a^{h,pu}_{i,t}$, $(l(a^{\alpha}), a^{\beta})P_i(l(a^{\beta}), a^{\beta})$ holds.

We are interested in understanding if individuals consider that is more costly, in terms of their own utility functions, to engage in perceived healthy lifestyles *vis a vis* perceived unhealthy lifestyles. We consider that individuals obtain more utility from a lifestyle perceived healthy than a lifestyle perceived unhealthy if, conditional on both lifestyles involving the same time and the financial cost being the same, they prefer the former to the latter. We did not directly asked the respondents which lifestyle is more costly to them. Instead, the strategy that we use to test this assumption consists of assessing whether individuals who currently adopt lifestyles perceived healthy would switch to lifestyles perceived unhealthy if they were informed that the actual impact on health is the same across the two kinds of lifestyles, conditional on the new complementary activities being no worse than the original ones.

Assume that there exists a set of complementary activities $a^o_{i,t}{}'$ which may or may not be equal to $a^o_{i,t}$, with $c(a^o_{i,t}{}') \geq c(a^o_{i,t})$, meaning that the set of complementary activities $a^o_{i,t}{}'$ allows to achieve equal or higher consumption than $a^o_{i,t}$. Consider now a set of activities $a^{\gamma}_{i,t} = \{a^{h,ph}_{i,t}, a^o_{i,t}{}'\}$ and a set of activities $a^{\delta}_{i,t} = \{a^{h,pu}_{i,t}, a^o_{i,t}{}'\}$.

Let us define the current situation among individuals who adopt lifestyles perceived healthy as $(l(a^{\alpha}), a^{\alpha})$. In our empirical application, we will assess if individuals who currently adopt lifestyles perceived healthy prefer $(l(a^{\gamma}), a^{\delta})$ over their current life situation $(l(a^{\alpha}), a^{\alpha})$, conditional on $d(a^{h,ph}_{i,t}) \geq d(a^{h,pu}_{i,t})$, meaning that the time allocated to lifestyles perceived unhealthy is equal to or less than the time allocated to lifestyles perceived healthy.

We assume that for individuals who currently engage in lifestyles perceived healthy it is the case that $(l(a^{\gamma}), a^{\alpha})R_i(l(a^{\alpha}), a^{\alpha})$, because the set $a^{\gamma}_{i,t}$ contains the same health-related lifestyles as $a^{\alpha}_{i,t}$ and it allows to achieve the same or higher consumption. Now, if it is costly for individuals to engage in lifestyles perceived healthy, among the individuals who adopt lifestyles perceived healthy it should be the case that $(l(a^{\alpha}), a^{\delta})P_i(l(a^{\alpha}), a^{\alpha})$, conditional on $d(a^{h,ph}_{i,t}) \geq d(a^{h,pu}_{i,t})$. This is so because $a^{\delta}_{i,t}$ allows to achieve the same or a better set of complementary activities (i.e. the time and consumption available to complementary activities is higher in $a^{\delta}_{i,t}$ than in $a^{\alpha}_{i,t}$). Moreover, if it is the case that $(l(a^{\gamma}), a^{\alpha})R_i(l(a^{\alpha}), a^{\alpha})$ and $(l(a^{\alpha}), a^{\delta})P_i(l(a^{\alpha}), a^{\alpha})$, it follows that $(l(a^{\gamma}), a^{\delta})P_i(l(a^{\alpha}), a^{\alpha})$.

In contrast, if there are individuals who keep their perceived healthy lifestyles, even when they are informed that their lifestyles have no health advantages, so that their preferences correspond to $(l(a^{\alpha}), a^{\alpha})P_i(l(a^{\gamma}), a^{\delta})$, we will infer that these individuals obtain more utility from lifestyles perceived healthy *vis a vis* lifestyles perceived unhealthy. If this is the case for a significant proportion of individuals, then there is no unanimous agreement about which kind of lifestyle is more costly, which would mean that health-related lifestyles cannot be understood as effort (as specified by Lefranc and Trannoy) with respect to health outcomes.

4.2.2. Empirical design

To test this hypothesis in the field, the following approach was taken. Respondents were asked to complete a questionnaire with three questions, each of which has two items: a screening item and the main choice task. Each question is related to a different lifestyle: diet, smoking and physical activity. We choose these lifestyles because these are among the risk factors that contribute the most to the burden of disease in Chile (Institute for Health Metrics and Evaluation (IHME), 2021) and members of the general public are familiar with them as risk factors for health. The screening item consists of asking the respondents to *self-assess how adequate their lifestyles are with respect to the protection of their health* (see Table 4.1). Only those respondents who report having at least 'adequate'

lifestyles [alternatives (b) and (c) in the screening item] were faced with the main choice task.

In the main choice task respondents who declare having healthy lifestyles were asked to imagine a hypothetical or counterfactual scenario where the impact on health of adopting 'less healthy' lifestyles was the same as the impact of engaging in their current (healthy) lifestyles. This hypothetical situation corresponds to a scenario were $(l(a^{\gamma}), a^{\delta})$ is feasible. Given this counterfactual scenario, respondents were asked if they would adopt less healthy lifestyles. The null hypothesis is that the proportion of those who prefer not to change their current lifestyles [alternative (i) in the main choice task] is not statistically different from zero.

For each lifestyle, the scenario described a situation where $d(a_{i,t}^{h,ph}) \geq d(a_{i,t}^{h,pu})$ and $c(a_{i,t}^{o}{}') \geq c(a_{i,t}^{o})$, meaning that perceived unhealthy lifestyles involve no more time or financial costs compared to perceived healthy lifestyles. The reason why the questions are set up this way is because if the opportunity cost (time-wise or financially) of perceived unhealthy lifestyles were higher, some responses may become un-interpretable. Some respondents may choose to keep their current lifestyles, perceived to be healthy, even when they are informed there is no particular health benefit to it. If the opportunity cost of perceived unhealthy lifestyles were higher, then their choice to keep their current lifestyle may be because they enjoy their current lifestyle more, or because they are indifferent between the lifestyles but enjoy the higher other consumption associated with the healthy lifestyle. By specifying that the opportunity cost of perceived unhealthy lifestyles is not higher *vis a vis* perceived healthy lifestyles, responses to keep the current lifestyles can be interpreted to mean that the respondent prefers the current lifestyle, irrespective of their health effects. Note that the opposite is not true. If in the main choice task, a respondent is willing to adopt the less healthy lifestyle, we cannot distinguish if she enjoys the less healthy lifestyle more or if she equally enjoys both lifestyles but prefers the less healthy lifestyle because it is less time-consuming or its financial cost is lower *vis a vis* their current lifestyle.

Table 4.1: *Questions included in the screening item and main choice task*

	Screening item	**Main choice task** [Shown to those who answer alternatives (b) or (c) in the first item]
First question	Which alternative best describes what you think about your diet? a) I think I have an unhealthy diet; b) I think I have a fair diet, but it could be healthier; c) I think I have a healthy diet.	First, think about the kind of food you think is unhealthy. Now imagine that it became possible to eat unhealthy food without having any negative impact on your health. Would you choose to eat more unhealthy food? i) No, because I enjoy my diet; ii)Yes, but I would still eat healthy food since I like it; iii) Yes, I would eat more unhealthy food.
Second question	Do you smoke? a) Yes, very often, b) Occasionally, c) No	Imagine that you could smoke for free (smoke more without paying more) and without having any negative impact on your health. Would you start smoking (smoke more)? i) No, because I do not enjoy smoking; ii)Yes, I would start smoking (smoke more often).
Third question	Which alternative best describes what you think about your physical activity? a) I'm not physically active; b) I take some exercise, but I should exercise more; c) I take regular exercise; d) I take too much exercise.	Imagine that it became possible to keep healthy without exercising. Would you keep exercising? i) Yes, because I enjoy exercising; ii) Yes, but I would exercise less than now; iii) No, I would stop exercising.

Note: Translated from the original in Spanish.

In the scenario on smoking, respondents were told that they could smoke for free (if they were non-smokers) or smoke more without paying more (if they were smokers), in which case $c(a^o_{i,t}{}') \geq c(a^o_{i,t})$. We assume that among non-smokers (occasional smokers), smoking (smoking more) will not involve allocating a significant amount of time to this task. In the scenario on physical activity we assume that engaging in less physical activity will free-up time that could be allocated to other activities. If these activities were non productive activities, $c(a^o_{i,t}{}') = c(a^o_{i,t})$. In contrast, the extra time could be used in productive activities, in which case $c(a^o_{i,t}{}') > c(a^o_{i,t})$. In addition, engaging in less physical activity may free-up resources if individuals pay for access to sports facilities, which also entails that $c(a^o_{i,t}{}') > c(a^o_{i,t})$. In the scenario on diet we adopt a different strategy. We asked the respondents whether they consider that adopting a less healthy diet will involve about the same, less or higher food expenditure. We then focus our attention to those respondents who consider that a less healthy diet will be as expensive as, or cheaper than, their current diet, in which case $c(a^o_{i,t}{}') = c(a^o_{i,t})$ and $c(a^o_{i,t}{}') > c(a^o_{i,t})$, respectively. As with smoking, we assume that those who have at least an adequate diet do not require additional time to adopt a less healthy diet.

Respondents were also asked three questions aimed to understand if their use of the word 'effort' (*esfuerzo* in Spanish) concurs with the notion of healthy lifestyles as costly activities (see Table 4.2). We consider that for health-related lifestyles to coincide with this notion of effort, respondents should agree that i) an activity involves more effort if is more unpleasant than another and ii) engaging in healthy lifestyles involves more effort than adopting unhealthy lifestyles. Questions E1 and E2 aim to confirm that respondents interpret effort as a matter of how unpleasant or how costly it is for individuals to engage in a given activity (lifestyle). In question E1, we expect respondents to answer that individual 2 exerts higher effort since is more costly for her to engage in healthy lifestyles compared to individual 1. In question E2 we expect respondents to agree with the statement because if someone enjoys a given lifestyle, adopting that lifestyle is not costly. Question E3 assess whether respondents consider that engaging in healthy lifestyles involves higher effort compared to adopting unhealthy lifestyles. We expect respondents to agree to this statement.

Table 4.2: *Questions about the notion of 'effort'*

Question	Wording	Alternative answers
E1	Imagine that there are two individuals (namely individuals 1 and 2) who have healthy lifestyles, but who would prefer to engage in unhealthy lifestyles. The reason they not do so is because they want to protect their health. Individual 1 does not have a hard time engaging in healthy lifestyles, whereas individual 2 does. Who is exerting more effort?	Individual 1/ Individual 2/ Both exert the same effort/I don't know how to answer.
E2	To what extent do you agree with the following statement: "People who enjoy engaging in healthy lifestyles are not necessarily exerting effort".	Strongly agree/ Agree/ Disagree/ Strongly disagree.
E3	To what extent do you agree with the following statement: "People who engage in healthy lifestyles exert more effort than people who engage in unhealthy lifestyles"	Strongly agree/ Agree/ Disagree/ Strongly disagree.

Note: Translated from the original in Spanish.

4.2.3. Study design

The survey collected primary data through an online questionnaire conducted with a representative sample of the Chilean members of the public. The survey was part of a study that aims to test the acceptance of EO principles among members of the public. All the respondents faced the questionnaire reported in this Chapter and then they face the questionnaire reported in Chapter 6. The study had two phases, a pilot and the main study. In the pilot phase, 12 respondents were interviewed online by one of the authors (NS) to check the interpretation of the questions. Participants in the pilot were older than

30 years and their highest educational attainment was secondary education or less. In the main study, the questionnaire was presented using Qualtrics, and it was self-administered without an interviewer. The sample was recruited from an existing panel at the Centre for Experimental Social Sciences (CESS) at the University of Santiago. Quotas were defined to match the demographics of the Chilean population in terms of sex, age groups (20 to 49 years, and older than 50 years), and educational attainment (secondary education or less, and beyond secondary education). The target sample size was 600.

Based on the results of the pilot, there were two aspects that were emphasised in the survey's instructions. First, respondents were told that we were interested in their own assessment of how 'healthy' were their lifestyles. This is important because what is relevant for our study are the subjective beliefs that the respondents have when making their lifestyles choices, rather than what the evidence suggests regarding the impact of a given lifestyle on health. Second, respondents were told that they will be asked about hypothetical situations that were not feasible in real life and we encourage them to engage in the exercises. Although simple, during the pilot we found that most respondents were not keen to engage in the exercises when they were not warned about this.

All the respondents face the questions in the same order. They were first asked about their diet, then about smoking and physical activity. All the questions of the screening and main task were compulsory, whereas the questions about the notion of effort were not compulsory.

4.3. Results

The invitation to participate in the survey was answered by 5,387 people, from which 593 were selected based on the quotas-criteria and 568 completed the survey. Compared to the quotas defined in the study design (see Table 4.3), the age structure of respondents was similar (58.1% of respondents were younger than 50 years vs 56.0% in the population) and the gender composition as well (54.2% of women in the sample vs 52.3% in the popula-

tion), whereas the proportion of participants who achieve more than secondary school was slightly higher (39.8%) than in the population (32.5%). On average it took respondents 16 minutes to complete the survey. There were around 5% of respondents who complete the survey in less than five minutes and 5% that expended more than 40 minutes in the task [4].

Table 4.3: *Sample's demographic characteristics*

Category	**Target quota** %	**Sample** %
Men, 20-50 years, low education	15.7	13.0
Men, 50 years or older, low education	16.4	13.1
Men, 20-50 years, high education	11.9	14.6
Men, 50 years or older, high education	3.7	5.1
Women, 20-50 years, low education	15.5	15.1
Women, 50 years or older, low education	20.1	19.0
Women, 20-50 years, high education	12.9	15.6
Women, 50 years or older, high education	3.7	4.4
Total	100	100

Table 4.4 shows the results of the screening item for each lifestyle. There were 488 (85.9%) respondents who declare having a fair or healthy diet, 473 (83.3%) who were non-smokers or smoke occasionally and 346 (60.9%) practice at least some exercise. The number of participants who declare having at least adequate lifestyles in one, two and three lifestyles was 64 (11.3%), 215 (37.8%) and 271 (47.7%), respectively.

The results of the main choice task are shown in Table 4.5. There are different patterns by the kind of lifestyle. Among individuals who report having either a healthy or fair diet or who get at least some exercise, around 11% report that they will not change their behaviour if they could engage in less healthy lifestyles without any negative impact on their health. The corresponding figure is roughly 85% (57%) among those who do not smoke (smoke occasionally). From the 488 respondents who declare having at least a fair diet, a relatively low proportion (17.6%) believe that an unhealthy diet is more expensive than a healthy diet (data not shown). In this regard, we cannot rule out that among

[4] As it was mentioned, this survey was part of a bigger study. The figures reported here correspond to the time it took to the respondents to go through the full questionnaire of the study. In the pilot, we found that it took an average of 20 minutes to complete the full questionnaire. The questions that correspond to this paper were placed at the beginning of the questionnaire.

Table 4.4: *Distribution of answers to the screening item*

Diet			**Smoking**			**Exercise**		
Answer	n	%	Answer	n	%	Answer	n	%
Unhealthy	80	14.1%	Very often	95	16.7%	Not phys. active	222	39.1%
Fair	407	71.6%	Occasionally	79	13.9%	Some exercise	269	47.3%
Healthy	81	14.3%	No	394	69.4%	Regular exercise	72	12.7%
						Too much	5	0.9%
Total	568	100%	Total	568	100%	Total	568	100%

Note: The table shows the distribution of answers to the questions shown in the second column of Table 4.1 ('Screening item').

those who think that eating healthier is cheaper, some of them equally enjoy adopting an unhealthy diet but will not change their lifestyle in the hypothetical scenario because a healthier diet will allow them to achieve lower consumption. Among the 406 respondents who think that an unhealthier menu is equally or less expensive, 11.1% would not change their diet in the hypothetical scenario.

Given the theoretical model described in section 4.2.2, we infer that the respondents who are not willing to change their lifestyles in the counterfactual scenario obtain more utility from their current lifestyles than from less healthy behaviours. Since in the main choice task there is a significant proportion of respondents who are not willing to change their lifestyles we reject the null hypothesis that there is a unanimous agreement among individuals about how to rank lifestyles in terms of how costly they are. Therefore, none of these three lifestyles can be conceived as effort as specified by Lefranc and Trannoy.

So far, we have focused on one lifestyle at a time, but if we are to look at combinations of lifestyles as effort, then we need individuals to agree on how costly it is to engage in each combination of lifestyles. Therefore, if individuals unanimously agree on how to rank lifestyles regarding the combination of diet, exercise and smoking, those respondents who report having two or three healthy lifestyles should be willing to change these behaviours given a counterfactual scenario where they could engage in perceived unhealthy lifestyles

Table 4.5: *Distribution of answers to the main choice task -single lifestyles.*

Diet			**Smoking**						**Exercise**		
			Non smokers			*Occasional smokers*					
Answer	n	%	Answer	n	%	Answer	n	%	Answer	n	%
No more	55	11.3%	I will not smoke	335	85.0%	I will not smoke more	45	57.0%	I will exercise the same	37	10.7%
Some more unhealthy food	338	69.2%	I will smoke	59	15.0%	I will smoke more	34	43.0%	I will exercise less	114	32.9%
Much more unhealthy food	95	19.5%							I will stop exercising	195	56.4%
Total	488	100%	Total	394	100%	Total	79	100%	Total	346	100%

Notes: The table shows the distribution of answers to the questions shown in the third column of Table 4.1 ('Main choice task'). The labels of the answers in Table 4.5 correspond to a shortened version of the answers used in the questionnaire (see Table 4.1).

without negative health consequences.

Table 4.6 shows the proportion of individuals who are engaged in two or three healthy lifestyles and who will not change at least one of these behaviours given the counterfactual scenario. Asked if they would change at least one of their lifestyles if they could engage in perceived unhealthy lifestyles without any consequences for their health, 23% of those who declare having a healthy diet and being physically active agree. Amongst the other combinations of healthy lifestyles, the corresponding figure ranges from 83% to 90%. In this regard, compared to the case of single lifestyles, there is stronger evidence to reject the hypothesis that there is a unanimous agreement about how to rank a combination of lifestyles in relation to how costly they are.

Table 4.7 shows the results of the questions about how respondents interpret the word 'effort' in relation to health-related lifestyles. In question E1, around 65% of respondents

Table 4.6: *Distribution of answers to the main choice task -combination of lifestyles*

	Number of respondents who engage in two or three healthy lifestyles	Number of respondents who are not willing to change at least one lifestyle	%
Diet and exercise	318	73	23.0
Smoke and diet	414	343	82.9
Smoke and exercise	296	260	87.8
Smoke, exercise and diet	271	243	89.7

Note: For each combination of lifestyles the table shows the proportion of respondents who will not change at least one of these lifestyles given the counterfactual scenario of the main choice task.

agree that individual 2 is exerting more effort. Nearly 66% agree that enjoying engaging in healthy lifestyles does not involve exerting effort (question E2), whereas 78% of respondents agree that engaging in healthy lifestyles involves exerting more effort than adopting unhealthy behaviours (question E3). Among the 520 respondents who answer the three questions, 85 (16.3%) answer the three questions in a way consistent with the notion of healthy lifestyles as effort (their answers were "individual 2" in E1, "agree or strongly agree" on E2 and "agree or strongly agree" in E3). If one is willing to make inferences from these results, it could be argued that a minority of respondents jointly agree that i) effort is a matter of how costly is for each individual to engage in a given lifestyle, and ii) healthy lifestyles involve more effort.

Table 4.7: *Distribution of answers to questions about the use of the word effort*

	n	%	Cum %
E1 (Who is exerting more effort?)			
Individual 1	74	14.2	14.2
Individual 2	338	65.0	79.2
Both equal effort	105	20.2	99.4
Indecisive	3	0.6	100
Total	520	100	
E2 (Those who enjoy engaging in healthy lifestyles not necessarily exert effort)			
Strongly agree	126	24.2	24.2
Agree	218	41.8	66.0
Disagree	129	24.8	90.8
Strongly disagree	43	8.2	99.0
Indecisive	5	1.0	100
Total	521	100	
E3 (Those who engage in healthy lifestyles exert more effort)			
Strongly agree	193	34.0	34.0
Agree	250	44.1	78.1
Disagree	106	18.7	96.8
Strongly disagree	18	3.2	100
Indecisive	0	0	100
Total	567	100	

Cum %: cumulative percentage.

4.4. Discussion

There are two notions of effort in the EO literature. Fleurbaey defines effort as a matter of individuals' preferences, whereas in the framework proposed by Roemer effort is understood as a desert base with respect to a given outcome, but no operational definition of effort is provided [5]. Inspired in Roemer's framework, the work by Lefranc and Trannoy (2017) can be seen as an attempt to provide such a definition. The proposal of Lefranc and Trannoy (2017) involves a normative principle and an empirical assumption. The normative principle (i.e. the principle of minimal reward) is that individuals exerting higher effort deserve better outcomes, while the empirical assumption is that for any combination

[5] Feinberg (1970) defines a desert base as a characteristic or prior activity in virtue of which a person deserves something.

of inputs there is unanimous agreement over the ranking of the sets of inputs in terms of how costly they are.

In this paper this definition of effort was adapted to the health context and interpreted as follows: everything else being equal, for any given pair of health-related lifestyles, respondents unanimously agree which lifestyle is more costly than the other. This assumption was rejected for the three kinds of lifestyles and for the combinations of these lifestyles. Based on this evidence, we should expect the proportion of individuals who agree regarding how to rank different combinations of lifestyles to decrease as the number of lifestyles increases. We interpret these results as evidence that the assumption of a unanimous notion of lifestyle-related effort among the population can be rejected.

However, we did not test whether members of the public support the minimal reward principle. Nevertheless, it can be inferred from the results that even if members of the public agree on this principle, they will not agree on what constitutes EO since they do not agree on which activities are more costly.

The study has several limitations. The sample was recruited through a non-probability sampling method. Also, we acknowledge that the study may suffer from bias introduced by the framing and presentation of the questionnaire. In addition, the survey asked the respondents to think about scenarios such as smoking, exercising and diet having no impact on health, which are highly hypothetical. As it was mentioned in Section 4.2.3, the survey includes a statement before the questions to inform the respondents that they will be faced with imaginary scenarios that are not plausible and to explain the purpose of the task. Nevertheless, we cannot rule out that some respondents may have failed to engage with these questions because of this reason.

In spite of these limitations, the study shows that if there is no agreement over how to rank the inputs associated with a particular outcome in terms of exertion required, the notion of effort as unanimously costly activities is an imperfect approximation. The notion of effort proposed by Lefranc and Trannoy can be conceived as a way of overcoming one

of the limitations of Roemer's framework, namely the absence of an operational definition of effort. However, if the assumption behind the notion of effort as unanimously costly activities does not hold, the challenge of providing an operational definition of effort remains unsolved.

Authorship statement

A working paper of this chapter was discussed at the Summer 2021 meeting of the Health Economists' Study Group (HESG). The paper was written in co-authorship with Aki Tsuchiya. A "CRediT" author statement (Elsevier, 2020) for this paper is as follows:

Nicolas Silva: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - Original draft, Project administration. **Aki Tsuchiya**: Supervision, Writing - Reviewing and Editing.

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Chapter 5: Compensation and the indirect effect of circumstances

Abstract

The Equality of Opportunity framework assumes that a given distribution of outcomes is a function of factors for which the individuals should be held accountable (referred to as effort) and factors that are beyond the individuals' responsibility (referred to as circumstances). Circumstances can influence the distribution of outcomes by shaping: i) the return to effort (direct effect) or ii) the distribution of effort (indirect effect). The theoretical literature has mainly focused on the former. This study explores how the normative principles that embody the idea of Equality of Opportunity should be interpreted depending on whether the indirect effect of circumstances is considered legitimate or not. The paper explores some limitations of the compensation principles aimed to reduce inequalities due to the indirect effect of circumstances. An alternative compensation principle is proposed and a questionnaire-experimental study that adapts these concepts to the inter-generational transmission of smoking habits explores to what extent this principle is favoured by members of the public.

5.1. Introduction

The theory of Equality of Opportunitty (EO) or Inequality of Opportunitty (IO) has flourished in recent years both in terms of its theoretical foundations and in terms of empirical applications. The basic assumption of this theory is that individuals' outcomes can be conceived as a function of legitimate factors that are in the realm of individuals' responsibility (referred to as effort) and illegitimate factors for which the individuals should not be held accountable (referred to as circumstances) (for a general introduction to EO, see Roemer and Trannoy (2016)). According to this theory, EO will be achieved to the extent that inequalities arise strictly due to the effect of effort, with no influence of circumstances. The theoretical literature has formalised this idea in terms of two kinds of principles: compensation and reward. In broad terms, compensation principles concern how to reduce inequalities among individuals with different circumstances, whereas reward principles inform how to account for inequalities due to effort among individuals with the same circumstances. There are different versions of compensation and reward, many of which have been shown to be incompatible among them (for a survey of the EO axioms and its incompatibilities see Ramos and Van de gaer (2016); Bosmans and Öztürk (2021)).

Furthermore, there are two ways in which circumstances can influence the distribution of outcomes, which are sometimes referred to as a direct and indirect (or mediated) effects of circumstances (Bourguignon et al., 2007; Jones, 2019). The first can be understood as a difference in the return to effort across individuals with different circumstances, whereas the second corresponds to the effect of circumstances on the distribution of effort. The direct effect of circumstances constitutes the core of the EO theory in the sense that individuals who have the same effort should not get different outcomes due to their circumstances. In contrast, as will be discussed later, there are different normative positions regarding the indirect influence of circumstances on the distribution of effort. Although the principles (and their incompatibilities) that embody the idea of EO have been explored in depth in the theoretical literature, we argue that there are gaps in how these axioms should be interpreted in relation to different normative positions with respect to the indirect effect of circumstances.

In this regard, one of the objectives of this paper is to contrast how the definitions and principles of EO depend on whether the unequal distribution of effort across types is considered legitimate or not. We will argue that the theoretical literature on EO does not always distinguish between these two positions due to the assumptions made regarding the structure of the data. For instance, when defining the EO principles, the review of the theoretical literature by Bosmans and Öztürk (2021) assumes that each combination of circumstances and effort occurs once, which is equivalent to assuming that effort is equally distributed among individuals with different circumstances. In contrast, the review by Ramos and Van de gaer (2016) assumes that each combination of circumstances and effort occurs 'at most' once. This allows to cover situations where the support of the effort distribution differs conditional on circumstances (i.e. among individuals with a given combination of circumstances some effort categories may not occur), but it does not allow to cover situations where there is a different proportion of individuals in each effort category across groups with different circumstances.

Moreover, if one looks at the foundations of EO in economics (to distinguish it from the philosophical tradition on which economic-EO is inspired), the main theories of EO hold different conceptions about the interplay between circumstances and effort. The model proposed by Fleurbaey (Fleurbaey, 1994, 1995a,b, 2008) does not explicitly incorporate the possibility of an unequal distribution of effort across types. This is coherent with the notion of responsibility adopted by Fleurbaey (the so-called 'preference approach'), which has its roots in the works of Rawls (1971) and Dworkin (1981a,b), and which conceives of effort as a matter of preferences. According to the normative perspective adopted by Fleurbaey, individuals should be held accountable for their preferences, to the extent that they identify themselves with them and that preferences have been formed in an acceptable manner. Therefore, if there is an unequal distribution of preferences across individuals with different circumstances, this is not necessarily unfair.

In contrast, the model proposed by Roemer explicitly incorporates the possibility of an unequal distribution of effort across types (Roemer, 1993, 1996, 1998). Roemer's norma-

tive perspective has been categorized as part of the 'control approach'. This perspective, which has its roots in the works of Cohen (1989) and Arneson (1989), suggests that preferences are shaped by many external factors that are beyond the individuals' responsibility and that individuals should be held accountable for what lies within their control. In line with this view, Roemer's model considers the influence of circumstances on effort to be illegitimate, and distinguishes between 'raw effort', which is the realized level of effort for each individual, and 'accountable effort', which is a measure that allows inter-type comparisons of responsibility by removing the effect of circumstances on the distribution of effort (Roemer and Trannoy, 2015). Although it is tempting to conclude that Roemer's model assumes an unequal distribution of preferences across individuals with different circumstances is illegitimate, this is not necessarily the case. Roemer's model does not provide an operational definition of effort, so establishing a comparison between Fleurbaey's and Roemer's models is challenging (for a comparison of both theories see Fleurbaey and Schokkaert (2011); Roemer (2012); Fleurbaey (2012); Roemer and Trannoy (2016); Trannoy (2016)).

In this regard, apart from the open question of what effort is in Roemer's theory, according to this framework, the unequal distribution of effort by types is illegitimate. However, as it will be discussed in Section 5.3, the compensation principles in that framework are based on a restrictive assumption about the nature of effort. Once that assumption is relaxed, there is an incompatibility between compensation strategies among individuals with the same accountable effort and basic notions of neutrality. Moreover, even if the unequal distribution of effort is judged illegitimate, it may be desirable to reduce IO across types while holding individuals accountable for their raw effort rather than their accountable effort. Nonetheless, this cannot be achieved with the compensation principles that have been suggested in the literature so far. In this respect, we aim to explore an alternative compensation strategy that could overcome some of these limitations.

In addition to discussing how the normative principles of EO can be applied to the scenario of an unequal distribution of effort across types, we aim to explore to what extent members of the public support some of these principles. There are several questionnaire-

experimental studies that have analysed the acceptability of the EO principles (see for example Schokkaert and Devooght (1998, 2003); Le Clainche and Wittwer (2015)). However, to the best of our knowledge, no studies have yet explored the attitudes of members of the public about inequalities that arise due to the inter-generational transmission of preferences (which we interpret as effort). We focus on the transmission of smoking habits from parents to children. There is ample evidence that suggests that smoking by household members, and parents in particular, have a significant impact on children's smoking uptake (Leonardi-Bee et al., 2011; Wellman et al., 2016). In this regard, we are interested in exploring the attitudes of members of the public towards the reduction of health inequalities due to an unequal distribution of preferences among children of parents with different smoking habits.

The paper is structured as follows. The next section introduces the (main) EO principles. Section 5.3 discusses how these principles should be interpreted depending on the normative position adopted regarding the indirect effect of circumstances. Section 5.4 presents the empirical study. Section 5.5 concludes.

5.2. Description of EO principles

5.2.1. The model

An economy is composed of a finite number of $i(i = 1, ..., N)$ individuals. Individuals' outcomes u_i are continuous variables and are the result of an outcome function $U(e, c, t)$, where e is a vector of individuals' efforts, c is a vector of individuals' circumstances and t is a vector that captures transfers. The outcomes can be decomposed into $u_i = v_i + t_i$, with $v_i = V(e, c)$ being the Pre-transfer outcome. The economy can be partitioned into different types. Individuals belong to the same 'type' τ if they share the same set of circumstances. The circumstances of individuals of a given type are denoted by c_τ.

Effort is determined by a function $E(\varepsilon, c)$, where ε is referred to as 'accountable effort' and is equally distributed across types. In this regard, accountable effort can be thought of

as a latent effort or as an underlying disposition to effort that is expressed differently depending on the constraints imposed by different circumstances. The counterfactual effort $\bar{e}$ corresponds to the effort that an individual would have had she belong to a reference type $\bar{\tau}$. We use the term 'responsibility' r to refer to factors for which the individuals should be held accountable. As it will be explained later, depending on the normative approach, r could either correspond to e, $\bar{e}$, or ε.

A group $g^{\tau,r}$ will be defined as the individuals with the same circumstances and the same responsibility. The number of individuals who are from the same type is denoted by n^{τ}, n^{r} denotes the number of individuals who share the same responsibility, and $n^{\tau,r}$ the number of individuals in the same group. The proportion of individuals of a given type τ is denoted by $p(c_{\tau})$ and the distribution of effort by type is denoted by $p(e; c_{\tau})$. At this point is useful to distinguish between two different mechanisms by which circumstances can lead to an unequal distribution of outcomes across types. One is a direct effect of circumstances, which corresponds to the result of the action of circumstances through the function V, conditional on effort: $V(c; e)$. The other is an indirect effect which corresponds to the impact of circumstances in the distribution of effort: $p(e; c)$.

We consider only transfers that respect the principle of Equal Treatment of Equals (ETE), which states that individuals with the same characteristics (c, e) should receive the same resource transfer. This principle translates a basic notion of neutrality. Since individuals who belong to the same type are subject to the same constraints, the effort chosen by them is entirely under their responsibility. Therefore, among individuals of the same type, effort is a legitimate source of inequality and it would be unfair to establish different transfers among those who choose the same effort. The function $t = T(c, e)$ will be called transfer policy.

An outcome distribution Y is represented by a three dimensional matrix $Y = [Y_{i,\tau,e}] \in \mathcal{D}$ of dimensions $m^{\tau} \times m^{e} \times N$, with $\mathcal{D} \equiv \{-\} \cup \mathbb{R}_{++}^{m^{\tau} \times m^{e} \times N}$. Entry $Y_{i,\tau,e}$ is the outcome u_i obtained for individual i of type τ and effort e. In contrast, $Y_{i,\tau,e}$ equals $\{-\}$ if such a combination of circumstances and effort does not occur for individual i. For every dis-

tribution in a domain $\mathcal{D}$, a social ordering function defines an ordering over all possible distributions, with $Y^2 \succeq Y^1$ meaning that Y^2 is at least as good as Y^1, $Y^2 \succ Y^1$ meaning that Y^2 is better than Y^1 and $\sim$ denoting the corresponding symmetric relation. For a distribution Y^1 we will denote by $Y^1(\tau)$ to the distribution of outcomes among a given type and $u_i^1 = v_i^1 + t_i^1$ to the outcomes of a given individual i.

5.2.2. EO Principles

We will review some key definitions and principles of EO and discuss how the normative perspective on the influence of circumstances in the distribution of effort shapes these. This section cover three concepts: *definitions* of EO, *reward* principles, and *compensation* principles. The definitions of EO describe the conditions under which a given distribution of outcomes achieves EO. The compensation principles describe transfer policies to reduce IO. The reward principles are about how to account for inequalities among individuals of the same type.

We start by focusing on the two main approaches to describe what constitutes a distribution that achieves EO: the *ex-ante* and the *ex-post* approaches. The *ex-ante* view can be traced back to the frameworks proposed by Van de gaer (1993) and Kranich (1996). Such an approach focuses on comparing the opportunities or 'opportunity sets' $O(\tau)$ faced by individuals with different circumstances. In the next section, we discuss how opportunity sets can be specified depending on the normative perspective about the interplay of circumstances and effort. Either way, *Ex-ante* Equality of Opportunity (EOA) is achieved if the opportunity sets are equivalent, regardless of circumstances. In order to compare opportunity sets it is necessary to define how to aggregate the information contained in $O(\tau)$, according to a function ϕ, which will be addressed in Section 5.3 below.

Ex-ante Equality of Opportunity is satisfied iff for all $(\tau, \tau') \in \{1, ..., m^\tau\}$, $\phi(O(\tau)) = \phi(O(\tau'))$.

The *ex-post* view was proposed by Roemer (1993, 1996, 1998) and Fleurbaey (1994,

1995a,b, 2008). According to this approach, *Ex-post* Equality of Opportunity (EOP) is achieved if individuals with the same responsibility obtain the same outcome, irrespective of their circumstances.

Ex-post Equality of Opportunity is satisfied iff for all $r \in \{1, ..., m^r\}$ and for all i and $j \in \{1, ..., n^r\}$, $u_i = u_j$.

The reward principles are about how to account for differences in outcomes within a type. There are two main versions of reward: liberal and utilitarian reward. Liberal reward is inspired by a notion of neutrality with respect to the influence of legitimate factors on the distribution of outcomes (Fleurbaey, 2008). This principle suggests that transfer policies should not modify the inequality (in absolute terms) among individuals of the same type. We follow the definition provided by Fleurbaey and Peragine (2013) which states that a reduction in the inequality of transfers among individuals of the same type improves the situation.

Liberal reward: For all distributions Y^1 and $Y^2 \in \mathcal{D}$, $Y^2 \succ Y^1$ if there exists $\tau \in \{1, ..., m^\tau\}$, and r and $r' \in \{1, ..., m^r\}$ such that,

$$T^1(c_\tau, r) > T^2(c_\tau, r) > T^2(c_\tau, r') > T^1(c_\tau, r') \ ,$$

and $t^1 = t^2$ for all other combinations of type and responsibility.

According to utilitarian reward, there should be no inequality aversion for individuals with the same circumstances. One way to capture this axiom is to state that the social ordering function should be neutral with respect to transfers within a type (Peragine, 2004b).

Utilitarian reward: For all distributions Y^1 and $Y^2 \in \mathcal{D}$, $Y^2 \sim Y^1$ if there exists $\tau \in \{1, ..., m^\tau\}$, and r and $r' \in \{1, ..., m^r\}$ such that, for all $i \in \{1, ..., n^{\tau,r}\}$ and all $j \in \{1, ..., n^{\tau,r'}\}$

$$u_i^2 = u_i^1 + t_i^1 \text{ and } u_j^2 = u_j^1 - t_j^1 \,,$$

$$\sum_{i=1}^{n^{\tau,r}} t_i^1 = \sum_{j=1}^{n^{\tau,r'}} t_j^1,$$

and Y^1 and Y^2 coinciding everywhere else.

The summation across individuals in the same group entails that the total amount of transfers received by individuals in group $g^{\tau,r}$ is equal to the amount of transfers taken from individuals in group $g^{\tau,r'}$. Since the number of individuals in each group may differ, the size of t_i^1 is not necessarily equal to t_j^1.

In contrast, to reward principles, which deal with inequalities among individuals with the same circumstances, compensation axioms are focused on inequalities between types. There are two main compensation approaches that have been proposed in the literature. *Ex-ante* Compensation (EAC) seeks to reduce differences in opportunities across types. This is embodied in the following axiom which says that, when there is one type τ that has better opportunities than another type τ', improving the situation of a group of individuals in type τ worsens the situation. [1]

Ex-ante compensation: For all distributions Y^1 and $Y^2 \in \mathcal{D}$, $Y^1 \succ Y^2$ if there exists τ and $\tau' \in \{1, ..., m^\tau\}$, such that for any r and $r' \in \{1, ..., m^r\}$, with $r = r'$ or $r \neq r'$, and for all $i \in \{1, ..., n^{\tau,r}\}$ and all $j \in \{1, ..., n^{\tau',r'}\}$, such that $\phi(O(Y^1(\tau))) > \phi(O(Y^1(\tau')))$,

$$u_i^2 = u_i^1 + t_i^1 \text{ and } u_j^2 = u_j^1 - t_j^1 \,,$$

$$\sum_{i=1}^{n^{\tau,r}} t_i^1 = \sum_{j=1}^{n^{\tau',r'}} t_j^1,$$

and Y^1 and Y^2 coinciding everywhere else.

[1] There are different versions of EAC. The versions vary depending on how opportunity sets are defined and regarding the shape of the function ϕ used to evaluate the opportunity sets (see for example Peragine (2004a); Fleurbaey and Peragine (2013)). We provide a more general definition that can be interpreted differently depending on the definitions of opportunity sets and the function ϕ.

In contrast, *Ex-post* Compensation (EPC) occurs when there is a reduction of inequalities among individuals with the same level of responsibility (Ooghe et al., 2007). The characterizations of EOP and the EPC that we provide differ from other definitions available in the literature. Usually, EOP and EPC are expressed in relation to inequalities among individuals with the same effort and different circumstances. In contrast, we have defined the *ex-post* approach in terms of inequalities among individuals with the same responsibility, with no reference to circumstances. This definition is more general, and will be helpful later, when we discuss the normative implications of the interplay of circumstances and effort on the *ex-post* approach.

Ex-post Compensation: For all distributions Y^1 and $Y^2 \in \mathcal{D}$, $Y^2 \succ Y^1$ if there is $r \in \{1, ..., m^r\}$ and $\{1, ..., n^r\} = \{\{1, ..., q^r\}, \{q^r + 1, ..., k^r\}, \{k^r + 1, ..., n^r\}\}$ such that for all $i \in \{1, ..., q^r\}$ and all $j \in \{q^r + 1, ..., k^r\}$, with $u_i^1 > u_j^1$,

$$u_i^1 - t_i = u_i^2 > u_j^2 = u_j^1 + t_j \ ,$$

$$\sum_{i=1}^{q^r} t_i^1 = \sum_{q^r+1}^{k^r} t_j^1,$$

and Y^1 and Y^2 coinciding everywhere else.

5.3. EO principles and the indirect effect of circumstances

This section discusses how the normative principles described in the previous section should be interpreted depending on whether the indirect effect of circumstances is considered legitimate or not. We first cover the *ex-ante* approach and then reward principles and the *ex-post* approach.

We would argue that the way in which opportunity sets are defined should differ depending on the normative position regarding the unequal distribution of effort across types. There are two ways in which the distribution of effort may vary across types. There

could be i) an equal support in the distribution of effort across types and an unequal relative frequency in each effort category, ii) an unequal support of the effort distribution across types and an equal or unequal distribution of effort in the effort categories that overlap across all types.

Table 5.1 is an example of the first case. There are two types (τ and τ') and three effort categories ($e = 1, e = 2, e = 3$). Each cell shows the relative frequency of effort by type and the outcome achieved for each effort category, conditional on type. If the indirect effect of circumstances is considered legitimate, the definition of opportunity sets should not incorporate information about the relative frequency of effort in each type. In fact, in this case, we should conclude that there exists EO since, conditional on the same effort, there is no inequality in outcomes across types. Consequently, opportunities should be defined in terms of the shape of the outcome function without incorporating information about the relative frequency of effort in each type [2].

Table 5.1: *An example of an unequal distribution of effort across types, with an equal support of the effort distribution*

	Effort categories		
Type	$e = 1$	$e = 2$	$e = 3$
τ	$p(e = 1; \tau) = 0.25$ $u = 2$	$p(e = 2; \tau) = 0.50$ $u = 4$	$p(e = 3; \tau) = 0.25$ $u = 6$
τ'	$p(e = 1; \tau') = 0.50$ $u = 2$	$p(e = 2; \tau') = 0.25$ $u = 4$	$p(e = 3; \tau') = 0.25$ $u = 6$

Table 5.2 is an example of the second case. The support of the effort distribution differs by type. The effort category $e = 1$ is not realised among individuals of type τ whereas the effort category $e = 3$ is not realised among individuals of type τ'. In this case, is not possible to affirm that there is no inequality in achievements conditional on effort, since there is no information about what would have been the achievements of individuals of type τ (τ') had they exert effort $e = 1$ ($e = 3$). One could think on two possibilities to compare opportunity sets across types in a case like this. If there is no reason to think that

[2] Bosmans and Öztürk (2022) offer an alternative definition of EAC when the relative frequency of effort differs across types. Their approach consists in proposing a weaker version of EAC which applies only to scenarios where effort is equally distributed across types.

the achievements of individuals on those effort categories that are not observed will differ across types and the unequal distribution of effort across types is considered legitimate, one should conclude that there exists EO in the distribution shown in Table 5.2. Consequently, opportunities should be defined in terms of the shape of the outcome function for those effort categories that overlap across types. In this case, opportunity sets should rely only on information about the outcomes for individuals who exert effort $e = 2$. If it is not possible to affirm that the achievements of individuals for those effort categories that are not observed will (eventually) be equal across all types, then the opportunity sets across types for which the support of the effort distribution differs cannot be compared.

Table 5.2: *An example of an equal support of the effort distribution across types*

	Effort categories		
Type	$e = 1$	$e = 2$	$e = 3$
τ	$p(e = 1; \tau) = 0.25$ $u = 2$	$p(e = 2; \tau) = 0.75$ $u = 4$	$p(e = 3; \tau) = 0$
τ'	$p(e = 1; \tau') = 0$	$p(e = 2; \tau') = 0.25$ $u = 4$	$p(e = 3; \tau') = 0.75$ $u = 6$

Let us define $\{1, ..., m^{\Sigma}\}$ to the collection of effort categories that overlap across all types, to distinguish it from $\{1, ..., m^{e}\}$, which is the set of all the effort categories. In both cases (equal support or unequal support of the distribution of effort) if the indirect effect of circumstances is judged legitimate, the opportunity sets should rely on information about the shape of the outcome function for those effort categories that overlap across all types, and it can be defined as follows (note that if the support of the effort distribution is equal across types, $m^{e} = m^{\Sigma}$):

$$O(\tau) = \{U(e, c_{\tau}, t) : e \in \{1, ..., m^{\Sigma}\}\} . \tag{5.1}$$

In order to evaluate the opportunity sets across types it is necessary to define how to aggregate the information contained in $O(\tau)$. The most common approach is to define the value of the opportunity set of a type by its average outcome (or the sum of outcomes) (Van de gaer, 1993). In this case the value of the opportunity set corresponds to:

$$\phi(O(\tau)) = \frac{1}{m^{\Sigma}} \sum_{1}^{m^{\Sigma}} U(e, c_\tau, t) \ . \tag{5.2}$$

In contrast, if the influence of circumstances on effort is considered illegitimate, opportunities should include information about both the shape of the outcome function and the distribution of effort. In this case, there is IO from an *ex-ante* standpoint if the support of the effort distribution differs by type or if the relative frequency of individuals in each of the effort categories differs across types. Therefore, there is IO in the examples shown in Tables 5.1 and 5.2. In this case the opportunity set is defined by:

$$O(\tau) = \{((p(e;\tau), U(e, c_\tau, t)) : e \in \{1, ..., m^e\}\} \ . \tag{5.3}$$

And the value of the opportunity set corresponds to:

$$\phi(O(\tau)) = \frac{1}{n^{\tau}} \sum_{1}^{n^{e,c_\tau}} U(e, c_\tau, t) n^{e,c_\tau} \ , \tag{5.4}$$

which equals the weighted average of outcomes for each type.

In consequence, the interpretation of the EOA and EAC will change in line with how opportunity sets are defined. When the unequal distribution of effort is considered legitimate, EOA and EAC evaluate opportunities according to $\phi(O(\tau))$ as defined in Equation 5.2. In contrast, when the unequal distribution of effort across types is considered illegitimate, EOA and EAC evaluate opportunities according to $\phi(O(\tau))$ as defined in Equation 5.4. To distinguish between both kinds of principles we will refer to EOA and EAC in the former case and to Alternative-EOA (A-EOA) and Alternative-EAC (A-EAC) when opportunities are evaluated according to $\phi(O(\tau))$ as defined in Equation 5.4.

Most often, the assumptions of the theoretical models in the literature are not suited to analyse the case of an unequal distribution of effort by types. For instance, the model by Fleurbaey and Peragine (2013) assumes that the support of the effort distribution is the same across types and it defines opportunity sets in terms of the shape of function $U(e, c, t)$ as in Equation 5.1. Therefore, such a framework do not allow to assess a sce-

nario where there is an unequal distribution of effort across types. The model by Ramos and Van de gaer (2016) also defines opportunity sets in terms of the shape of function $U(e, c, t)$, but it incorporates information about the support of the distribution of effort. Hence, according to such characterization there exists EOA provided that the support of the effort distribution is the same across types and that the function U is independent of circumstances. However, it does not allow to assess a scenario where the relative frequency of effort differs across types.

Liberal and Utilitarian Reward are about how to deal with differences in outcomes among individuals with the same circumstances. As it was discussed earlier, individuals of the same type are subject to the same constraints, therefore effort constitutes a legitimate source of inequality among them. In this regard, the interpretation of the reward principles should not be modified with respect to whether the unequal distribution of effort across types is deemed fair or unfair.

The interpretations of EOP and EPC depend on how to define responsibility. If the influence of circumstances on the distribution of effort is considered legitimate, effort constitutes an adequate measure of inter-type responsibility. Therefore EOP is realized when individuals who share the same effort obtain the same outcomes, and EPC is about reducing inequalities among individuals with the same effort and different circumstances.

In contrast, when the unequal distribution of effort by types is judged illegitimate, the *ex-post* approach cannot use effort as a measure of responsibility across types since effort is a function of circumstances. Instead, a measure of responsibility that removes the effect of circumstances on effort should be used. One alternative would be to compute a measure of responsible effort $\bar{e}$, which corresponds to the effort that a person of a given type would have achieved had she been subject to the constraints faced by individuals of a reference type. Alternatively, we can rely on information about the individuals' accountable effort ε, since accountable effort is equally-distributed across types. In this case EOP is realized when individuals with the same responsible effort (or the same accountable effort) receive the same outcome, and EPC seeks to reduce inequalities among individuals with the same

responsible (or accountable) effort. We will refer to EOP and EPC when effort is used as a measure of inter-type responsibility and to A-EOP and A-EPC when either responsible or accountable effort are used instead.

The unequal distribution of effort across types has important implications for the *ex-post* approach to compensation. A-EPC may involve heterogeneous transfers among individuals with the same effort and circumstances. This occurs because, within a type, individuals with the same effort may have different levels of responsible effort. Assume that among individuals of type τ and effort e, there are individuals with responsible effort $\bar{e}$ and $\bar{e'}$. Now, assume that we want to hold individuals accountable for their responsible effort and that there is inequality among individuals with responsible effort $\bar{e}$ which will be reduced through an A-EPC strategy. Moreover, this would entail unequal transfers among individuals with characteristics (c_τ, e), because among them there are individuals with different levels of responsible effort. More formally, if in each type there is not a one to one correspondence between effort and responsible effort, a reduction of inequalities among individuals with the same responsible effort will violate ETE. This is summarized by the following proposition.

Proposition 1 If the unequal distribution of effort by types is considered illegitimate and $E : (e; c_\tau) \to (\bar{e}; c_{\bar{\tau}})$ is not biyective, then A-EPC and ETE are incompatible.

As it was mentioned in the introduction, in Roemer's framework the influence of circumstances on the distribution of effort is considered illegitimate. In our view, in that framework, there is no incompatibility between A-EPC and ETE due to the assumptions made about the nature of effort. In the canonical model proposed by Roemer it is assumed that: i) outcomes are a strictly increasing function of effort, ii) outcomes are continuous variables and iii) the cumulative distribution function (CDF) of outcomes for each type is a strictly monotonic function. According to this model, individuals should be responsible for their rank in the CDF of outcomes among individuals of their type. From these assumptions, it follows that there is a one-to-one mapping between effort and responsible effort across types. For clarity of exposition, let us introduce some additional

notation. The following functions are defined: $V_\tau^{-1} : v \to e$ is the inverse function of V for a given type, $F_\tau : \mathbb{R} \to [0,1]$ is the type-specififc CDF of the outcome v, and F_τ^{-1} the quantile function. Been $\pi_{i,\tau}$ the ranking of an individual i of type τ according to F_τ, the counterfactual level of effort of individual i had she belong to type $\bar{\tau}$ corresponds to:

$$V_{\bar{\tau}}^{-1}(F_{\bar{\tau}}^{-1}(\pi_{i,\tau})) \ .$$

In this case, F_τ is invertible because it is assumed that is a strictly monotonic function, and that function V is invertible because it is a bijective function given the assumption that outcomes are a strictly increasing function of effort.

However, if the CDF of outcomes is not strictly monotonic (as it is the case with discrete probability distributions) there will not be a one-to-one correspondence between effort and responsible effort across types, even if the function V is invertible. Consider for instance the distribution shown in Table 5.3. There are two types (τ, τ') and three effort categories $e = \{1, 2, 3\}$. There is no direct effect of circumstances, with $v = 2e$. The distribution of effort among individuals of type τ is $p(e;\tau) = (0.20, 0.40, 0.40)$ and among individuals of type τ' is $p(e;\tau') = (0.40, 0.40, 0.20)$. In this case, since the distribution of outcomes is discrete, the quantile function will assign a given outcome value to a given percentage interval. For instance, among individuals in type τ the quantile function will assign the quantile value $v = 1$ to any percentage point in [0,0.2), whereas among individuals in type τ', the quantile function will assign the quantile value $v = 1$ to any percentage point in [0,0.4). Each cell in the table shows the effort and outcome that corresponds to a given interval in the cumulative distribution of outcomes for each type. It is clear from the table that there is not a one to one mapping between effort and responsible effort in each type. For example, among individuals with characteristics $(c_{\tau'}, e = 1)$, those in the interval $[0, 0.20)$ would have exerted effort $e = 1$ had they faced the same constraints that individuals in type τ whereas those in the interval $[0.20, 0.40)$ would have exerted effort $e = 2$. Now, consider an A-EPC strategy which consists of equalizing outcomes among individuals in the interval $[0.20, 0.40)$. Such a compensation strategy will violate ETE since among individuals with characteristics $(c_{\tau'}, e = 1)$ some will receive transfers while

others not, whereas among individuals $(c_\tau, e = 2)$ some will face negative transfers while others do not.

Table 5.3: *An example of a distribution of achievements and effort when the CDF of outcomes is not invertible*

	CDF of v				
Type	[0.00,0.20)	[0.20,0.40)	[0.40,0.60)	[0.60,0.80)	[0.80,1.00]
τ	$e = 1$ $v = 2$	$e = 2$ $v = 4$	$e = 2$ $v = 4$	$e = 3$ $v = 6$	$e = 3$ $v = 6$
τ'	$e = 1$ $v = 2$	$e = 1$ $v = 2$	$e = 2$ $v = 4$	$e = 2$ $v = 4$	$e = 3$ $v = 6$

Moreover, it could be argued that even if the unequal distribution of effort across types is judged illegitimate, using responsible or accountable effort as a measure of responsibility may be inadequate since this entails holding individuals responsible for actions they have not taken. Responsible effort corresponds to the effort that an individual would have exerted had she faced different circumstances, whereas accountable effort corresponds to a latent effort or a predisposition to exert different effort depending on the constraints faced. In this regard, even if the individuals would have exerted different effort under different circumstances, it can be argued that they should be held accountable for their realized level of effort e. Hence, it may be desirable to compatibilise achieving a reduction of inequalities in opportunity sets while reducing (or not increasing) inequalities among individuals with the same effort. Moreover, this cannot be achieved through A-EAC because such a compensation strategy and EPC are incompatible (Proof provided in the appendix).

Proposition 2 A-EAC and EPC are incompatible.

In this respect, we would like to propose a different ex-ante compensation strategy that may help to reduce inequalities in opportunity sets (according to $\phi(O(\tau))$ as defined in Equation 5.4) while reducing or not increasing inequalities among individuals with the same effort. This principle is attractive only when there are types that have better opportunities than others due to an unequal distribution of effort. In such a case, a type

that is better off than another one according to the *ex-ante* evaluation of opportunity sets is that which has a higher proportion of individuals in effort categories with a higher return to effort. Then, a transfer policy from individuals with higher effort to individuals with lower effort would reduce the inequality of opportunity sets between types. Moreover, such a transfer policy will not increase inequalities among individuals with the same effort.

Alternative compensation: For all distribution of outcomes Y^1 and $Y^2 \in \mathcal{D}$, $Y^2 \succ Y^1$ if there exists e and $e' \in \{1, ..., m^e\}$ and τ and $\tau' \in \{1, ..., m^\tau\}$ such that for all $i \in \{1, ..., n^{\tau,e}\}$, all $j \in \{1, ..., n^{\tau,e'}\}$, all $l \in \{1, ..., n^{\tau',e}\}$, and all $g \in \{1, ..., n^{\tau',e'}\}$ with $V(\cdot, e) > V(\cdot, e')$, $p(e; c_\tau) > p(e; c_{\tau'})$ and $\phi(O(Y^1(\tau))) > \phi(O(Y^1(\tau')))$,

$$u_i^1 - t = u_i^2 > u_j^2 = u_j^1 + t \ ,$$

$$u_l^1 - t = u_l^2 > u_g^2 = u_g^1 + t$$

and Y^1 and Y^2 coinciding everywhere else.

Consider the examples shown in tables 5.4 and 5.5. The former shows a distribution Y^1 and the latter the distribution Y^2, where Y^2 results from applying the alternative compensation principle to the distribution Y^1. Each table shows two effort categories (e, e') and two types (τ, τ'). The cells show the number of individuals in each combination of effort and type, and the outcome obtained by individuals in each cell. The opportunity set for type τ is better than for τ' because in the former the proportion of individuals at effort category $e = 2$ is bigger. The compensation strategy reduces the inequality due to effort by introducing a transfer $t = 1$ from individuals with effort $e = 2$ to those with effort $e = 1$. This will reduce the inequality in the value of the opportunity sets between types, while respecting ETE, and it will not increase inequalities among individuals with the same effort.

Since this compensation strategy involves reducing inequalities within types it will

Table 5.4: *An example of the alternative compensation principle: distribution* Y^1

	Effort categories	
Type	e'	e
τ	$n = 1$ $u = 5$	$n = 9$ $u = 10$
τ	$n = 4$ $u = 5$	$n = 6$ $u = 10$

Table 5.5: *An example of the alternative compensation principle: distribution* Y^2

	Effort categories	
Type	e'	e
τ	$n = 1$ $u = 8$	$n = 9$ $u = 9$
τ	$n = 4$ $u = 8$	$n = 6$ $u = 9$

clash with liberal reward. Hence we have the following proposition.

Proposition 3: Liberal reward and alternative compensation are incompatible.

5.4. Empirical study

We are interested in assessing whether members of the public are willing to reduce inequalities that arise strictly due to the unequal distribution of effort across types and how such inequality reduction should be achieved. In particular, we would like to know whether members of the public prefer an A-EAC strategy or the alternative compensation principle suggested in the previous section.

To this purpose, we conducted a questionnaire-experimental study where the attitudes of members of the public regarding inequalities due to the inter-generational transmission of smoking preferences were explored. Adapting this situation to the framework of EO, parents' smoking habits are considered circumstances, children's preferences correspond to effort and children's lifespan is the outcome. In a scenario like this, a preventive policy would focus on reducing the exposure of children to smoking role models. Such a strategy

entails correcting the distribution of effort at its origin. Moreover, we are interested on a different problem which is how to reduce inequalities once effort (smoking habits) has been adopted. Furthermore, we assume that there is not a direct effect of circumstances, so the differences in the distribution of health outcomes across types is entirely explained due to a higher proportion of smokers among the children of smoking parents.

5.4.1. Sampling strategy

A short online survey was conducted among Chilean members of the public using Qualtrics software. The study had two phases, a pilot and the main study. In the pilot phase, 15 members of the public were interviewed online for about one hour to refine the wording of the questions and the overall structure of the survey. The participants of the pilot were older than 30 years, their highest educational attainment was secondary education or less, and were recruited through social media. In the main study the sample was recruited from an existing panel at the Centre for Experimental Studies (CESS) at the Universidad de Santiago. A non-probabilistic quota sampling strategy was used. Quotas were defined to match the characteristics of the Chilean population in terms of age, sex and education.

5.4.2. Survey design

The questionnaire faced respondents with a base-case scenario where there are different groups of individuals whose average or mean age at death (MAD) differs. After being introduced to the scenario, participants were asked to give a recommendation between alternative Programmes that could increase the lifespan of different individuals. The base-case scenario describes four groups of young adults who are equal with respect to all their characteristics (education, occupation, region of living, etc), besides their own smoking habits and their parents' smoking habits. There are 150 individuals whose parents were smokers and 150 individuals whose parents were non-smokers. Among the children of smoking parents, there are 100 smokers and 50 non-smokers. Among the children of non-smoking parents, there are 50 smokers and 100 non-smokers. Irrespective of the parents' characteristics, smokers live 10 years less than non-smokers.

Table 5.6 shows the distribution of effort and responsible effort across types. In this case, responsible effort corresponds to the counterfactual distribution of preferences had all the individuals had non-smoking parents. In such a counterfactual scenario half of the smokers among the children of smoking parents would have been non-smokers. In the table, x corresponds to the lifespan among non-smokers. The respondents were asked to choose between four alternative Programmes (A,B,C,D) that can increase the lifespan of different groups of individuals. The total benefit in terms of added life years was the same across the different Programmes (the figures used in the survey are available in the Appendix).

Programme A increases the lifespan of smokers by two years. This programme is compatible with the alternative compensation principle suggested in the previous section. It reduces inequality in the MAD between types and it does not increase inequality among individuals with the same effort. Moreover, such an allocation goes against the liberal reward principle since it reduces inequalities among individuals of the same type. Programme B increases the lifespan of the children of smoking parents by two years. This programme is compatible with A-EAC and Liberal Reward since it entails a reduction of *ex-ante* IO between types, while allocating equal transfers within types. This Programme increases inequality among individuals with the same effort. In terms of the reduction of IO from an *ex-ante* standpoint, Programme B is more effective than Programme A since it reduces the inequality in MAD between the children of smoking vs non-smoking parents in two years, whereas Programme A reduces it by approximately 0.7 years [3]. Programme C can be thought as a counter-compensation strategy since it increases the lifespan among non-smokers and increases the inequality in the MAD between types. Programme D increases the lifespan of all groups by one year. This programme is consistent with a normative position that considers that the intergenerational transmission of preferences should not be compensated.

[3]Programme A increases in two years the lifespan among smokers. There are 100 smokers among the children of smoker parents, which means that the average increase in lifespan among those whose parents smoke was $\frac{100*2}{150}$, whereas, among the children of non-smoking parents, it is $\frac{50*2}{150}$.

Table 5.6: *Allocation strategies used in the survey*

Parents	e	$\bar{e}$	Base	A	B	C	D	E
Smokers	S, n=50	S, n=50	$x-10$	$x-8$	$x-8$	$x-10$	$x-9$	$x-10$
	S, n=50	NS, n=50	$x-10$	$x-8$	$x-8$	$x-10$	$x-9$	$x-4$
	NS, n=50	NS, n=50	x	x	$x+2$	$x+2$	$x+1$	x
Non-smokers	S, n=50	S, n=50	$x-10$	$x-8$	$x-10$	$x-10$	$x-9$	$x-10$
	NS, n=50	NS, n=50	x	x	x	$x+2$	$x+1$	x
	NS, n=50	NS, n=50	x	x	x	$x+2$	$x+1$	x

S: smoker, NS: non-smoker, x: average age at death among non-smokers, e: realised effort, : responsible effort.

Notes: The table translates the allocation strategies shown to the respondents. Column two describes the observed distribution of smokers and non-smokers whereas column three shows the counterfactual distribution. Column four describes the average age at death among smokers and non-smokers. Columns five to nine show the average age at death for each group after the implementation of Programmes A,B,C, D and E.

Programme E was not included in the questionnaire since it violates ETE. Nevertheless we find useful to discuss this alternative Programme since it is an allocation strategy compatible with A-EPC. As shown in the table, this allocation strategy will allocate all the benefits to half of smokers among the children of smoking parents, since it is assumed that they would not have been smokers had they had non-smokers parents. This Programme violates ETE since allocates different benefits among individuals with the same effort and circumstances (smokers who are children of smoking parents receive different benefits).

Most respondents found it challenging to understand simple concepts regarding probabilities. Given this limitation, the original questionnaire was simplified and tested on a new sample of respondents until an acceptable level of understanding was reached by the participants in the pilot. Also, the survey included several slides with training material aimed to improve the respondents' understanding of the task.

We are interested in exploring what is the most preferred Programme for each respondent. The simplest strategy to obtain such information would be to face respondents with the four Programmes simultaneously. We explore the feasibility of this kind of design during the pilot phase of the study. The results of the pilot showed that most respondents

feel overwhelmed and are not able to compare the four Programmes at the same time. Due to this constraint, the following strategy was adopted. Each respondent was shown a sequence of scenarios comparing two Programmes at a time. Besides opting for one of the Programmes, a third alternative was included that aims to capture indifference and incomplete preferences ("Both Programmes are equally good, or I do not know how to answer this question and I would prefer not to choose any.").

We interpret that the most preferred Programme of each participant is the one which is preferred to each of the three alternative Programmes. The main assumption behind this design is that respondents' choices satisfy the principle of Expansion Consistency (Sen, 1971), which states that if an alternative is chosen in several small contests it should also be chosen in a larger contest that includes all the alternatives involved in the small contests. This entails that if a respondent chooses Programme A against Programmes B, C and D, she should also choose Programme A when faced with the four Programmes at the same time. The sequence of scenarios was a function of the answers to each question and it was designed to minimize the number of scenarios shown to each respondent. The sequence was the same for all respondents, conditional on the answers to each question. The questionnaire ended when there was one Programme that beats the others or when a single most preferred alternative could not be retrieved either because respondents' choices: i) were not acyclic or ii) show indifference or incompleteness between two mutually exclusive pair of alternatives (e.g. a respondent is indifferent or cannot choose between Programme A and B and between C and D).

5.4.3. Results

The survey was completed by 257 participants. During the pilot we estimated that it should take about 15 minutes to go through the survey. The average time of response among the participants in the main study were 22 minutes and the percentiles 5 and 95 were 1 and 55 minutes, respectively. In the analysis, we included only the responses of participants to whom it took between 5 and 50 minutes to complete the questionnaire. We consider that is not plausible to complete the questionnaire in less than five minutes

and that taking more than 50 minutes could either point to a lack of understanding in the exercise or a poor engagement with the task.

From the 228 valid responses, in nearly 27% of cases, it was not possible to identify the most preferred alternative of the respondents. In almost all cases (95%) this was because the choices made by the participants violate acyclicity. In the rest of cases, this was because participants declare to be indifferent or not being able to choose between two mutually exclusive pair of alternatives.

Table 5.7 shows the results corresponding to those participants for whom their most preferred alternative was identified. The majority of respondents chose Programme D, which is the alternative that offers equal benefits to each group. This alternative does not reduce inequalities between types. Among the two Programmes that reduce inequalities between types, the number of respondents who choose Programme A was around three times higher than those who choose Programme B. If one is willing to make inferences from these results, it could be argued that respondents privilege a reduction of inequalities between types that do not increase inequalities among individuals with the same effort, even if this entails going against Liberal Reward. It is interesting that around 21% of the respondents chose Programme C, which corresponds to the counter-compensation strategy, which increases inequalities between smokers and non-smokers and between the children of smoking and non-smoking parents.

Table 5.7: *Distribution of the most preferred alternative among participants*

Programme	n	%
Programme A	39	23.5
Programme B	14	8.4
Programme C	35	21.1
Programme D	78	46.7
Total	166	100

5.5. Discussion

Although in most empirical applications it is assumed that the direct and indirect effect of circumstances are illegitimate, the theoretical literature has focused on the former, and little has been said about how the EO axioms should be interpreted depending on whether the unequal distribution of effort across types is considered legitimate or not. This paper shows that when there is an indirect effect of circumstances which is considerate unfair, the *ex-post* approach to compensation may violate a basic impartiality requirement, which is that individuals with the same effort and circumstances should be subject to the same transfers.

This has important implications for the canonical model of EO developed by Roemer, which favours a compensation strategy among individuals with the same accountable effort. As we have shown, the assumptions in Roemer's model guarantee that there will be no clash between such a compensation strategy and ETE. However, if the CDF of a given outcome is not a strictly increasing function, it is not possible to guarantee that there will be no incompatibility. Moreover, the empirical CDF of any continuous variable, such as income, will never be a continuous but a step function, in which case it cannot be guaranteed that there is no incompatibility between A-EPC and ETE [4].

We have argued that, even if the unequal distribution of effort is judged as illegitimate, it may be desirable to use effort, rather than responsible effort, as a measure of inter-type responsibility. Consider for instance the scenario used in the empirical study. In that scenario, responsible effort corresponds to the counterfactual smoking behaviour of individuals had they face different role models in their childhood. There are two considerations regarding using responsible effort as a measure of inter-type responsibility. First, responsible effort is not observable, so in practice, it will not be feasible to rely on such a

[4] In this regard, it could be argued that econometric tools could be used to smooth such an empirical distribution while considering that in the universe of population, the distribution is continuous. This will allow obtaining measures of inequality of opportunity based on the smoothed distribution. However, from a policy perspective the problem cannot be solved in this way because a compensation policy should allocate transfers according to the observed level of effort and not according to the level of effort predicted based on some statistical estimation technique.

measure. Second, even if it were observable, it is hard to hold individuals responsible for choices they have not to make. In particular, it will be hard for smokers to accept that only those who would have been non-smokers under different childhood circumstances should receive the benefits of a given programme. In this regard, the alternative compensation principle proposed in this Chapter is attractive since it reduces inequalities between types and at the same time, it avoids holding individuals responsible for their counterfactual level of effort.

Based on the results of the survey, it seems that the alternative compensation principle that was suggested in this paper finds support among members of the public and that is preferred to an A-EAC strategy. This is consistent with respondents being keen on reducing inequalities in opportunity sets without increasing inequalities due to effort. The questionnaire-experimental study also showed that most respondents chose an alternative that does not reduce inequalities across types (Programme D). Moreover, this does not necessarily means that respondents would not want to reduce inequalities due to an unequal distribution of preferences. Perhaps, respondents would have preferred Programme E or a preventive strategy, neither of which were included among the alternatives.

There are several caveats in relation to this experiment. The sample was recruited through a non-probability sampling method and the sample size is small. The order of the alternatives shown to the respondents was not randomized. In this regard, we cannot discard the presence of order bias in our design. In addition, we rely on the principle of Expansion Consistency to identify the most preferred alternative of each participant. However, we have not provided evidence about to what extent this principle holds among respondents.

As it was explained in section 5.4.2, during the pilot we found that most respondents could not understand basic notions of probabilities and most of them found the tasks of the questionnaire challenging. In this regard, the high proportion of acyclic preferences calls into question the validity of the results. This is consistent with the low levels of proficiency in literacy, numeracy and problem-solving observed in the country (OECD,

2016). As it is usually done in questionnaire-experimental studies we could have targeted university students instead of targeting members of the public, since (probably) students have a higher level of understanding. However, although students may be better equipped to answer this kind of questionnaire, we are trying to obtain a valid measure of what are the preferences of Chilean members of the public. In this regard, the low levels of functional literacy of the population pose a major challenge for this kind of study since we are in a situation where we can either i) obtain a valid measure of preferences for a non-representative sample of members of the public (e.g. university students), or ii) obtain a biased measure of preferences for a representative sample of members of the public. Unfortunately, neither of these alternatives serves our purpose well.

Despite these limitations, the study found that a compensation strategy that involves reducing inequalities within types may be a strategy that may find some support among members of the public.

Authorship statement

A "CRediT" author statement (Elsevier, 2020) for this paper is as follows:

Nicolas Silva: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - Original draft, Reviewing and Editing, Project administration.

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Chapter 6: Liberal reward and healthy lifestyles: A questionnaire-experimental study

Abstract

The literature on equality of opportunity distinguishes between two sets of factors: effort (factors which individuals should be held accountable for) and circumstances (factors which are beyond the individuals' responsibility). Equality of opportunity involves the attainment of two kinds of principles. Compensation principles are about reducing inequality among individuals with different circumstances, whereas reward principles inform how to deal with inequalities due to effort, among individuals with the same circumstances. The liberal reward principle suggests that a redistributive policy should be neutral with respect to the inequality that arises due to legitimate factors, which implies that individuals who have the same circumstances should receive the same redistribution. This study seeks to apply these concepts to the interplay between lifestyles and health. Furthermore, the paper aims to challenge the above notion of neutrality and propose an allocation that prioritizes individuals who choose 'unhealthy' lifestyles even if lifestyle heterogeneity results from individuals exerting their preferences over the same choice set. A questionnaire-experimental design is used to understand to what extent these concepts find support among a representative sample of Chilean adults.

6.1. Introduction

Inspired by luck-egalitarianism (or responsibility-sensitive egalitarianism), Equality of Opportunity (EO) has become a widely used theory to evaluate fairness in the distribution of achievements within society (see Roemer and Trannoy (2015) for a review). According to EO, a given distribution of achievements is a function of a set of factors that are beyond an individual's responsibility (referred to as circumstances) and a set of factors for which the individual should be held accountable (referred to as effort). For a given partition of circumstances and effort, EO will be attained if two principles hold: compensation and reward (for a review of principles see Ramos and Van de gaer (2016); Bosmans and Öztürk (2021)).

A compensation principle is about reducing inequalities among individuals with different circumstances, whereas a reward principle is about dealing with inequalities in achievements entirely due to differences in effort among individuals with the same circumstances. Frameworks of EO differ by the version of the reward and compensation principles they favour and how effort and circumstances are defined (Fleurbaey, 2009; Fleurbaey and Schokkaert, 2011).

In the EO framework developed by Fleurbaey (2008), effort is understood as a matter of individuals' preferences, which should be respected [1]. Preferences in this framework cannot be equated to choices or revealed preferences since choices are also a function of the menu of alternatives faced by the individuals, which may be unfairly constrained due to circumstances. However, among individuals with the same circumstances (i.e. who face the same menu of alternatives), inequalities with respect to a given achievement can be considered legitimate since they are a function of the individuals' preferences. The reward principle that follows from this definition of effort is called 'liberal reward'. The liberal reward principle is based on a notion of neutrality in the sense that a redistributive policy should be independent of (or not react to) changes originating in legitimate factors.

[1] Two special cases when there may be a duty to override an individual's preference is when the individual does not endorse their preferences (e.g. addictions and cravings) and when the individual has immature or impaired cognitive skills (e.g. children, adults with dementia).

This entails that individuals who have the same circumstances should receive the same redistribution so as not to change the inequality (in absolute terms) among them.

Applied to the measurement of Inequality of Opportunity (IO), the liberal reward principle informs a condition called 'no influence of legitimate factors', according to which "a measure of unfair inequality should not reflect legitimate variation in outcomes, i.e. inequalities which are caused by differences in the responsibility variables" (Fleurbaey, 2009, p.75).

This paper has three aims. First, to understand how this definition of effort could be applied to the relationship between health-related lifestyles and health outcomes. Second, to offer an alternative approach to reward that, instead of being neutral, can be used to justify prioritizing the worst-off (in terms of health outcomes) among individuals with the same circumstances. Third, to assess to what extent these principles find support among members of the public.

6.2. The liberal reward principle and health inequalities due to chosen lifestyles

According to the liberal reward principle, any distribution that results from individuals choosing from the same menu of choice-outcome pairs (and who therefore have the same circumstances) is legitimate. In the context of health-related lifestyles and health outcomes, the liberal reward principle will be understood as follows.

Let $\boldsymbol{X_i}$ denote a vector of aspects of life that may matter to an individual i. This vector includes the individuals' health status H_i, their lifestyles L_i, and a vector $\boldsymbol{Z_i}$ of other life dimensions. We focus on a scenario where a group of individuals share the same set of characteristics $\boldsymbol{Z}$ and they need to choose from a set Ω which is composed of a set of lifestyles and health status pairs $(L, H) : \Omega = \{(L_1, H_1), (L_2, H_2), \ldots, (L_M, H_M)\}$.

Let $L \in \boldsymbol{L}$ be a vector of dimension M that describes the set of feasible lifestyles that

individuals can choose, and $H \in \mathbb{R}_+$ a cardinal measure of health. For two given pairs of lifestyles and health status (L, H) and (L', H'), we say that a lifestyle L is healthier than a lifestyle L', if $H > H'$.

Against this background, now imagine that a decision-maker needs to decide how to further improve the health status of these individuals at a given cost. According to the liberal reward principle, if the decision-maker uses an absolute measure of inequality, the only way to do this in a neutral manner is by improving the health of all individuals by the same degree, since only such an allocation will maintain the original inequality of health.

6.3. The argument against the liberal reward principle

We would like to focus on one possible argument against the liberal reward principle that may favour a more egalitarian distribution of health. According to Fleurbaey (2008), there may be a justification for reducing inequalities when a given menu of alternatives is less favourable for individuals with certain kinds of preferences.

From the individuals' perspective, the shape of the choice set ω is beyond their control, so the individuals' cannot influence the (health) return to each lifestyle. Moreover, the individuals may have different preferences for health and lifestyles. In this regard, even if individuals are to be responsible for their preferences they should not be held accountable for how favourable the shape of the choice set is with respect to their preferences. In the following section, we address how to assess how favourable the shape of a given choice set is to different kinds of individuals' preferences.

6.3.1. Evaluating individuals' life situations according to their preferences

We assume that each individual i has a preference ordering R_i regarding the combination of life situations in terms of both L and H. If i weakly prefers (L, H) to (L', H') it is

denoted by $(L_i, H_i)R_i(L_i', H_i')$. Furthermore, let $(L_i, H_i)I_i(L_i', H_i')$ denote indifference and $(L_i, H_i)P_i(L_i', H_i')$ denote strict preference.

It will be assumed that, for any individual i and conditional on any lifestyle L, the ranking of any pair of health statuses H and H' is the same, and that such a ranking is the same across individuals. For a given individual i, conditional on any health status H, the ranking of any pair of lifestyles L and L' is the same. Moreover, for at least one health status H, and for at least one pair of lifestyles L and L', there is no unanimous agreement about how to rank (H, L) and (H, L'). This entails that i) individuals coincide about their most preferred health status, ii) individuals differ regarding their most preferred lifestyles and iii) the utility from lifestyles does not depend on the utility from health status. The most preferred lifestyle for each individual will be denoted by L_i^1.

We discuss two criteria that could be used to make interpersonal comparisons in terms of (L, H, R), namely the weak dominance principle and equivalent health.

Adapted to this scenario, according to the *weak dominance principle* Decancq et al. (2015) an individual is better off than another if she has better health when both individuals have their most preferred lifestyles. More formally it can be defined as follows:

Weak dominance principle. (L_i^1, H_i, R_i) *is equally well off as* (L_j^1, H_j, R_j) if $H_i = H_j$, *and strictly better if* $H_i > H_j$.

Decancq et al. (2015) argue that a basic requirement to assess individual life situations respecting the individuals' preferences is the personal preference principle. Adapted to this scenario, this principle asserts that from the perspective of a single individual (L, H, R) is as good as (L', H', R) if $(L, H)R(L', H')$ and strictly better if $(L, H)P(L', H')$.

Equivalent income is a metric that allow to compare the life situations of individuals with respect to non-income attributes (Fleurbaey, 2016). Given a set of life dimensions, equivalent income equals the amount of money that makes an individual indifferent

between her current situation and a counterfactual scenario where the non-income life dimensions are fixed at a reference category. We apply the same concept here, using a cardinal measure of health, instead income. Therefore, it is possible to characterize the life situations of individuals in terms of equivalent health $\bar{H}_i$, which corresponds to the counterfactual level of health that, when combined with a reference level of lifestyles L^*, is as preferable to the individual as her current situation.

The equivalent level of health is therefore defined as the solution $\bar{H}_i$ to the following equation:

$$(L_i, H_i)I_i(L^*, \bar{H}_i)$$

As it happens with equivalent income, the choice of the reference category (lifestyles in this case) is not normatively neutral since this metric implicitly prioritizes those individuals who have a stronger (as opposed to weaker) preference for the reference category. As shown by Decancq et al. (2015), when the personal preference principle and the weak dominance principle are combined, this is equivalent to adopt the equivalent approach using as the reference the most preferred category of each individual, which in this case it corresponds to the most preferred lifestyle for each individual L_i^1. Choosing the most preferred lifestyle as the reference is attractive since, for those individuals who choose their most preferred lifestyle, weak dominance holds, so their life situations can be compared strictly in terms of their health status.

6.3.2. Assessing how favourable a choice set is for different kinds of preferences

We will use equivalent health to measure how favourable a given menu of alternatives is for individuals with different kinds of preferences. Consider a choice set like the following, where individuals need to choose between two lifestyle-health pairs:

$$\Omega = \{(H, L^h), (H - \theta, L^{uh})\} ,$$

with $H > \theta > 0$. We will refer to L^h and L^{uh} as healthy and unhealthy lifestyles, respectively.

We will focus on four kinds of preferences and discuss the choice behaviour an equivalent health associated with those preferences. The first column in Table 7.2.1 shows four kinds of preferences, the second column shows the most preferred lifestyle associated with each preference and the third column shows the choice behaviour that follows from applying each preference to the choice set Ω, while the fourth column shows the equivalent health with $L^* = L_i^1$ for each kind of preference.

These preferences can be summarised as follows. Individuals with preferences of the kind R^1 prefer to adopt L^{uh} even if this involves poor health. Individuals with preferences R^2 adopt L^h because they want to achieve a better health status, but they dislike engaging in healthy lifestyles. Individuals with preferences R^3 only cares about health while individuals with preferences of the kind R^4 enjoy adopting healthy lifestyles.

We now provide a more detail explanation of each kind of preference. Individuals with preferences R^1 have a strong preference for the unhealthy lifestyle and their most preferred lifestyle is the unhealthy lifestyle. They will choose the unhealthy lifestyle even if there is a health disadvantage as large as γ attached to such behaviour (with $\gamma >> \theta$). Therefore, when faced with the choice set Ω, they choose $(H-\theta, L^{uh})$. Their equivalent health (using L_i^1 as the reference) equals their current health status since they have adopted their most preferred lifestyle.

Individuals with preferences R^2 have a strong preference for the unhealthy lifestyle, but the strength of their preference is weaker compared to individuals with preferences of the kind R^1. Their most preferred lifestyles is the unhealthy lifestyle. They will choose the unhealthy lifestyle, provided that the resulting health loss is smaller than θ. Therefore, when faced with the choice set Ω, they choose (H, L^h). Their equivalent health equals $H - \theta + \delta$, where δ is a fixed positive quantity close to zero ($\theta >> \delta > 0$). Accordingly, they are indifferent between their current situation (H, L^h) and a situation that offers a health status slightly better than $H - \theta$ in combination with the unhealthy lifestyle.

Those with preferences R^3 have a weak preference for the unhealthy lifestyle and their most preferred lifestyle is the unhealthy lifestyle. They will choose the unhealthy lifestyle only if the resulting health loss is very small. Given this, faced with the choice set Ω, they choose to adopt the healthy lifestyle. Their health equivalent equals $H - \delta$, since they are indifferent between their current situation an a situation that combines the unhealthy lifestyle with a health status slightly worse than H.

Individuals with preferences R^4 have a strong preference for the healthy lifestyle and their most preferred lifestyle is the healthy lifestyle. Therefore, when faced with the choice set Ω, they choose (H, L^h). Their equivalent health equals their current health status since they have adopted their most preferred lifestyle.

Table 6.1: *Four kinds of preferences*

Preferences	$\mathbf{L_i^1}$	**Choice behaviour**	**Equivalent health** $L^* = L_i^1$
$R_i^1 = (H - \gamma, L^{uh})P_i(H, L^h)$, with $\gamma >> \theta$	(L^{uh})	$(H - \theta, L^{uh})$	$H - \theta$
$R_i^2 = (H, L^h)P_i(H - \theta, L^{uh})$, $(H, L^h)I_i(H - \theta + \delta, L^{uh})$, with $\theta >> \delta > 0$	(L^{uh})	(H, L^h)	$H - \theta + \delta$
$R_i^3 = (H, L^h)P_i(H - \theta, L^{uh})$, $(H, L^h)I_i(H - \delta, L^{uh})$, with $\theta >> \delta > 0$	(L^{uh})	(H, L^h)	$H - \delta$
$R_i^4 = (H - \theta, L^h)P_i(H, L^{uh})$	(L^h)	(H, L^h)	H

L^{uh}: unhealthy lifestyle, L^h: healthy lifestyle, L^*: reference level of lifestyle for the equivalent health measure.

Notes: The first column of the table represents four kinds of preferences (R^1, R^2, R^3, R^4). The second column shows the most preferred lifestyle (L_i^1) for each kind of preference. The third column describes the choice behaviour given each kind of preference and the choice set Ω. The fourth column represents the equivalent level of health for each kind of preference, using the most preferred lifestyle (L_i^1) as the reference.

Table 7.2.1 also illustrates, in terms of equivalent health, how favourable the choice set Ω is for each kind of preference. Given a criterion to assess how favourable a choice set is with respect to the individuals' preferences, and considering that individuals should

not be held accountable for the shape of the choice set, the following principle can be proposed: an allocation which prioritizes those individuals for whom the choice set is less favourable without changing the ranking of individuals in terms of H produces a distribution which is at least as good as the original distribution.

6.4. The empirical study

6.4.1. Research objectives

First, we would like to explore the views of members of the public towards health inequality attributed to chosen lifestyles and to examine if the liberal reward principle finds support among them. Second, we would like to assess if members of the public support an allocation that prioritizes the worst-off defined by the health equivalent approach. To explore these research questions we conducted a questionnaire-experimental study. In this section, we cover the basics of the methodological strategy, whereas the empirical design is covered in the next section.

The 'base scenario' used in the questionnaires is the following. We focus on a hypothetical situation where there are two groups of individuals who have the same characteristics and they need to choose from a set Ω which is composed of a set of pairs of lifestyles and health status:

$$\Omega = \{(H, L^h), (H - \theta, L^{uh})\} ,$$

with $H > \theta > 0$.

There are public resources to improve the health of each person by quantity ρ, with $\rho < \theta$, and the following three alternative allocation strategies can be achieved at the same cost:

$$\Omega^A = \{(H, L^h), (H - \theta + \rho, L^{uh})\}$$

$$\Omega^B = \{(H + \rho, L^h), (H - \theta, L^{uh})\}$$

$$\Omega^C = \{(H + 0.5\rho, L^h), (H - \theta + 0.5\rho, L^{uh})\}$$

Note that the allocation strategy Ω^C is compatible with the liberal reward principle (assuming the inequality measure is based on absolute difference) because it improves the health status of each group by the same amount.

The first objective is to assess if the liberal reward principle finds support among members of the public. We ask respondents to imagine a scenario represented by the above and assess the extent to which respondents choose a strategy other than Ω^C. Moreover, to establish that the respondents' choice pertains to inequalities that are attributable to freely chosen lifestyles, we include a control scenario where respondents are asked to choose among the same three allocation strategies, but with the health inequality being caused by several factors besides lifestyles (see next section).

Our second objective is to assess if members of the public are willing to prioritize the worst-off in terms of equivalent health, with $L^* = L_i^1$. In addition, we want to explore if the responses of members of the public vary in relation to the magnitude of the inequality in terms of equivalent health and the kind of preference that individuals have. Consider the inequalities in terms of equivalent health that are shown in Table 6.2. We denote by $\bar{H}(R)$ the equivalent health among individuals with preferences R. In the first case, when comparing the life situations of individuals with preferences R^2 and R^1, the inequality in terms of equivalent health is close to zero, since both individuals have strong preferences for unhealthy lifestyles. In contrast, the inequality between individuals with preferences R^3 and R^1 is close to θ, because individuals with preferences R^3 are only willing to engage in their most preferred lifestyle (i.e. the unhealthy lifestyle) provided that they can achieve a health status slightly worse than $H-\theta$. Similarly, the inequality between individuals with preferences R^4 against individuals with preferences R^1 equals the difference in the health status of these individuals, since individuals with preferences R^4 and R^1 adopt

their most preferred lifestyle and their equivalent health equals their current health status.

Table 6.2: *Inequality in terms of equivalent health for three preferences pairs*

Contrasts for three pairs of preferences	**Inequality in equivalent health, with $L^* = L_i^1$**
$\bar{H}(R^2) - \bar{H}(R^1)$	$\cong 0$
$\bar{H}(R^3) - \bar{H}(R^1)$	$\cong \theta$
$\bar{H}(R^4) - \bar{H}(R^1)$	θ

Notes: The table describes the inequality in terms of equivalent health for three pairs of preferences. For example, $\bar{H}(R^2)$ corresponds to the equivalent level of health given preference R^2 using the most preferred lifestyle as the reference. The equivalent level of health for each kind of preference is shown in Table 7.2.1.

We would like to explore if the choices of allocation strategies by members of the public vary with respect to the preferences of the individuals of the hypothetical scenario. In order to do this we use scenarios that replicate the comparisons shown in Table 6.2. It is plausible that members of the public will be less willing to prioritize the worst-off when the individuals who adopt healthy lifestyles have strong preferences for unhealthy lifestyles (R^2 vs R^1) which implies that the inequality in terms of equivalent health is minimal, and more willing to prioritize the worst-off when weak dominance holds (R^4 vs R^1) or when the individuals who adopt the healthy lifestyle have a weak preference for the unhealthy lifestyle (R^3 vs R^1), which in both cases involve an inequality in equivalent health with the same (or almost same) magnitude (θ).

Moreover, members of the public may have pre-established beliefs regarding the preferences of individuals with healthy and unhealthy lifestyles, and may not necessarily take into account the information about preferences provided in the questionnaire. We try to capture the beliefs of respondents by asking them whether they think engaging in healthy lifestyles involves more effort *vis a vis* adopting unhealthy lifestyles. Arguably, the common use of the term 'effort' refers to actions that are costly for the individual, so individuals exerting effort to engage in healthy lifestyles means that they experience a

disutility by engaging in such behaviours. In this regard, individuals with preferences of the kind R^3 and R^4 do not 'exert effort' to engage in healthy lifestyles; the former chooses the healthy lifestyle because they only care about health and the latter do so because they enjoy the healthy lifestyle. In contrast, individuals with preferences R^2 exert effort since they experience disutility from engaging in healthy behaviours and to some extent will be willing to achieve a worse health status in order to avoid healthy lifestyles.

6.4.2. The empirical design

To assess the attitudes of members of the public towards health inequality due to chosen lifestyles the following design was implemented. Respondents were randomly allocated to four sub-samples. Each sub-sample was faced with exercises with a hypothetical scenario that described two groups of young adults who live up to different ages (Table 6.3). The exercises differ regarding the information provided to the respondents about the cause behind this health inequality. In exercise 1 the respondents were told that the two groups differ concerning several factors that explain this difference: "Their occupation, education, income, health-related lifestyles, etc.". The order in which these factors were presented to the respondents was randomized. The idea was to remind the respondents of the same set of different possible causes but without giving any specifics. Exercises 2 and 3 were about two groups of young adults who have different health-related lifestyles. Exercise 2 compared a group of those who smoke and a group of those who do not, while Exercise 3 compared a group of those who have a healthy diet, get exercise and have a normal weight and a group of those who have an unhealthy diet, do not get exercise and are overweight [2]. In both exercises, respondents were told that apart from these lifestyles, both groups i) share the same characteristics in terms of income, educational status, occupation, and so on; ii) are of equal size, and iii) have the same number of men and women.

Exercise 1 is used as a 'control' scenario. This scenario allows contrasting the attitudes of respondents regarding health inequalities when health inequality is 'due to several rea-

[2] The reason to group these three risk factors in exercise 3 is that evidence shows that the joint impact of these lifestyles in adult life expectancy is similar to the impact of smoking.

Table 6.3: *Empirical design: information about preferences shown to each sub-sample across the three exercises*

	Sub-samples			
	1	**2**	**3**	**4**
Exercise 1: inequality due to multifactorial cause	No information about preferences	No information about preferences	No information about preferences	No information about preferences
Exercise 2: inequality due to smoking	No information about preferences	R^1 vs R^2	R^1 vs R^3	R^1 vs R^4
Exercise 3: inequality due to diet, exercise and obesity	No information about preferences	R^1 vs R^2	R^1 vs R^3	R^1 vs R^4

sons' and when this inequality is strictly due to chosen lifestyles. Respondents were asked to imagine that the government needs to choose between three alternative programmes (programmes A, B and C, corresponding to Ω^A, Ω^B, and Ω^C above) which cost the same and that will improve the population's health by extending people's life. Participants were asked to provide a recommendation about which programme to implement. Programme A extended the life of those in the first group only by two years; Programme B extended the life of those in the second group only by two years; whereas Programme C extended the life of those in both groups by one year each. Respondents could indicate the programme that they would recommend, or indicate indifference ("All the programmes are equally good"). Furthermore, to allow for incomplete preferences, respondents could indicate being indecisive ("I do not know how to answer, or I would prefer not to make this kind of choice.").

To assess if respondents support an allocation that prioritizes the worst-off according to the health equivalent approach and the weak dominance principle, sub-samples 2, 3 and 4 receive information about the preferences of the individuals in the hypothetical scenarios of exercises 2 and 3. Across the three sub-samples, respondents were told that those with 'unhealthy' lifestyles have preferences of the kind R^1, whereas participants in sub-sample 2, 3 and 4 were told that those who engage in healthy lifestyles have prefer-

ences of the kind R^2, R^3 and R^4, respectively. Tables A.6.1 and A.6.2 in the Appendix show the way these preferences were described to the respondents.

To understand what may be the beliefs of respondents regarding the kind of preferences of individuals who adopt healthy lifestyles, participants were asked to what extent they agree with the following statement: "*People who engage in healthy lifestyles exert more effort than those who adopt unhealthy lifestyles*". Answer categories were: strongly agree, agree, disagree, strongly disagree, I do not know how to answer.

6.4.3. Test of hypothesis

A multinomial probit model was used to test if the attitudes of the respondents towards health inequality differ when this is caused by chosen lifestyles or due to multiple factors. Only respondents allocated to sub-sample 1 were included in this analysis since this sub-sample was the only one that did not receive information about preferences. Given that we are contrasting the answers of the same respondents across three different exercises, cluster standard errors were used. For each answer category, the difference in the relative frequency of answers between the exercises was estimated by computing the average marginal effect (AME). For each respondent, the AME computes the difference in the predicted probability of each answer category when facing a given pair of exercises and then it computes the average difference across observations. A similar strategy was used to test if the distribution of answers in exercises 2 and 3 varies depending on the information about preferences faced by respondents in sub-samples 2, 3 and 4.

We test if the attitudes of the respondents vary depending on their beliefs about whether individuals who engage in healthy behaviours exert effort. The answers were dichotomised into strongly agree-agree, and disagree-strongly disagree. A probit model was used and the difference in the relative frequency of answers was estimated by computing the AME. We excluded from all the analyses the answers that indicate incomplete preferences ("*I do not know how to answer, or I would prefer not to make this kind of choice.*").

6.4.4. Study design

This study collected primary data through an online survey conducted with a representative sample of the Chilean members of the public. As it was mentioned in Section 4.2.3, respondents were first asked to answer the set of questions reported in Chapter 4 ('effort survey') and then the questions reported in this chapter ('liberal reward survey'). Although the answers to the liberal reward survey could have been influenced by the exposure to the effort survey, there should be no heterogeneity in such an influence since all the participants were exposed to the effort survey and the order of the questions in that questionnaire was the same for all the participants.

The questionnaire was presented using Qualtrics, and it was self-administered without an interviewer. The sample is recruited from an existing panel at the Centre for Experimental Social Sciences (CESS) at the University of Santiago. Quotas were defined to match the demographics of the Chilean population in terms of sex, age groups (20 to 49 years, and older than 50 years), and educational attainment (secondary education or less, and higher than secondary education). The target sample size was 720 (180 per subsample).

The study included a pilot phase where 12 respondents were interviewed online to check the interpretation of the questions. One of the main challenges for the pilot was to translate each kind of preference into clear descriptions. After trialing several versions, the versions shown in Tables A.6.1 and A.6.2 in the Appendix were selected for achieving a reasonable balance between simplicity and accuracy in representing the theoretical definition of each kind of preference.

6.5. Results

There were 5,388 people who expressed their intention to participate. From these, 760 people were selected to match the demographic characteristics defined in the quotas and 675 completed the questionnaire: 157 in sub-sample 1, 188 in sub-sample 2, 180 in sub-

sample 3 and 150 in sub-sample 4. On average, it took respondents 36 minutes to complete the questionnaire. There were 58 (7.6%) respondents who complete the questionnaire in less than five minutes and 38 (5%) who complete the task in more than one hour. Overall, the majority of respondents across the three sub-samples and the three exercises chose one of the allocation strategies (or declared to be indifferent between them) whereas the proportion of respondents that declare to be indecisive ("*I do not know how to answer, or I would prefer not to make this kind of choice.*") was not higher than 1.5% in any of the exercises (data not shown).

Table 6.4 shows the results across the three exercises among sub-sample 1. The allocation compatible with the liberal reward principle (Programme C) was supported by 34.6% of the respondents when inequality is due to smoking and 42.4% when is due to diet, exercise and obesity. In both scenarios, roughly 33% of respondents choose to reduce health inequality due to chosen lifestyles, whereas around 30% and 23% chose to increase it when inequality is due to smoking and due to diet, exercise and obesity, respectively.

The fourth (sixth) column of Table 6.4 reports the estimated difference in the relative frequency of each answer between exercise 1 and exercise 2 (3). The results show that the attitudes of respondents differ depending on the cause of inequality. Compared to the scenario where health inequality is due to multifactorial causes, when faced with the scenarios where the health inequality is due to chosen lifestyles, a lower proportion of respondents choose to reduce health inequalities or choose a neutral allocation and a higher proportion of respondents choose to increase the health inequality.

Tables 6.5 and 6.6 show the answers to exercises 2 and 3 across the sub-samples 2, 3 and 4. The AME is used to estimate the difference in the relative frequency of each answer between sub-sample 2 and sub-samples 3 and 4. As it was expected, compared to respondents in sub-sample 2 (who face a scenario where the individuals who choose healthy lifestyles have strong preferences for unhealthy lifestyles), a higher proportion of respondents in sub-sample 3 and 4 chose the allocation that increases the health inequality while a lower proportion chose an allocation that preserves or reduces the health

Table 6.4: *Attitudes towards health inequality given different causes: sub-sample 1*

Choice alternatives	**Exercise 1: multifactorial cause** %	**Exercise 2: smoking** %	**Exercise 1 vs exercise 2 AME (p-value)**	**Exercise 3: diet, exercise and obesity** %	**Exercise 1 vs exercise 3 AME (p-value)**
Programme A (ineq. red.)	40.1	33.3	-6.8 (0.15)	33.5	-6.6 (0.17)
Programme B (ineq. incr.)	7.6	29.6	21.9 (0.00)	22.8	15.1 (0.00)
Programme C (neutral)	47.8	34.6	-13.1 (0.00)	42.4	-5.4 (0.28)
Indifferent	4.5	2.5	-1.9 (0.30)	1.3	-3.1 (0.06)
Total	100.0	100.0		100.0	
N	157	159		158	

Notes: The fourth and sixth columns of the table show the computed difference between the proportion of respondents choosing each alternative in exercise 1 vs exercise 2 and exercise 1 vs exercise 3, respectively. The differences and their statistical significance were obtained by computing the Average Marginal Effect (AME) after running a multinomial probit model using the choice alternatives as the dependent variable and the exercise as the independent variable. Since the choice alternative is a categorical variable, the AME represents the average predicted difference in the probability of choosing a given choice alternative between two kinds of exercises.

inequality. However, almost none of these differences were statistically significant.

As was discussed in Section 6.4.2, respondents may have their own beliefs regarding the kind of preferences among individuals with healthy lifestyles. If participants answer the survey based on their own beliefs rather than on the information provided in the survey, the results on Tables 6.5 and 6.6 will be biased. To understand the beliefs of respondents we asked them to declare to what extent they consider that adopting healthy behaviours involve more effort than adopting unhealthy lifestyles.

Around 77% of respondents either agree or strongly agree with this statement, whereas 23% disagree or strongly disagree. Table 6.7 compares the answers to exercises 2 and 3

Table 6.5: *Attitudes towards inequality conditional on beliefs about lifestyles' preferences, exercise 2*

	Exercise 2: smoking				
	Sub-sample 2	**Sub-sample 3**	**Sub-samples 2vs3 AME (p-value)**	**Sub-sample 4**	**Sub-samples 2vs4 AME (p-value)**
	R^1**vs**R^2	R^1**vs**R^3		R^1**vs**R^4	
Choice alternatives	%	%		%	
Programme A (ineq. red.)	32.7	39.8	-7.1	42.4	-9.7
			(0.18)		(0.07)
Programme B (ineq. incr.)	19.7	13.4	6.3	16.4	3.3
			(0.13)		(0.44)
Programme C (neutral)	45.6	42.5	3.1	36.7	8.9
			(0.57)		(0.11)
Indifferent	2.0	4.3	-2.3	4.5	-2.5
			(0.23)		(0.20)
Total	100.0	100.0		100.0	
N	147	186		177	

Notes: The fourth column of the table shows the computed difference in the proportion of respondents choosing each choice alternative in sub-sample 2 vs sub-sample 3. The sixth column shows the difference between sub-sample 2 and sub-sample 4. The differences and their statistical significance were obtained by computing the Average Marginal Effect (AME) after running a multinomial probit model using the choice alternatives as the dependent variable and the sub-sample as the independent variable. Since the choice alternative is a categorical variable, the AME represents the average predicted difference in the probability of choosing a given choice alternative between two sub-samples.

across these two groups. Among those who agree or strongly agree, nearly 21% of respondents chose Programme B, whereas this figure is close to 10% among those who disagree or strongly disagree. These differences are statistically significant for exercises 2 and 3. On the other hand, among those who disagree or strongly disagree, the proportion of respondents who choose Programme C is higher than among those who agree or strongly agree, although is statistically significant only for the smoking exercise. In addition, the proportion of respondents who choose to reduce health inequality (Programme A) was higher among those who disagree or strongly disagree and statistically significant only for exercise 3.

Table 6.6: *Attitudes towards inequality conditional on beliefs about lifestyles' preferences, exercise 3*

	Exercise 3: diet, exercise and obesity				
	Sub-sample 2	**Sub-sample 3**	**Sub-samples 2vs3 AME (p-value)**	**Sub-sample 4**	**Sub-samples 2vs4 AME (p-value)**
	R^1**vs**R^2	R^1**vs**R^3		R^1**vs**R^4	
Choice alternatives	%	%		%	
Programme A (ineq. red.)	33.1	38.4	-5.2	41.0	-7.9
			(0.32)		(0.14)
Programme B (ineq. incr.)	20.0	16.8	3.2	14.5	5.5
			(0.45)		(0.19)
Programme C (neutral)	43.4	41.1	2.3	41.6	1.8
			(0.67)		(0.74)
Indifferent	3.4	3.8	-0.4	2.9	0.5
			(0.87)		(0.78)
Total	100.0	100.0		100.0	
N	145	185		173	

Notes: The fourth column of the table shows the computed difference in the proportion of respondents choosing each choice alternative in sub-sample 2 vs sub-sample 3. The sixth column shows the difference between sub-sample 2 and sub-sample 4. The differences and their statistical significance were obtained by computing the Average Marginal Effect (AME) after running a multinomial probit model using the choice alternatives as the dependent variable and the sub-sample as the independent variable. Since the choice alternative is a categorical variable, the AME represents the average predicted difference in the probability of choosing a given choice alternative between two sub-samples.

Table 6.7: *Attitudes towards inequality conditional on beliefs about lifestyles' preferences*

	Exercise 2: smoking			**Exercise 3: diet, exercise and obesity**		
Choice alternatives	**Agree or strongly dis-agree** %	**Disagree or strongly dis-agree** %	**AME (p-value)**	**Agree or strongly dis-agree** %	**Disagree or strongly dis-agree** %	**AME (p-value)**
Programme A (ineq. red.)	36.7	39.9	-4.2 (0.37)	34.8	45.7	-11.1 (0.01)
Programme B (ineq. incr.)	21.3	9.1	13.9 (0.00)	20.6	10.0	11.7 (0.00)
Programme C (neutral)	38.3	48.9	-11.2 (0.01)	41.4	42.1	-1.7 (0.73)
Indifferent	3.6	2.1	1.5 (0.41)	3.2	2.1	1.0 (0.55)
Total	100.0	100.0		100.0	100.0	
N	441	143		437	140	

Notes: The fourth column of the table refers to exercise 2 and it shows the computed difference in the proportion of respondents choosing each choice alternative between respondents who agree vs those who disagree with the notion of healthy lifestyles as effort. The seventh column of the table reports the computed difference for exercise 3. The differences and their statistical significance were obtained by computing the Average Marginal Effect (AME) after running a multinomial probit model using the choice alternatives as the dependent variable and the respondents' beliefs as the independent variable. Since the choice alternative is a categorical variable, the AME represents the average predicted difference in the probability of choosing a given choice alternative between respondents who agree or strongly agree vs those who disagree or strongly disagree with the notion of healthy lifestyles as effort.

If one is willing to draw some conclusions based on these results, it could be said that a significant proportion of respondents are more (less) willing to reduce or maintain (increase) a health inequality when the inequality in terms of equivalent health is large enough and/or when the weak dominance principle holds. We are not suggesting that members of the public think in line with the theory behind these approaches. Moreover, these concepts can be explained using a less demanding rationale, which is that respondents think that individuals do not necessarily deserve (or do not need to be rewarded for) better health when they either enjoy or do not care about adopting healthy lifestyles.

6.6. Discussion

Despite EO becoming a widely used framework to assess the distribution of achievements in society, several aspects regarding the definition of effort and the reward principles that follow from it remain under-researched.

According to the liberal reward principle, if an inequality reflects choices made from the same choice set by individuals with different preferences, such an inequality is legitimate. There are several reasons to challenge this principle, for instance when the choice set has been defined in an objectionable manner or when preferences have been formed in an objectionable manner (Olson, 2012). Although these are important aspects, we consider that these reasons do not undermine the strength of the liberal reward principle. In this study we have argued that even when health inequalities are the result of freely chosen lifestyles and the choice set has not been formed in an objectionable manner, an allocation of health gains that prioritize the individuals with worst health can be justified on the basis that a given choice set may be more favourable to some kinds of preferences.

The results allow us to conclude that the liberal reward principle is supported by a high proportion of respondents. However, a significant fraction of respondents chose to either reduce or increase health inequalities due to lifestyles. Moreover, the study provides evidence that the beliefs of respondents about the preferences of individuals who engage in different lifestyles influence their opinion about how to deal with inequalities.

The proportion of respondents who choose to reduce the health inequality in exercises 2 and 3 is similar among sub-samples 3 and 4 (about 40%). Recall that in the scenario shown to sub-sample 4 the individuals who choose lifestyles that happen to be healthy are better off according to the weak-dominance principle. In other words, more than 50% of the respondents choose an allocation that is not compatible with such a principle. This is unexpected considering that the weak dominance principle is a very appealing concept.

The choice of reference categories is a crucial aspect of the equivalent approach since

it involves a normative decision that implicitly gives priority to some preferences over others. Choosing the most preferred lifestyle for each individual as the reference can be defended based on the weak dominance principle adapted to health - one is better off than another if one is healthier than the other when both have chosen their most preferred lifestyle. On the other hand, it is difficult to find reasons to choose a given, any other, 'kind of lifestyle' as the reference.

Depending on the scenario, between 15 and 30% of respondents chose an allocation strategy that increases the health inequality due to chosen lifestyles [3]. This is compatible with the health equivalent approach with $L^* = L^h$ (i.e. healthy lifestyles). We do not expect respondents to reason according to the health equivalent approach. Moreover, using L^h as the reference can be translated to simpler reasoning: priority should be given to those who have strong preferences for healthy lifestyles or who have weak preferences for unhealthy lifestyles. One possible explanation to defend this position is from a virtue ethics perspective, according to which individuals should pursue healthy lifestyles and society should not prioritize those who lack the will to avoid engaging in morally objectionable behaviours (Hursthouse and Pettigrove, 2018). Unfortunately, we do not have information in the questionnaire that could help us to understand if respondents who choose the allocation strategy Ω^B support such a normative position. Furthermore, there may be other reasons to explain favouring individuals who choose healthy lifestyles. For instance, it could be that respondents consider that individuals with unhealthy lifestyles should be responsible for the negative externalities of their behaviour.

An interesting exercise would be to contrast the attitudes of members of the public towards health inequalities, controlling for their beliefs about the preferences of individuals who adopt healthy and unhealthy lifestyles, and their implicit reference categories. One possible way of translating the implicit reference categories could be the following. Using the most preferred lifestyle as the reference is compatible with the idea that there are no right or wrong lifestyles and that a better society is one in which individuals achieve their

[3] A similar result was found in the study by Schokkaert and Devooght (2003). In that study, they characterize an allocation strategy that rewards high effort and punishes low effort as 'countercompensation'.

Table 6.8: *Combinations of beliefs about preferences and reference categories that could be explored in the field*

References \ Beliefs	Individuals who engage in unhealthy lifestyles are not willing to change their behaviours unless they receive a big compensation.	Most individuals who engage in healthy behaviours enjoy their lifestyles.
People should adopt healthy lifestyles, because is the right thing to do and those who adopt healthy lifestyles should be rewarded for it.	I	II
There are no right or wrong lifestyles. A better world is one in which people can adopt the lifestyles that makes them happy without suffering severe health consequences.	III	IV

Notes: The first column of the table shows how to translate different reference categories to simple words. Using healthy lifestyles as the reference category in the health equivalent approach is compatible with the idea that people 'should' adopt healthy lifestyles whereas using the most preferred lifestyle as the reference relates to the idea that there are no right or wrong lifestyles. The first row describes how to translate two kinds of beliefs about preferences into simple words. The second column describes the belief that people who engage in unhealthy lifestyles have strong preferences for unhealthy lifestyles whereas the third column describes the belief that individuals who engage in healthy lifestyles do not exert effort.

most preferred lifestyles without suffering severe health consequences. On the contrary, using healthy lifestyles as the reference embodies the idea that adopting healthy lifestyles is 'the right thing to do' and that those who adopt healthy lifestyles should be rewarded for it. Consider for instance the combinations of beliefs about preferences and reference categories shown in Table 6.8. We should expect respondents whose ideas correspond to cell I to favour an allocation strategy that prioritises individuals who adopt healthy lifestyles and respondents whose ideas correspond to cell IV to prioritise individuals who adopt unhealthy lifestyles. Respondents whose ideas are compatible with cells II and III should be more likely to adopt a neutral allocation strategy.

There are several reasons to be cautious about the results of this study. The sample was recruited through a non-probability sampling method and the sample size is small. We also acknowledge that the study is subject to other biases introduced by the framing and presentation of the questionnaire. Sub-samples 2, 3 and 4 were asked to think about specific preferences on lifestyles. However, it seems that some respondents may not have engaged and answered based on their prior beliefs about why people choose certain lifestyles or why health inequalities should or should not be reduced. As it happens with any stated preference study, the preferences elicited may not reflect what the individuals would reveal in real-life situations. These limitations notwithstanding, the study found that the liberal reward principle finds limited support among members of the public and that there is room for an alternative notion of reward that could favour the reduction of inequalities that originate in differences in health-related lifestyles.

Authorship statement

A working paper of this chapter was discussed at the Summer 2021 meeting of the Health Economists' Study Group (HESG). The paper was written in co-authorship with Aki Tsuchiya. A "CRediT" author statement (Elsevier, 2020) for this paper is as follows:

Nicolas Silva: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - Original draft, Project administration. **Aki Tsuchiya**: Supervision, Writing - Reviewing and Editing.

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Chapter 7: Inequality of opportunity: disentangling preferences from unfair constraints

Abstract

Inequality of Opportunity has become a widely used framework for the measurement of unfair inequalities. While the theoretical literature takes as given the existence of factors for which individuals are not responsible or 'circumstances' and factors for which the individuals should be held accountable or 'effort', we argue that the empirical literature usually either fails to provide i) an operational definition of what circumstances and effort are, or ii) an effective empirical strategy to disentangle both kinds of factors. The paper follows the so-called 'preference approach' and offer an operational definition of legitimate and illegitimate sources of inequalities, where the former are the individuals' preferences after a given age threshold (the 'canonical moment') and the latter are parents' choices that lead to illegitimate constraints. In this regard, the paper shows why the canonical moment has a crucial role to unpack the effect of preferences from illegitimate constraints. We provide an empirical application of this normative position where we look at the influence of the access to home educational resources on 15-years-old children's beliefs about their future.

7.1. Introduction

Inspired by luck-egalitarianism, the theory of Equality of Opportunity (EO) or Inequality of Opportunity (IO) postulates that the distribution of achievements across society can be understood as the result of a process where two kinds of factors interact: circumstances and effort (Roemer, 1996). While the former are factors that are beyond the individuals' responsibility and therefore are considered as illegitimate sources of inequality, the latter are factors for which the individuals should be held accountable, and therefore are considered as legitimate sources of inequality.

It could be said that IO is now a well-established framework to assess unfair inequalities. The empirical literature on IO has grown rapidly, and has been applied in many countries and to several domains such as income, education and health, among others (see Brunori et al., 2013; Jusot and Tubeuf, 2019; Palmisano et al., 2021).

This paper has three aims. First, we discuss how the applied IO literature has defined the partition into legitimate and illegitimate sources of inequality. We argue that, despite IO becoming a prevalent framework for the assessment of unfair inequalities, most of the empirical studies fail to provide an operational definition of effort and circumstances. Second, based on what has been called 'the preference approach', we aim to offer an operational definition of effort and circumstances, in which effort corresponds to individuals' preferences and circumstances to the influence of parents' choices that lead to illegitimate constraints. Third, we show why the canonical age has a crucial role to assess IO according to the preferences approach and to unpack the legitimate influence of preferences from the illegitimate influence of constraints and provide an empirical application to assess IO according to such a normative position.

7.2. The partition between circumstances and effort

Different areas of knowledge have contributed to the development of IO measurement. The axiomatic analysis defines normative principles which should be reflected in the measures

of IO. These measures are adapted for the empirical analysis, and appropriate methods of estimation are implemented. Based on some normative views about where to locate the so-called 'responsibility cut' (Schokkaert and Devooght, 2003) (i.e. how to define the partition between effort and circumstances), an operational definition of circumstances and effort should be provided, and adapted to the set of data available to the researcher. As will be covered in the next section, we consider that most of the empirical studies do not appropriately accomplish this last component. This argument is not new and, as will be discussed later, has already been made, perhaps in a different way, by Fleurbaey (2008) and Fleurbaey and Schokkaert (2009).

The main assumption of the EO theory is that individuals $i(1, ..., n)$ can be characterised by three attributes: an outcome V_i, a set of circumstances $\boldsymbol{\tau_i}$ (the literature uses the term 'type' to denote individuals who share the same circumstances) and a set of efforts $\boldsymbol{E_i}$, whereas some authors also include a set of factors that capture luck $\boldsymbol{L_i}$ (Lefranc et al., 2009; Lefranc and Trannoy, 2017). The 'canonical' model of EO (Ferreira and Peragine, 2016) assumes that there is a function that assigns an outcome to each combination of circumstances and effort (to which luck could be added). Define:

$$\boldsymbol{V} = \begin{bmatrix} V_1 \\ \vdots \\ V_n \end{bmatrix}, \boldsymbol{\tau} = \begin{bmatrix} \boldsymbol{\tau_1'} \\ \vdots \\ \boldsymbol{\tau_n'} \end{bmatrix}, \boldsymbol{E} = \begin{bmatrix} \boldsymbol{E_1'} \\ \vdots \\ \boldsymbol{E_n'} \end{bmatrix}, \boldsymbol{L} = \begin{bmatrix} \boldsymbol{L_1'} \\ \vdots \\ \boldsymbol{L_n'} \end{bmatrix},$$

V_i', $\boldsymbol{\tau_i'}$, $\boldsymbol{E_i'}$ and $\boldsymbol{L_i'}$ being the transpose of $\boldsymbol{V_i}$, $\boldsymbol{\tau_i}$, $\boldsymbol{E_i}$ and $\boldsymbol{L_i}$, respectively.

The theoretical literature assumes that the definitions of V, $\boldsymbol{\tau}$, $\boldsymbol{E}$ and $\boldsymbol{L}$ are given. In other words, the theoretical literature defines principles which definitions are valid to the extent that they are applied to a dataset D^{IO}, which is a quadruplet $(V, \boldsymbol{\tau}, \boldsymbol{E}, \boldsymbol{L})$.

Based on this assumption, the axiomatic analysis has produced two kinds of normative principles to characterise EO: compensation and reward. The basic idea of compensation is that inequalities due to circumstances should be eliminated, whereas reward principles

suggest how to deal with the differences that arise due to effort. There are different versions of these principles that capture different normative views about what is needed to achieve EO (Fleurbaey and Schokkaert, 2011a; Bosmans and Öztürk, 2021). Moreover, it is well known that several of these principles are incompatible with each other.

Several *measures* of IO have been proposed which aim to reflect some version of compensation and reward (Ramos and Van de gaer, 2016). In this regard, IO measures assume that circumstances and effort exist. In this regard, the IO *parameters* are attributes of a population that result from applying these IO measures to the 'true' matrix D^{IO}. However, in the applied analysis, the researcher does not have access to D^{IO}. Therefore, one of the challenges of the empirical analysis consists of developing *estimators* and measurement approaches to compute IO in the presence of this data constraint.

Fleurbaey (2008) and Fleurbaey and Schokkaert (2009) have argued that, to empirically implement a given normative view about how to partition a set of observable variables into legitimate and illegitimate sources of inequalities, a structural model needs to be specified that can disentangle the different channels that relate these variables to the outcomes being assessed. We echo this position and argue that, despite the enormous progress that the axiomatic and the empirical analyses have made, the literature has failed to provide an adequate operational definition of circumstances, effort and luck.

By 'operational definition' we mean that circumstances, effort and luck should be linked to a structural model and a set of potentially observable data, D. Potentially observable data includes both observed data and data that may not be observable (or that may be observable with error) for practical reasons. Hence, to provide a coherent measure of IO, researchers should start by defining a partition into circumstances, effort and luck based on what they consider to be the set of potentially observable data. In other words, researchers should be capable of offering a mapping from the set of potentially observable data D to the matrix D^{IO} ($D \rightarrow D^{IO}$). In our view, structural models should reflect how we understand phenomena that generate the set of outcomes. This kind of model can be understood as a function v that links the vector of circumstances, effort and luck to a

vector of outcomes $V_i = v(\boldsymbol{\tau_i}, \boldsymbol{E_i}, \boldsymbol{L_i})$.

We fully acknowledge that the researcher will only have access to a set of observed data D^o which is a subset of D, and that in general those variables of D that can be observed will be measured with error. We would argue that the set of observable data D^o (such as data from population surveys) can be thought of as the result of a function g whose inputs are the 'true' vector of outcomes, circumstances, effort and luck $D^o = g(V_i, \boldsymbol{\tau_i}, \boldsymbol{E_i}, \boldsymbol{L_i})$. Therefore, D^o can contain information about circumstances, effort and luck, or may contain information about variables which are functions of these factors. Accordingly, empirical applications aim to obtain IO estimators based on the information available in D^o.

7.2.1. Normative theories and empirical applications about where to locate the 'responsibility cut'

The control approach

There are two main philosophical traditions about where to locate the so-called responsibility cut. The control approach, which has its roots in the works of Cohen (1989) and Arneson (1989), suggests that individuals should be held accountable for those factors which are under their control and that influence the outcomes of interest. At first sight, one may consider that individuals' choices are good candidates to be defined as factors that are under the control of individuals. Nonetheless, choices are also influenced by external factors, among others: decision-making abilities, choice architecture patterns, the influence of the environment (e.g. marketing and social media), and family and social background. According to the control approach, individuals should not be held accountable for their choices unless one can 'correct' for the effect of factors which are not under their direction (Fleurbaey and Schokkaert, 2011a). However, as has been suggested in the literature (Fleurbaey and Schokkaert, 2009, 2011a; Fleurbaey, 2008), once we start listing all the factors that may contribute to explain our choices, we may end up considering a deterministic model where there is not much room for control.

The control approach is the dominant perspective in empirical applications. The main framework that adopts this normative position was developed by Roemer (1996; 1998). According to the framework, each society should be able to decide which factors are beyond the individuals' control (i.e. circumstances). Factors that are typically considered as circumstances in this literature are innate ability or genetic characteristics and childhood socioeconomic characteristics. Furthermore, Roemer considers that the unequal distribution of effort across types is unfair, and that we should focus on a measure of 'accountable' effort that remove this effect (Roemer and Trannoy, 2015).

The framework describes few aspects of what can be understood as effort: i) it is an input of the objective of which distribution is being assessed (such as the number of hours of work if the objective is labour income or the number of smoked cigarettes if the outcome is the probability of experiencing lung cancer, etc.); ii) it can be multidimensional, but needs to be collapsed into a single index since it should be possible to rank individuals according to the effort they exert.

Besides these two properties, there is not an operational definition of effort and accountable effort. Instead, the framework assumes that effort exists, and provides a method to identify accountable effort based on information about circumstances and outcomes [1]. According to this method, accountable effort corresponds to the ranking of individuals in their type-specific effort distribution. Key to this method is what has been labeled by Ramos and Van de gaer (2016) as the Roemer Identification Assumption (RIA). According to Fleurbaey and Schokkaert (2011a), RIA consists of the following: i) the effort exerted by each individual is a function of their circumstances and a latent variable E^* (accountable effort), which distribution is independent of circumstances, such that all the individuals have equal access to it irrespective of their type, ii) E^* is a one-dimensional parameter, and iii) the outcomes over which EO will be assessed are a strictly monotonic increasing function of E^*. If these three assumptions hold, the unobservable rank on the

[1] With complete information (i.e. assuming circumstances and outcomes are fully observable) Roemer's method allow to identify accountable effort. If some circumstances are unobservable, results based on this methods provide a 'lower bound' of the 'true' IO.

type-specific effort distribution coincides with the observable rank in the type-specific outcome distribution. As a consequence, accountable effort is identified without the need of providing an operational definition of it.

However, Roemer et al. (2003) and Lefranc et al. (2009) have argued that, besides circumstances and effort, the distribution of outcomes can also be shaped by luck and that, in such a case, RIA fails to identify accountable effort. This is because RIA assumes that effort is a residual factor when the distribution of outcomes is explained only by circumstances and effort. Therefore, once it is acknowledged that the distribution of outcomes is also shaped by luck, Roemer's proposal fails to provide a workable operationalisation of accountable effort in terms of how to rank different combinations of inputs that individuals choose to achieve certain outcomes.

Other empirical strategy to measure accountable effort under the control approach consists of 'removing' the effect of circumstances on individuals' choices using regression techniques. This strategy, suggested first by Schokkaert et al. (2004) and Bourguignon et al. (2007) has been implemented extensively in studies that assess IO in health (see Jusot and Tubeuf (2019) for a review of studies assessing IO in health). The basic idea is to regress the variables that capture individuals' choices (e.g. health-related lifestyles decisions) on a vector of circumstances. If circumstances and outcomes were fully observable, the predicted residuals of those equations could be used as a 'cleaned' (from circumstances) measure of effort (i.e. accountable effort) [2]. Implicit in this method is the assumption that choices are a function of circumstances and other unobserved factors, and that individuals should be held accountable only for the latter. However, these unobserved factors are never described according to a structural model, so again a workable operationalisation of effort is missing. Furthermore, as it has been discussed by Fleurbaey (2008), if we were to remove all the exogenous factors that influence individuals' choices we would en up with a purely random component, which, according to the control approach, it should not be categorized within the realm of individuals' control.

[2]Since not all the circumstances are observable, the predicted residuals are thought of as a combination of effort and unobserved circumstances. Therefore, the residuals are an upper bound of true effort.

An alternative that has been used to account for the fact there will always be unobserved circumstances is to provide upper bounds of IO (Hufe et al., 2022). The strategy introduced by Hufe et al. (2022) to compute the upper bound of IO assumes that all the individuals' time-invariant factors (both observed and unobserved) are circumstances. However, as these authors admit, this strategy assumes that time-varying circumstances do not exist and that the effect of all time-varying factors (which includes random factors) can be considered to be effort. Arguably, a better strategy to compute upper bounds of IO would be to regress a given outcome on a set of effort factors and assume that all the inequality that is not explained by these factors is illegitimate. However, this has not yet been done, probably because effort has never been operationally defined.

Rather than trying to identify effort, the dominant strategy in the income-related IO literature is to adopt an 'ex-ante' assessment according to which "opportunities are evaluated by the circumstances and the outcome possibilities for various levels of effort that individuals can exert" Fleurbaey and Peragine (2013, p. 2). The opportunities among individuals of the same type are usually summarised as the expected value of a given outcome, conditional on circumstances. Most of the time this is done by implementing reduced-form equations were outcomes are modeled only as a function of circumstances (Ramos and Van de gaer, 2016; Roemer and Trannoy, 2015). This strategy assumes that circumstances have a direct effect on individuals' outcomes and an indirect effect through the distribution of effort across types. By computing reduced-form equations these studies assume that both effects are illegitimate. Moreover, the studies that adopt this empirical strategy never provide an operational definition of effort. In this regard, it is not possible to know if inequalities across types are due to unobserved circumstances or effort, since effort may not exist because is not defined.

The preference approach

According to the preference approach individuals should be held accountable for their preferences, as long as they identify themselves with it. This is present in the work of

Rawls (1971) and Dworkin (1981a,b) who argue that individuals should be responsible for their preferences and their views about what constitutes a good life. In accordance with this notion of responsibility, in the IO framework proposed by Fleurbaey (2008; 2009) effort is equated to the individuals' preferences regarding the achievements that are relevant for their wellbeing [3]. According to EO framework developed by Fleurbaey, individuals' preferences should be respected. This does not mean that individuals should be held accountable for their choices, since when the individuals' menus of alternatives differ due to circumstances, their choices are unfairly constrained. In other words, preferences are a legitimate source of inequalities whereas the impact of individuals circumstances' in the constraints they face are not.

A similar notion of responsibility was proposed by Le Grand, although he uses the term 'equity' rather than EO: "Define the factors beyond individual control as constraints. These constraints limit the range of possibilities over which individuals can make their choices. Define the set of possibilities bounded by the constraints as the choice set. Then, a distribution is equitable if it is the outcome of informed individuals choosing over equal choice sets." (Le Grand, 1991, p. 87)

Although in principle the preference approach provides a clearer definition of the factors under the individuals' responsibility, its empirical application is not trivial. We are aware of two empirical studies which have applied this approach. Burchardt and Le Grand (2002) aim to understand the extent to which the the menu of occupations is the result of constraints beyond the individuals' control or a consequence of their preferences. The study propose to distinguish between different 'layers' or set of constraints: from constraints for which the individuals have no control to those that can be readily changed by the individuals. Among the constraints that are considered to be beyond the individuals' control are sex, ethnicity, other genetic inheritance, age, and parental social class. Furthermore, the study assumes that preferences are randomly distributed among individuals

[3] The original framework developed by Fleurbaey distinguishes between factors for which the individuals are responsible and those for which they are not but does not use the term 'effort' (Fleurbaey, 1995, 2008). In latter works the term effort has been used instead of responsibility factors (see for example Fleurbaey and Schokkaert (2011a); Fleurbaey and Peragine (2013))

who face the same constraints.

García-Gómez et al. (2015) measure IO in mortality. The study uses a recursive system of equations that models the interdependency between lifestyles, hospitalisations and mortality. The study compares several normative positions about how to partition the explanatory variables into legitimate and illegitimate sources of inequality. To implement the preference approach ('authentic preference' approach in the paper) the study assumes that lifestyles' choices are the result of individuals' preferences, cognitive abilities and budget constraints; and that only the first of these is a legitimate source of inequality. Since preferences are not directly observed, the study uses a set of variables that are considered legitimate factors that influence preferences, among them, age, sex, home ownership, marital status, religion, region and urbanisation of the area of residence. The highest level of education achieved is used as a proxy for economic constraints and cognitive abilities.

We would like to highlight one important challenge of these empirical applications, which is how to disentangle the effects of explanatory variables that may simultaneously influence the constraints that individuals face and shape their preferences. More generally, it is hard to think of variables that can be considered to be strictly related to individuals' choice constraints while not related to individuals' preferences and *vice versa*.

Take for instance the categorization of sex according to both studies. Burchardt and Le Grand (2002) argue that the influence of sex is a constraint beyond the individuals' control with respect to the probability of being employed. By contrast, according to García-Gómez et al. (2015) sex is a legitimate factor with respect to health-related lifestyle heterogeneity. As García-Gómez et al. (2015) highlight, sex may have a dual feature: it is a fixed characteristic and it may shape the individuals' preferences. In this respect, if the menu of alternatives available to individuals depend on sex (for instance, if there is discrimination in the labour market), such effect can be considered illegitimate. On the other hand, sex may shape preferences, and therefore be considered a legitimate driver of inequality. Furthermore, Burchardt and Le Grand (2002, p. 6) argue that beliefs which are "subject to strong cultural norms (like those relating to family responsibilities)" are less

under the individuals' control compared to other factors. In our view, from this normative position it follows that if the preferences of individuals' with respect to family responsibilities differ by gender, such differences are illegitimate, since these can be either shaped by genetic inheritance of by cultural transmission, and in both cases these causes are beyond the individuals' control. Moreover, looking into legitimate and illegitimate drivers of preference formation corresponds to the control rather than the preference approach.

Similarly, in the study by García-Gómez et al. (2015), it is assumed that education captures economic constraints which are considered an unfair source of lifestyle inequalities. However, education may also shape the individuals' preferences, particularly if it is correlated with characteristics of the parents which may both influence the individuals' education opportunities and their preferences. Moreover, education itself is also the result of individuals' preferences. Similarly, religion and characteristics of the region of living are supposed only to influence the individuals' preferences, but these factors may also shape the individuals' choice constraints. For instance, the cost of adopting different lifestyles may vary across regions.

To summarise, we would argue that the empirical applications which are inspired by the control approach do not provide an operational definition of what constitutes effort. Moreover, the empirical studies that build on the preference approach provide an operational definition of effort but fail to specify statistical models that could distinguish between preferences and constraints beyond the individuals' responsibility.

7.3. An operational definition of effort and circumstances

Our aim is to provide an empirical application to assess IO according to the preference approach. We start by providing a sketch of a structural model based on the set of potentially observable data from which illegitimate and legitimate variables could be distinguished from each other. Given that we adopt the preference approach, our main challenge is how to specify a statistical model that could correctly distinguish between preferences and

illegitimate constraints. In this section we describe the theoretical model and discuss how to operationalise the partition into legitimate and illegitimate factors. In the next section we attempt to relate this structural model to a set of observable data from which IO can be assessed.

7.3.1. A structural model based on potentially observable data

In this model, the life of individuals is a sequence of time periods in which they need to make decisions regarding their future. Individuals are indexed by i and the time periods correspond to the age of individuals and are indexed by t. At each time period individuals have a set of endowments $X_{i,t}$. These endowments describe the characteristics of the individuals and what they have, such as genetic make-up, innate ability, social connections, skills, health status, their stock of information, durable goods and income, among other characteristics. Individuals are born with a set of endowments ($X_{i,0}$) some of which are time-invariant, such as innate ability or genetics, whereas others are not. Moreover, it is assumed that these characteristics can change between periods, but cannot change within a given period of time.

At each period of time, the individuals make choices about allocating their time to different tasks and about what to consume. The combination of tasks and consumption within a period of time will be called activities. The combination of activities that each individual experiences at each period is denoted by $a_{i,t}$. Besides activities, the characteristics of individuals are a function of their characteristics in the previous period of time, and random variability $\zeta_{i,t}$, which we equate to luck.

$$X_{i,t} = x(a_{i,t-1}, X_{i,t-1}, \zeta_{i,t}) \; . \tag{7.1}$$

Individuals can only choose their activities from a restricted choice set A, which shape is determined by the individuals' characteristics: $a_{i,t} \in A(X_{i,t})$. Consider for instance that a person chooses to climb a mountain in a given period of time. Such an activity can only be performed by individuals with a certain health status and certain skills. Importantly,

the activities performed at each time period will shape the characteristics of the individuals in the next time period. In the previous example, climbing a mountain may have an effect on the individual's health and put him at a higher risk of an accident compared to alternative activities.

We will define a future life project $l \in L$ as a combination of activities from time period $t+1$ up to T, with T the lifespan of individuals: $l = (a_{i,T}, a_{i,T-1}..., a_{i,t+1})$. We assume that individuals choose which activities to perform in the current period of time t with certainty. Furthermore, the activities performed in the current period of time will shape the probability of being alive in the next period of time and the probability of having different characteristics in the next period of time. Since the activities that individuals can choose from at each period of time are restricted by the choice set $A(X_{i,t})$, a given life project l can be thought as an element of a lifetime choice set A^L which shape depends on the combination of individuals' characteristics in each period of time: $l \in A^L(X_{i,T}, X_{i,T-1}, ..., X_{i,t})$.

The subjective probability of achieving a given life project will be denoted by $\phi_{i,t}(l)$, whereas the vector of probabilities of achieving each life project in L is denoted by $\boldsymbol{\phi_{i,t}}(l)$. The probability of achieving a given life project is equal to the probability of experiencing a given combination of characteristics $\pi(X_{i,T}, \pi(X_{i,T-1}), ..., \pi(X_{i,t+1})$, conditional on engaging in the set of activities $l = (a_{i,T}, a_{i,T-1}..., a_{i,t+1})$:

$$\phi_{i,t}(l) = \pi_i(X_{i,T}; a_{i,T-1}, X_{i,T-1})\pi(X_{i,T-1}; a_{i,T-2}, X_{i,T-2})...\pi(X_{i,t+1}; a_{i,t}, X_{i,t}) \ . \quad (7.2)$$

We assume that the probabilities shown in Equation 7.2 are subjective and reflect the individuals' knowledge regarding the consequences of adopting certain activities. This knowledge will be understood as a function of the information available to the individuals regarding the consequences of adopting different activities, their cognitive ability to process that information and how much they trust each source of information or their own personal epistemological beliefs $B_{i,t}$. We will assume that information and cognitive

ability belong to the set of individuals' characteristics. Hence we have that the subjective probability of achieving a given life project is a function of the individuals' characteristics and their beliefs:

$$\phi_{i,t}(l) = \Phi(X_{i,t}, B_{i,t}) \ . \tag{7.3}$$

When individuals choose which activities they will perform in the current period of time, they need to take into account both the utility they get from those activities and how such activities will shape their characteristics in the next period of time, which in turn it will restrict the set of activities they can perform in the future. In consequence, when choosing activities at each period of time the individuals need to consider how those activities will shape their probabilities of achieving different life projects. In this regard, we assume that individuals have ordinal preferences $R_{i,t}$ over different combinations of the activities they can perform and the probabilities of achieving each future life project: $\big(\boldsymbol{\phi_{i,t}}(l), a_{i,t}\big)$.

The decision-making process can be equated to a state dependent utility model (Karni, 2009), where individuals choose certain actions (activities in this case) which have a direct impact on the decision-maker's wellbeing, and which shape the probability of occurrence of future states of the world (characteristics). Furthermore, the choice of which activities to perform in the current period of time can be conceived as a bet on the future state of the world. For instance, conditional on being healthy one can choose to pursue a risky and highly pleasurable sport activity in the present and 'bet' that one will be healthy enough in the next period of time to pursue a set of activities that require being healthy.

Given the individuals' preferences $R_{i,t}$, individuals can define what will be their future actions at some point in the future t', conditional on a given set of characteristics $X_{i,t'}$. Accordingly, given the individuals' preferences and their beliefs regarding the probability of achieving future life projects, individuals can make predictions about the probability of achieving a given life project $\Pi_{i,t}(l)$, whereas the set of probabilities for each life project in L corresponds to $\boldsymbol{\Pi_{i,t}}(l)$. Each of these predictions is a function Γ of $\boldsymbol{\phi_{i,t}(l)}$ and $R_{i,t}$:

$$\Pi(l)_{i,t} = \Gamma(\boldsymbol{\phi_{i,t}(l)}, R_{i,t}) \ . \tag{7.4}$$

Note that $\phi_{i,t}(l)$ is the subjective probability of achieving a given life project if an individual is willing to engage in the set of actions that constitutes l, whereas $\Pi_{i,t}(l)$ corresponds to the subjective probability of achieving a life project l conditional on the future actions that the individual thinks she will engage with in the future, taking into account their preferences. For instance, an individual may believe that she has a very high probability of becoming a blue collar worker in the future if she pursues the activities that are required to achieve such an occupation. However, she may think that she has a low probability of actually becoming a blue collar worker because she will not engage in the activities that are required to achieve such an occupation.

We consider relevant to distinguish between those activities that are chosen by the individuals themselves and those chosen by someone else on their behalf. During the first periods in the life of individuals their characteristics only depends on their parents' choices $C^P_{i,t}$, their innate characteristics and luck. Over the next periods of time the characteristics of children depend on their characteristics at $t-1$, their parents' choices, the children's choices $C_{i,t}$ and luck. Moreover, the choices made by the parents on behalf of their children are a function c^p of the parents epistemological beliefs $B^P_{i,t-1}$, their preferences $R^P_{i,t-1}$, the parents' characteristics $X^P_{i,t-1}$, their child's preferences $R_{i,t-1}$ and their child's characteristics $X_{i,t-1}$. Similarly, the children's choices are a function c of their epistemological beliefs $B_{i,t-1}$, their preferences $R_{i,t-1}$ and their characteristics $X_{i,t-1}$. Therefore, the children's characteristics at a given time period t can be represented as a function x which depends on their previous characteristics, their parents' choices, their own choices and random variation $\zeta_{i,t}$:

$$X_{i,t} = x(c^p(X^P_{i,t-1}, B^P_{i,t-1}, R^P_{i,t-1}, X_{i,t-1}, R_{i,t-1}), c(X_{i,t-1}, B_{i,t-1}, R_{i,t-1}), X_{i,t-1}, \zeta_{i,t}) \ . \tag{7.5}$$

It will be assumed that the epistemological beliefs are the result of a formation process

(Equation 7.6) where individuals are born with certain epistemological beliefs $B_{i,0}$ which are shaped at each time period by the interaction of individuals with other models of beliefs formation, such as the parent's beliefs (B^P). Epistemological beliefs are also influenced by the interaction with friends, the school and mass media, among others. These interactions are captured by parents and children's choices, since these choices foster the encounter of children with these sources of epistemology formation. Besides these factors, epistemological beliefs depend on a time-varying random component $\psi_{i,t}$:

$$B_{i,t} = b(c^p(X^P_{i,t-1}, B^P_{i,t-1}, X_{i,t-1}, B_{i,t-1}), c(X_{i,t-1}, B_{i,t-1}), B^P_{i,t-1}, B_{i,t-1}, \psi_{i,t}) \ . \tag{7.6}$$

We now turn to the process of children's preferences formation (Equation 7.7). We assume that individuals are born with certain preferences $R_{i,0}$ which are shaped by the interaction of individuals with external *stimuli* at each time period. Such *stimuli* could be the preferences of other individuals, such as parents, teachers and friends, or the interaction with other sources of preferences-transmission such as social media or advertising. Therefore, the formation of preferences is conceived as a dynamic process that depends on several factors: a time-varying random component $\xi_{i,t}$, the direct influence of parents' preferences and the indirect influence of parents' choices and children's choices. These two last factors have an indirect effect since they foster different children's experiences (such as socialization with different groups of people who have different preferences) that in turn could shape their preferences. We chose to specify a model of preference formation that does not allow for the genetic transmission of preferences. In contrast, in this model preferences' heterogeneity between individuals of different cultural background or gender is acquired during the process of preference formation (e.g. parents will transmit to their children different views about what ought to be the preferences according to their gender). Moreover, whether genetic transmission of preferences exists or not, it will not change the conclusions of our analysis.

$$R_{i,t} = r(c^p(X^P_{i,t-1}, R^P_{i,t-1}, X_{i,t-1}, R_{i,t-1}), c(X_{i,t-1}, R_{i,t-1}), R^P_{i,t-1}, R_{i,t-1}, \xi_{i,t}) \tag{7.7}$$

7.3.2. The responsibility cut and the role of the canonical moment

In this section we will use the model described in the previous section as a vehicle to define which factors are legitimate or illegitimate drivers of inequality (or where to locate the 'responsibility cut'). We then explain what is the normative position adopted in this paper and discuss why some of the factors categorized either as circumstances or effort in other studies does not align with our normative views.

Consider first whether individuals should be responsible for their preferences. As it was mentioned in Section 7.2.1, according to the control approach, individuals should not be responsible for factors which are beyond their control. In this regard, preference formation is a complex process, which is usually overlooked by standard economic models, which treat preferences as exogenous Hausman (2011, 2020). Arguably, as shown in Equation 7.7 many of the factors that shape individuals' preferences are beyond the individuals' control. Moreover, as it has been discussed in the literature, if we take into account all the exogenous factors that shape our preferences, we may end up concluding that individuals are not responsible for their preferences (Fleurbaey, 2008; Fleurbaey and Schokkaert, 2011a). An alternative perspective has been provided, among others, by Dworkin (1981a; 1981b) according to whom individuals should be responsible for their preferences, as long as they identify themselves with them, because these constitute a fundamental part of their identity. In this respect, an important aspect is 'when' individuals become responsible for their preferences. It could be argued that before certain age, children should not be held accountable for their own decisions. This is similar to the idea by Arneson (1990) that there exists a 'canonical moment' after which individuals become responsible for their choices. In this regard, the normative position adopted in this paper is that individuals' preferences should be respected from the canonical moment onward.

We consider that the canonical age (denoted by t^a) could be set around age 15. It could be argued that in western societies, children around age 15 are hold accountable for several important choices. For instance, at this age, in many countries students are required to choose a specialization area, which will most likely shape their educational

prospects (Câmara Leme et al., 2020). Similarly, many countries have lowered the voting age to 16 (Eichhorn and Bergh, 2021). As well, in several jurisdictions the age of criminal responsibility is defined around age 15 (Dunkel, 2014). Arguably, there could be different canonical ages depending on the kind of choice involved. Moreover, in this study we will assume that there exists a unique canonical age after which individuals are held accountable for their preferences.

Another important aspect concern the individuals' epistemological beliefs. Conditional on the same information and the same capacity to process that information, two individuals may weight the evidence in different ways, and therefore arrive to different conclusions regarding the consequences of their actions. According to the preference approach, it is legitimate that individuals of different types have different preferences. But, what about individuals' beliefs? I would argue that an individual's endorsed epistemological beliefs after the canonical moment defines an individual's identity as much as their preferences.

We now turn to define which factors could be considered to be beyond the individuals' responsibility. One normative position would be to argue that individuals should not be held accountable of time-invariant characteristics ($X_{i,0}$), such as genetic make-up or innate ability. Another normative position would be to consider that parents' characteristics ($X^P_{i,t}$) are beyond the children's responsibility. Moreover, the parents of a child may share the same characteristics with parents of another child and yet have different preferences and therefore choose differently. In this regard, rather than focus on parents' characteristics one could consider that any influence of parents' choices on children's characteristics is beyond the children's responsibility.

The above mentioned normative positions are not mutually exclusive. Then it is possible to construct a normative position in which the children should not held accountable for their time-invariant characteristics, their parents' choices and their own choices (perhaps, up to the canonical moment). According to Equation 7.5, this is equivalent to say that children should not be responsible for their characteristics ($X_{i,t}$) up to a certain age. Such a normative position could be equated with the position adopted by Hufe et al. (2017,

p. 501) according to whom "all measurable achievements and behaviors of children, before an age of consent is attained" could be considered circumstances. However, as it has been argued by Brighouse and Swift (2014), a society that aims to equalise the children's characteristics should teach and raise children in the same way. However, in such a case the role of the family would be undermined. In this regard, equality of opportunity should be sacrificed to some extent in order "to allow parents and children to enjoy the goods of family life" (Brighouse and Swift, 2014, p. 36).

In this paper we echo the position by Brighouse and Swift (2014) that in order to promote the realization of family goods, to some extent it should be legitimate that parents from different families choose differently. Moreover, rather than defining a list of the parents' choices that could be regarded as legitimate sources of inequality, we will focus on some parents choices that, everything else equal, could be regarded as illegitimate drivers of inequality. The parents' choices that constitute illegitimate sources of inequalities will be denoted by $C_{i,t}^{P*}$, with $C_{i,t}^{P} = \{C_{i,t}^{P*}, C_{i}^{P**}\}$, and $C_{i,t}^{P**}$ being the parental choices other than C_{i}^{P*}. We will define as illegitimate parent's choices, those that are related with children's access to home educational resources. In this regard, irrespective of other parents' choices, we will consider that is unfair if children face different life prospects due to an unequal access to educational resources at home.

Before proceeding to the empirical application, we would like to discuss why the categorization into legitimate and illegitimate factors used by previous studies does not align with our normative approach. We focus on four factors: choices made in adulthood, parents' characteristics, individuals' characteristics in adulthood and sex.

As it has been described by Ramos and Van de gaer (2016), individuals' choices in adulthood, such as health related-lifestyles or the number of hours of work per week are sometimes used as proxies of effort in studies on health and income, respectively. Moreover, individuals' choices cannot be considered legitimate factors according to our normative approach since besides being a function of the individuals' preferences, choices also depend on the individuals' characteristics, which may have been illegitimately shaped

by legitimate parents' choices during childhood.

Parents' characteristics, such as education or occupation are frequently categorized as circumstances in the literature (see for example Brunori et al. (2013)). Arguably, parents' characteristics can shape children's life through different channels. For instance, individuals with different occupations may have different preferences or different epistemologies and transmit these to their children. Alternatively, individuals with different occupations may face different economic constraints which in turn could shape the children's access to several resources during childhood. Holding individuals responsible for their preferences and their epistemological beliefs after the canonical moment entails that only the effect of parents' occupation through their economic constraints should be regarded as illegitimate.

Some studies have included education among circumstances. The reasons for categorizing education as circumstances differ between studies. Carrieri and Jones (2018) include the level of secondary schooling achieved by age 18 among circumstances because it is considered that such achievement is beyond the individuals' responsibility. There are two aspects that we would like to discuss regarding this statement. First, in several educational systems students are entitled to make choices regarding alternative kinds of secondary education at younger ages. In this regard, it is debatable whether the canonical age regarding such decisions can be set ate age 18 or whether it should be set at an early age, in which case adolescents should be (at least partially) responsible for their secondary-education achievements. Second, if children should not be responsible for their school achievements, it is worth asking whether they should be responsible for any of their characteristics by age 18 (e.g. their health status, their skills, their lifestyles, etc). Such a normative position would be equal to the position by Hufe et al. (2017) that we already discussed earlier in this section. As it was mentioned in Section 7.2.1, García-Gómez et al. (2015) use the highest level of education achieved as a proxy of illegitimate economic constraints regarding the choice of health-related lifestyles. Given the normative position adopted in this paper, neither education nor any characteristic at adulthood can be regarded as purely illegitimate since such characteristics are both a function of the individuals' preferences.

Sex and ethnicity, among other time-invariant characteristics have also been categorized as circumstances in the literature since these are exogenous factors which cannot be considered to be under the individuals' responsibility (Niehues and Peichl, 2014). According to the normative position that we adopt, the overall effect of sex and ethnicity on inequalities cannot be illegitimate since the process of preferences and epistemological beliefs is (arguably) shaped by both factors (either through genetic or cultural transmission). This does not mean that sex and ethnicity cannot be understood as illegitimate factors of inequality. Moreover, to unpack the legitimate from the illegitimate effect of sex and ethnicity it is necessary to disentangle its effect on individuals' constraints (e.g. discrimination in the labour market) from its effect on individuals' preferences and belief formation.

7.4. Empirical application

7.4.1. An alternative way of assessing IO

The normative position adopted in this study claims that individuals should be held accountable for their preferences and their epistemological beliefs after the canonical moment (t^a) and that the influence of parents' choices regarding the access to home educational resources is illegitimate. To assess if there exists IO according to this normative position we should compare the individuals' outcomes in adulthood with their counterfactual outcomes had they faced different circumstances before the canonical moment, conditional on children's preferences and epistemological beliefs. However, obtaining such a counterfactual is not feasible. Given this limitation, this study implements an alternative strategy. We would argue that, if circumstances have an impact on children's subjective probabilities of achieving different life projects at the canonical moment, it could be inferred that circumstances will shape outcomes in adulthood, since the choices made by children at the canonical moment depend on those probabilities, and those choices will shape their future characteristics. In this regard, to assess if there exists IO we will test if parents' choices regarding the access to home educational resources influence children subjective probabilities about their future. In other words, we will consider that there

exists IO if there is a significant effect of C^{P*} over $\boldsymbol{\phi_{i,t^a}}(l)$.

Rather than directly measuring $\boldsymbol{\phi_{i,t^a}}(l)$, we focus on children's expectations or predictions at the canonical moment regarding their occupation at a given point in the future $E_{i,t^a}[o]$. We now turn to explain why focusing on children's predictions at the canonical moment may be used as a vehicle to assess the impact of C^{P*} over $\boldsymbol{\phi_{i,t^a}}(l)$. Since working in a particular occupation at a given point in time allows to define mutually exclusive sets of life projects, the individuals' expectation regarding their future occupation can be understood as a function j of their subjective probabilities regarding which set of life projects they expect to achieve, $\boldsymbol{\Pi_{i,t^a}}(l)$, which as it is shown in Equation 7.4 depend on $\boldsymbol{\phi_{i,t^a}}(l)$ and R_{i,t^a}. At the same time, $\boldsymbol{\phi_{i,t^a}}(l)$ is a function of the individuals' characteristics and their epistemological beliefs:

$$E[o]_{i,t^a} = g(\boldsymbol{\phi_{i,t}}(l), R_{i,t^a}) = g(\boldsymbol{\Phi}(X_{i,t^a}, B_{i,t^a}), R_{i,t^a}) \ , \tag{7.8}$$

where $\boldsymbol{\Phi}$ corresponds to a set of functions Φ.

This equation can be reduced, so that $E[o]_{i,t^a}$ can be understood as a function e of the children's characteristics at the canonical moment, their epistemological beliefs and their preferences:

$$E[o]_{i,t^a} = e(X_{i,t^a}, B_{i,t^a}, R_{i,t^a}) \ . \tag{7.9}$$

According to the theoretical model developed in Section 7.3.1, parents' choices have an impact on the three inputs of function e. Moreover, our normative position involves holding children accountable for their epistemological beliefs and preferences at the canonical moment. In this regard, to infer that parents' choices regarding home educational resources influence $\boldsymbol{\phi_{i,t^a}}(l)$, it will be necessary to show that these choices have an impact on $E[o]_{i,t^a}$ through the children's characteristics at the canonical moment X_{i,t^a}. In the empirical analysis, this will require to control for the effect of children's epistemological beliefs and preferences at the canonical moment.

As it was discussed in Section 7.3.2, we distinguish between parents' choices regarding home educational resources C^{P*} (which we interpret as circumstances) and other parents' choices C^{P**}. Combining Equations 7.5 and 7.9 we get:

$$\begin{aligned} E[o]_{i,t^a} = e(x(&c^{p*}(X^P_{i,t^a-1}, B^P_{i,t^a-1}, R^P_{i,t^a-1}, X_{i,t^a-1}, R_{i,t^a-1}),\\ &c^{p**}(X^P_{i,t^a-1}, B^P_{i,t^a-1}, R^P_{i,t^a-1}, X_{i,t^a-1}, R_{i,t^a-1}),\\ &c(X_{i,t^a-1}, B_{i,t^a-1}, R_{i,t^a-1}), X_{i,t^a-1}, \zeta_{i,t^a}),\\ &B_{i,t^a}, R_{i,t^a}) \ . \end{aligned} \tag{7.10}$$

This is the theoretical function that will be replicated in the empirical analysis in the next section. By looking at the influence of parents' choices on children's characteristics at the canonical moment, we make sure that those characteristics have not been legitimately shaped by the children's preferences or by their epistemological beliefs, since they are responsible for these factors from the canonical moment onward. According to model 7.5, children's preferences may shape their parents' choices. For instance, possibly the parents' choices regarding home educational resources are influenced by their children's preferences. However, from the fact that children's preferences influence parents' choices does not follow that parents' choices are legitimate, since children are not to be hold accountable for their preferences before the canonical moment. In summary, focusing on the children's predictions about their future at the canonical moment offers a unique chance to assess the normative position endorsed in this paper, because i) the impact of parents' choices on children's predictions about their future can be used as a proxy of the influence of parents' choices on children's long-term outcomes, and ii) the influence of parents' choices on the individuals' characteristics is not contaminated by the influence of individuals' preferences or by their epistemological beliefs.

7.4.2. From the structural model to a model based on observed data

As it will be described in detail in the next section, the available information that we use in the empirical analysis consists of a set of variables which describe the home edu-

cational resources available to children $C^{P*}_{t^a-1}$, a set of proxies for parents' choices (other than choices regarding home educational resources) $\boldsymbol{C^{P**}_{t^a-1}}$, a set of proxies for parents' epistemological beliefs $\boldsymbol{B^{P}_{t^a-1}}$, a set of proxies for parents' preferences $\boldsymbol{R^{P}_{t^a-1}}$, a set of proxies for parents' characteristics $\boldsymbol{S_{t^a-1}}$, a proxy for children's epistemological beliefs B_{t^a} and a set of proxies for children's preferences $\boldsymbol{R_{t^a}}$ at the canonical moment.

As described in Section 7.1, the specification of the statistical model that will be used to assess IO should operationalise how each of the observed variables can be linked to a structural model, which in this case corresponds to the model shown in Equation 7.10. In this regard, each of the factors in this equation can be understood as a function of the set of proxies described above.

Children's characteristics are a function of parents' choices, children's choices and unobserved factors $\boldsymbol{\varepsilon^{x}}$, where $\boldsymbol{\varepsilon^{x}}$ accounts for the effects of X_{i,t^a-1} and ζ_{i,t^a} in Equation 7.10:

$$X_{i,t^a} = x(C^{P*}_{i,t^a-1}, C^{P**}_{i,t^a-1}, C_{i,t^a-1}, \boldsymbol{\varepsilon^{x}_{i}}). \tag{7.11}$$

The parents' choices regarding home educational resources can be represented as a function of the set of proxies for parents' beliefs and preferences, the set of proxies for parents' characteristics, the set of proxies for children's preferences and $\boldsymbol{\varepsilon^{c*}}$, which captures all other unobserved factors which determine parents' choices regarding home educational resources:

$$C^{P*}_{i,t^a-1} = f^{CP}(\boldsymbol{B^{P}_{i,t^a-1}}, \boldsymbol{R^{P}_{i,t^a-1}}, \boldsymbol{S_{i,t^a-1}}, \boldsymbol{R_{i,t^a}}, \boldsymbol{\varepsilon^{c*}_{i}}). \tag{7.12}$$

In Equation 7.10, C^{P**}_{i,t^a-1} captures all the parents choices other than C^{P*}_{i,t^a-1}. In this case, C^{P**}_{i,t^a-1} can be represented as a function of the set of proxies for parents' beliefs and preferences, the set of proxies for parents' characteristics, the set of proxies for children's preferences, the set of proxies for parents' choices and other unobserved factors $\boldsymbol{\varepsilon^{c**}}$:

$$C^{P**}_{i,t^a-1} = f^{CP}(\boldsymbol{B^{P}_{i,t^a-1}}, \boldsymbol{R^{P}_{i,t^a-1}}, \boldsymbol{S_{i,t^a-1}}, \boldsymbol{C^{P**}_{i,t^a-1}}, \boldsymbol{R_{i,t^a}}, \boldsymbol{\varepsilon^{c**}_{i}}). \tag{7.13}$$

Similarly, children's choices can be understood as a function of the set of proxies for parents' preferences and epistemological beliefs, the set of proxies for parents' characteristics, parents' choices, the set of proxies for children's epistemological beliefs and preferences and $\boldsymbol{\varepsilon^c}$, which captures all other unobserved factors which determine children's choices:

$$C_{i,t^a-1} = f^C(\boldsymbol{B^P_{i,t^a-1}}, \boldsymbol{R^P_{i,t^a-1}}, \boldsymbol{S_{i,t^a-1}}, \boldsymbol{C^{P**}_{i,t^a-1}}, \boldsymbol{C^{P*}_{i,t^a-1}}, B_{i,t^a}, \boldsymbol{R_{i,t^a}}, \boldsymbol{\varepsilon^c_i}). \tag{7.14}$$

Children's preferences can be represented as function of the proxies for parents and children's preferences and parents' characteristics and choices:

$$R_{i,t^a} = f^r(\boldsymbol{B^P_{i,t^a-1}}, \boldsymbol{R^P_{i,t^a-1}}, \boldsymbol{S_{i,t^a-1}}, \boldsymbol{C^{P**}_{i,t^a-1}}, \boldsymbol{C^{P*}_{i,t^a-1}}, \boldsymbol{R_{i,t^a}}, \boldsymbol{\varepsilon^r_i}), \tag{7.15}$$

with $\boldsymbol{\varepsilon^r}$ capturing all other unobserved variables which determine children's preferences.

Children's epistemological beliefs are represented as a function of the proxies for parents and children's epistemological beliefs, parents and children's preferences and parents' characteristics and choices:

$$B_{i,t^a} = f^b(\boldsymbol{B^P_{i,t^a-1}}, \boldsymbol{R^P_{i,t^a-1}}, \boldsymbol{S_{i,t^a-1}}, \boldsymbol{C^{P**}_{i,t^a-1}}, \boldsymbol{C^{P*}_{i,t^a-1}}, B_{i,t^a}, \boldsymbol{R_{i,t^a}}, \boldsymbol{\varepsilon^b_i}) \,, \tag{7.16}$$

with $\boldsymbol{\varepsilon^b}$ capturing all other unobserved variables which determine children's beliefs.

Parents' epistemological beliefs and preferences are represented as a function of the proxies for parents and children's epistemological beliefs and preferences, respectively:

$$B^P_{i,t^a-1} = f^b(\boldsymbol{B^P_{i,t^a-1}}, \boldsymbol{\varepsilon^{bP}_i}) \,. \tag{7.17}$$

$$R^P_{i,t^a-1} = f^r(\boldsymbol{R^P_{i,t^a-1}}, \boldsymbol{\varepsilon^{rP}_i}) \,. \tag{7.18}$$

Given these functions, Equation 7.10 for the children's expectations regarding their future life projects can be written as:

$$E[o]_{i,t^a} = e'\Big(f^{CP*}(\boldsymbol{B^P_{i,t^a-1}}, \boldsymbol{R^P_{i,t^a-1}}, \boldsymbol{S_{i,t^a-1}}, B_{i,t^a}, \boldsymbol{R_{i,t^a}}, \boldsymbol{\varepsilon^{c*}_i}), \boldsymbol{B^P_{i,t^a-1}}, \boldsymbol{R^P_{i,t^a-1}}, \boldsymbol{S_{i,t^a-1}}, \boldsymbol{C^{P**}_{i,t^a-1}}, B_{i,t^a}, \boldsymbol{R_{i,t^a}}, \boldsymbol{\varepsilon^{c**}_i}, \boldsymbol{\varepsilon^{c}_i}, \boldsymbol{\varepsilon^{b^P}_i}, \boldsymbol{\varepsilon^{r^P}_i}, \boldsymbol{\varepsilon^{x}_i}, \boldsymbol{\varepsilon^{b}_i}, \boldsymbol{\varepsilon^{r}_i}\Big). \tag{7.19}$$

7.4.3. Data

We use data from the 2015 version of the Programme for International Students Assessment (PISA) study. PISA is a triennial worldwide survey of 15-year-old students lead by the Organisation for Economic Co-operation and Development (OECD) (OECD, 2022). The 2015 PISA study includes data from 72 countries. The aim of this Programme is to evaluate educational systems by measuring the students' performance in several areas of knowledge. The survey also includes information about students and their family background, aspects of students' lives, aspects of schools, and aspects of learning and the context of instruction. The parents' questionnaire focuses on the parents' background, their perceptions of and involvement in their child's school, their support for learning at home, aspects about school choice and their beliefs about their child's occupation at adulthood. In our empirical application we use data from Chile, where a representative sample of 7,053 students and parents was obtained.

As it was covered in the previous section, we aim to obtain data about the children's expectations regarding their future occupation, the children's home educational resources, proxies for parents' and children's preferences and epistemological beliefs, proxies for parents' characteristics and proxies for parents' choices. The children's expectation regarding their future is captured by their answer to the following question: *What kind of job do you expect to have when you are about 30 years old?*. The PISA study classifies the answers to this question according to the International Standard Classification of Occupations (ISCO) and the International Socio-Economic Index of Occupational Status (ISEI). ISCO

organizes occupations according to the tasks and duties involved in each job. The ISEI provides an ordinal scale of occupations based on "the attributes of occupations that converts a persons' education into income" (Ganzeboom and Treiman, 2003, p. 171). The index ranges from 16 to 90. Most of the ISEI categories in the sample have a relative frequency lower than 0.03 whereas the highest relative frequency for a single category was 0.13. To have a sufficient sample size in each category we merge adjacent categories until we obtain eight categories (where 1 is the group of occupations with lower income-generating capacity) with a relative frequency close to 0.125. This new 'job ordinal scale' of expected occupation ($E[o]_{i,t^a}$) was used in the 'main' model.

As it will be described later in this section, most of the exogenous regressors are related to science proxying beliefs and preferences related to science rather than beliefs and preferences more broadly. Therefore, we also implemented an 'alternative' model specification where the expected occupation was operationalised differently. In this case we created a categorical variable to capture ($E[o]_{i,t^a}$): non-science career, low-paid science career and high-paid science career. Based on the ISCO codes, occupations were classified as science or non-science related careers according to the categories used in the 2015 PISA report (OECD, 2016). Science-related careers with a job ordinal scale equal or less than four were categorized as low-paid science-related jobs, whereas high-paid science-related occupations are those with a job ordinal scale higher than four. Approximately 50% declare that their expected future occupation is a non-science related job, whereas 11% and 39% consider that they expect to work in a low-paid and a high-paid science-related job, respectively.

The parents' choices regarding their child's home educational resources are captured by a set of assets that the children declare to have or not in their home: a desk to study, a room of their own, a quiet place to study, a computer to use for school work, educational software, a link to the internet, classic literature, book of poetry, books on art, music or design, technical books, books to help with their school work, works of art, and a dictionary. Based on this set of questions we built a continuous index ($C^{P*}_{t^a-1}$) equal to the weighted sum of the three first components of a principal component analysis that in-

cludes all these assets as covariates. Weights correspond to the explanatory power of each component. Overall the three first components accounts for 42% of the variability. The index was standardized between 0 and 1 (low and high investment in home educational resources, respectively). The distribution of this index shows a negative skewness, with an average of 0.80 and a median of 0.84 [4].

The *parents' epistemological beliefs* $\boldsymbol{B^{P}_{t^{a}-1}}$ are captured by one index which captures parents' views about the importance of science to society (Parents' views science)[5] and a variable that captures their *beliefs regarding their child's occupation.* The beliefs of parents about their child's future career is captured by a binary variable that assesses whether they expect their child to go into a science-related career (Exp. child science career). Approximately 50% of parents believe their child will do so. *Children's epistemological beliefs* $B_{t^{a}-1}$ are captured by an index aimed to capture children's epistemological beliefs (Childrens' epist. beliefs) [6]. The preferences of children $\boldsymbol{R_{t^{a}-1}}$ are captured by two indexes which aim to measure the children's enjoyment of science (Children's science enj.) and their interest in broad science topics (Children's science int.) [7]. Unfortunately, the study did not include questions about other areas of knowledge. All these indexes (Parents' views science, Childrens' epist. beliefs, Children's science enj. and Children's science int.) are continuous variables and were estimated by the PISA study group using item-response theory (OECD, 2017).

[4] We chose to use principal component analysis since this is a standard method for constructing composite indicators. Nevertheless, we acknowledge the fact that there may be other methods, such as latent variable framework that may be suitable for this task.

[5] The questions used to build the index of parents' epistemological beliefs were the following: Science is important to help us to understand the natural world; Science is valuable to society; Science is very relevant to me, I find that science helps me to understand the things around me, advances in science usually bring social benefits. Parents were asked to declare to what extent they agree with these statements using a four-point Likert scale.

[6] The questions used to build the index of children's epistemological beliefs were the following: A good way to know if something is true is to do an experiment; Ideas in science sometimes change; Good answers are based on evidence from many different experiments; It is good to try experiments more than once to make sure of your findings; Sometimes scientists change their minds about what is true in science; The ideas in science books sometimes change. Children were asked to declare to what extent they agree with these statements using a four-point Likert scale.

[7] The questions used to build the index of science enjoyment were the following: I generally have fun when I am learning science topics; I like reading about science; I am happy working on science topics; I enjoy acquiring new knowledge in science and I am interested in learning about science. Students were asked to respond to what extent they agree with these statements using a four-point Likert scale. To build the index of science interest, students were asked to rate how interested they are in the following topics using a five-point Likert scale: biosphere, motion and forces, energy and its transformation, the universe and its history and how science can help us prevent disease.

The *parents' preferences* $\boldsymbol{R^P_{t^a-1}}$ are captured by: i) parents' views about environmental issues, and ii) a set of questions regarding the importance they attach to different reasons for choosing a school for their child. *Parents' views on environmental topics* were measured using a composed index (Parents' environmental concern). This index was built by the PISA study group using item-response theory (OECD, 2017) [8]. The set of aspects that parents were asked to rate in term of its *importance when choosing a school for their child* were the following (see Table 7.1): school adherence to a particular religious philosophy (Imp. school religion), school reputation (Imp. school reputation), low school expenses (Imp. low school expenses), the school pedagogic approach (Imp. school pedagogy), the academic achievements of the school's students (Imp. school achievement) and the distance from home (Imp. school distance). Parents were asked to rate these reasons in a 4-point scale of importance. For each aspect, if an answer category obtained a relative frequency lower than five percent, we reduced the 4-point scale into a 3-point scale by merging the two adjacent answer-categories with the lowest relative frequency. The vast majority of respondents considers important or very important the school achievement and school reputation, whereas religion is considered not important by most respondents. Parents' views regarding school distance, low expenses and school pedagogy were evenly split across categories.

Parents' human capital was used as a proxy for *parents' characteristics*. Parents' human capital was based on information about the mother's education and the father's occupation (as reported by the children)[9]. Five categories were defined based on the highest educational achievement of the mother according to the ISCED 2011 clasification (UNESCO Institute for Statistics., 2012): primary (ISCED level 0 or 1), low secondary education (ISCED level 2), high secondary (ISCED level 3), post-secondary non-tertiary (ISCED level 5B) and tertiary (ISCED level 5A and 6). Five categories were defined for

[8] *Parents' concern about environmental topics* was assessed by asking parents to rate the extent to which they see the following issues as a serious concern for society using a four-point Likert scale: extinction of plants and animals, clearing of forests for other land use, water shortages nuclear waste, extreme weather conditions and human contact with animal diseases.

[9] Information about the mother's education was obtained by asking the children to choose among different categories, whereas information about the father's occupation was obtained using free-text responses which were subsequently categorised by the PISA study group.

the father's occupation based on the ISCO-08 classification (International Labour Office, 2012) (up to the first digit): low-skilled blue collar workers (ISCO categories 8 and 9), high-skilled blue collar workers (ISCO categories 6 and 7), low-skilled white collar workers (ISCO categories 4, 5 and 6) and high-skilled white collar workers (ISCO categories 1, 2 and 3).

Table 7.1: *Descriptive statistics: parents' preferences*

School dimensions	Not important, or Not/somewhat	Somewhat important	Important	Very important
School religion	0.43	0.19	0.21	0.17
School reputation	0.09	-	0.34	0.58
School low expenses	0.24	0.24	0.28	0.24
School pedagogy	0.29	0.26	0.30	0.15
School achievement	0.14	-	0.39	0.48
School distance	0.24	0.23	0.29	0.24

Notes: Parents were asked to rate how important was each of these school dimensions when choosing a school for their child. The categories not important and somewhat important were merged for school reputation and school achievement.

Based on these categories, four groups $\boldsymbol{S}$ were defined (see Table 7.2): high (mother's education: tertiary; and father's occupation: high-skilled white collar), medium-high (mother's education: high secondary or post-secondary non-tertiary; and father's occupation: white collar; or mother's education: tertiary and father's occupation: low-skilled white collar), medium-low (mother's education: primary or low secondary; and father's occupation: white collar worker; or mother's education: high secondary; and father's occupation: high-skilled blue collar; or mother's education: post-secondary non tertiary; and father's occupation: blue collar), and low (mother's education: primary or low secondary; and father's occupation: blue collar; or mother's education: high secondary and father's occupation: low-skilled blue collar).

The proxies for parents' choices $\boldsymbol{C^{P**}_{t^a-1}}$ were captured by i) information about the school attended by the children and ii) information about parents' monitoring and involvement on their child's school achievements. Regarding the school characteristics, the following information was included (see Table 7.2): the proportion of teachers who hold a Ph.D (Proportion teacher Ph.D.), the proportion of science teachers over the total

number of teachers (Proportion of science teacher), the number of students per teacher (Student-teacher ratio) and the type of school (School type -Private independent, Private Government-dependent, and Public). Most children attend Private-Government dependent schools, while the proportion of children who attend Private and Public schools was similar among them. Most schools (75%) did not have any teacher with a Ph.D. degree. The average student-ratio was nearly 20 (5th/95th percentile: 10/32) and the average proportion of science teachers was 9% (5th/95th percentile: 3%/26%).

Table 7.2: *Descriptive statistics: parents' characteristics and parents' choices.*

Parents' characteristics	**Proportion**	**Parents' choices**	**Proportion/ Mean (SD)**
Parents' human capital		School type	
High	0.27	*Private indep.*	0.29
Medium-high	0.30	*Private-Government dep.*	0.43
Medium-low	0.21	*Public*	0.28
Low	0.23	Students-teacher ratio	19.68 (6.71)
		Prop. of teachers with Ph.D.	0.001
		Prop. of science teachers	0.09

Notes: Parents' human capital is a variable build based on the father's occupation and the mother's education. The three school types categories are: Private independent (schools that do not receive public funds), Private Government-dependent (mix of public and private funding), and publicly funded schools. Proportions (Prop.) are shown for categorical variables and mean and standard deviation (SD) are shown for continuous variables.

Four variables aim to capture information regarding parents' monitoring and involvement on their child's school achievements (see Table 7.3). In this case parents are asked regarding how often they discuss about the children's school performance, their future career or help them with their homework. Most parents (85%) discuss often with their child about their school achievements, about half of the parents discuss more than once a week with their child about their performance in science, whereas about a third help their child with their science homework or discuss with their child about science-related career options more than once a week.

Table 7.3: *Descriptive statistics: parents' involvement in their child school achievements*

Parents' choices	Never up to twice a year	Once or twice per month	Once a week up to everyday
Discuss school performance	0.04	0.11	0.85
Help in science homework	0.40	0.23	0.37
Discuss science performance	0.23	0.27	0.50
Discuss science career	0.54	0.22	0.24

Note: Parents were asked how often they engage in each of these activities with their child.

7.4.4. Models' specification and estimation

Our aim is to estimate a model which could capture the relationship between children's predictions about their future life projects and proxies for parents' and children's preferences and epistemological beliefs, parents' characteristics, parents' choices and home educational resources. Based on the theoretical model shown in Equation 7.19, the following models were specified:

$$E[o]'_{t^a} = C^{P*}_{t^a-1}\gamma + B^{P}_{t^a-1}\mu + \boldsymbol{R^P_{t^a-1}}'\boldsymbol{\alpha} + \boldsymbol{S'_{t^a-1}}\boldsymbol{\beta} + \boldsymbol{C^{P**}_{t^a-1}}'\boldsymbol{\varphi} + B_{t^a}\omega + \boldsymbol{R'_{t^a}}\boldsymbol{\theta} + \epsilon_{t^a} \quad (7.20)$$

$$C^{P*}_{t^a-1} = B^{P}_{t^a-1}\sigma + \boldsymbol{R^P_{t^a-1}}'\boldsymbol{\delta} + \boldsymbol{S'_{t^a-1}}\boldsymbol{\lambda} + \boldsymbol{R'_{t^a}}\boldsymbol{\kappa} + \eta_{t^a-1} \quad (7.21)$$

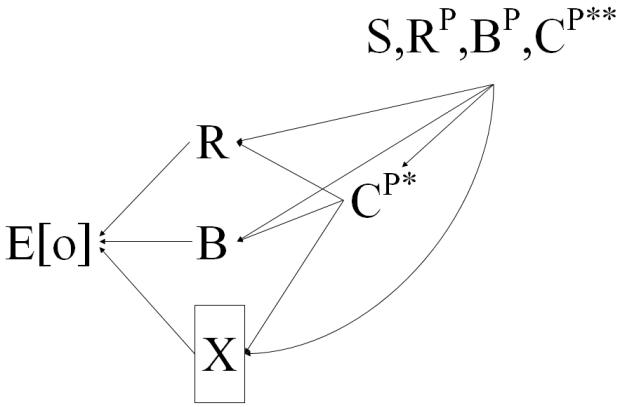
These equations constitute a recursive system of equations. In the main model the dependent variable corresponds to the job ordinal scale whereas in the alternative model the expected occupation is captured by a categorical variable (non-science related job, low-paid science-related job and high-paid science-related job). Accordingly, in the main model Equation 7.20 was estimated using an ordered probit model, whereas in the alternative model specification equation 7.20 was estimated using a multinomial probit model. In Equation 7.21, $C^{P*}_{t^a-1}$ corresponds to the home educational resources index. This equation was estimated using a linear model.

Recall from Section 7.3.1 that the structural model assumes that the effect of parents' choices regarding home educational resources influence children's beliefs regarding their future occupation by shaping the children's characteristics which in turn influence their subjective probabilities of achieving different life projects. Therefore, given the specification of Equations 7.20 and 7.21 we would interpret that there exists IO if the estimator for γ is different from zero and statistically significant.

Importantly, according to this model specification the error terms of Equations 7.20 and 7.21 are uncorrelated. This is based on the assumption that there are no unobserved factors that may have a common influence on $E[o]$ and C^{P*}. Figure 7.1 shows a Directed Acyclic Graph (DAG) of the relationships of the variables included in the model. In Equation 7.20 we control for a set of proxies for children's and parents' preferences and epistemological beliefs, parents' characteristics and parents' choices other than choices about home educational resources. This set of factors plays a dual role. First, they seek to exclude the possibility that other factors distinct from home educational resources may be responsible of the association between C^{P*} and $E[o]$. Second, by including proxies of children's preferences and children's epistemological beliefs at the canonical moment, we try to control for the 'mediated' effect of parents' choices regarding home educational resources that are mediated through children's preferences and children's epistemological beliefs, since these are legitimate sources of inequalities according to the normative position adopted in this paper.

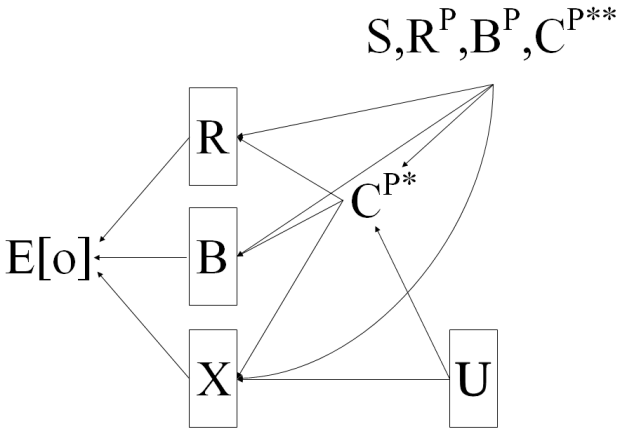
In Figure 7.1 children's characteristics (X) are shown inside a square. The square represents variables that are excluded from the model. Given the theoretical model implemented in this Chapter and assuming that we adequately control for children's preferences and children's epistemological beliefs, we interpret that the effect of C^{P*} on $E[o]$ is mediated by children's characteristics. Figure 7.2 shows the different sources of endogeneity of the model. If we do not observe (or we inadequately control for) children's preferences and beliefs, we cannot assume that the effect of C^{P*} on $E[o]$ is mediated by children's characteristics. Furthermore, if unobserved characteristics (U) correlated with C^{P*} and $E[o]$ exist, the observed effect of C^{P*} on $E[o]$ could be biased.

Figure 7.1: *Directed Acyclic Graph of the econometric model*



$E[o]$: expected occupation, R: child's preferences, B: child's beliefs, S: parents' characteristics, C^{P*}: home educational resources, R^P: parents' preferences, B^P: parents' beliefs, C^{P**}: parents' choices other than choices regarding home educational resources, X: child's characteristics.
Note: The square represents variables that are not included in the econometric model.

Figure 7.2: *Directed Acyclic Graph: potential sources of endogeneity*



$E[o]$: expected occupation, R: child's preferences, B: child's beliefs, S: parents' characteristics, C^{P*}: home educational resources, R^P: parents' preferences, B^P: parents' beliefs, C^{P**}: parents' choices other than choices regarding home educational resources, X: child's characteristics, U: unobserved variables.
Note: The square represents variables that are not included in the econometric model.

7.4.5. A note regarding the model specification

Note that the specification of the econometric model used is relatively simple, and is not of a complex structural model, as recommended by Fleurbaey and Schokkaert (2009, 2011b). Their recommendation involves three steps: i) to build a structural model to estimate the role of different causes of health inequality, ii) to categorize factors into legitimate and illegitimate sources of inequality, and iii) to measure unfair inequality.

In our view, the specification of the econometric model should respond to the research problem at hand. In this regard, contrary to what is suggested by Fleurbaey and Schokkaert, a coherent measure of unfair inequality may be obtained without the need of estimating a structural model. We agree with Fleurbaey and Schokkaert that researchers should start by making explicit how they understand the underlying process that generates the observed data. This requires building a theoretical model to understand the map of relationships between different factors. However, we consider that the implementation of a structural econometric model that fully reproduces the theoretical model is not always needed. In this regard, the theoretical model together with the normative criteria should inform how the econometric model should be specified. In some cases, it may be that the theoretical model and the normative position(s) adopted require the implementation of a structural model, but at other times it could be the case that a simpler model is well suited for the task.

It should also be noted that the focus of Fleurbaey and Schokkaert is to propose a strategy that could be used to assess unfair inequality according to different normative positions. We agree that in such a case a structural model would be the best strategy. However, the purpose of this research is to assess unfair inequality according to a very specific normative definition and not to implement different measures of unfair inequality. In this regard, given the theoretical model that we built and the DAG shown in Figure 7.1, the model specification shown in equation 7.20 should be adequate to assess inequality of opportunity according to the ethical position that we take.

7.4.6. Results

Main model

Table 7.5 shows the results of the recursive system of equations. From now on we refer only to those variables that have a statistically significant effect with a *p-value* $< 5\%$. Since the effect of the variables of the ordinal probit model needs to be interpreted with respect to each occupational category, we computed average marginal effects (see Appendix) for each variable with respect to the probability of children choosing $E[o] = 1$ (the group of occupations with least income-generating capacity) and $E[o] = 8$ (the group of occupations with the highest capacity). Having parents who have higher human capital is traduced in a positive average marginal effect with respect to the probability of children choosing $E[o] = 8$, a negative average marginal effect with respect to the probability of choosing $E[o] = 1$ and a positive effect on the investment in home educational resources. This goes in the expected direction since one can argue that, other things being equal, parents who are better educated could be more inclined to invest in their children's skills acquisition and therefore invest more in home educational resources. Moreover, higher investment in children's skill acquisition may positively influence the probability of achieving better-paid jobs and influence their expectations accordingly. Furthermore, parents may directly influence their children's preferences for better-paid jobs. In addition, conditional on parents' preferences, parents with higher social capital may have higher income, and therefore better capacity to invest in their children.

Table 7.4: *Regression results of the main model*

	E[o]	SE	$\mathbf{C}^{P*}$	SE
Children's epistemological beliefs	0.053**	(0.021)		
Children's science enjoyment	0.117***	(0.023)	0.010***	(0.002)
Children's science interest	0.023	(0.026)	0.010***	(0.003)
Parents' science view	0.012	(0.022)	0.010***	(0.002)
Parents' environmental concern	0.001	(0.027)	0.001	(0.003)
Exp. child science career: *Yes*	0.470***	(0.047)	-0.021***	(0.005)
Imp. school religion, *Baseline: NI*				
Somewhat important	-0.106*	(0.060)	- 0.002	(0.007)
Important	-0.053	(0.059)	0.018***	(0.006)
Very important	-0.051	(0.063)	0.014**	(0.007)
Imp. school reputation, *Baseline: NI/SI*				
Important	0.155*	(0.090)	0.022**	(0.010)
Very important	0.103	(0.090)	0.028***	(0.010)
Imp. school low expenses, *Baseline: NI*				
Somewhat important	-0.109*	(0.062)	-0.006	(0.007)
Important	-0.026	(0.062)	-0.027***	(0.007)
Very important	-0.037	(0.069)	-0.045***	(0.008)
Imp. school pedagogy, *Baseline: NI/SI*				
Somewhat important	0.000	(0.058)	-0.000	(0.006)
Important	-0.140**	(0.057)	-0.006	(0.006)
Very important	-0.040	(0.072)	-0.008	(0.008)
Imp. school achievement, *Baseline: NI/SI*				
Important	0.063	(0.069)	-0.004	(0.007)
Very important	0.160**	(0.073)	-0.002	(0.008)
Imp. school distance, *Baseline: NI*				
Somewhat important	-0.056	(0.062)	-0.004	(0.007)

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Table 7.4 – continued from previous page

	E[o]	SE	$\mathbf{C}^{P*}$	SE
Important	-0.102*	(0.059)	0.008	(0.007)
Very important	-0.132**	(0.063)	-0.009	(0.007)
Parents' human capital, *Baseline: High*				
Medium high	-0.130**	(0.063)	-0.044***	(0.006)
Medium low	-0.114	(0.074)	-0.090***	(0.007)
Low	-0.371***	(0.077)	-0.126***	(0.007)
Type of school, *Baseline: Private*				
Private Government-dependent	-0.170**	(0.066)		
Public	-0.288***	(0.070)		
Student-teacher ratio	-0.004	(0.004)		
Proportion teacher Ph.D.	10.07**	(4.730)		
Proportion of science teacher	1.496***	(0.548)		
Discuss school perf., *Baseline: Never/2 pa*				
One or two per month	-0.136	(0.126)		
Once a week to everyday	-0.097	(0.112)		
Help homework, *Baseline: Never/2 pa*				
One or two per month	-0.020	(0.057)		
Once a week to everyday	-0.071	(0.056)		
Discuss science perf., *Baseline: Never/2 pa*				
One or two per month	0.022	(0.066)		
Once a week to everyday	0.054	(0.067)		
Discuss science career, *Baseline: Never/2 pa*				
One or two per month	0.097	(0.055)		
Once a week to everyday	0.070	(0.060)		
Constant			0.871***	(0.012)
C^{P*}	0.475***	(0.149)		

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Table 7.4 – continued from previous page

	$\mathbf{E}[\mathbf{o}]$	SE	$\mathbf{C}^{P*}$	SE
Observations	2431		3744	

Standard errors in parentheses, NI: Not important, SI: Somewhat important, pa: per year.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

Parents who attach more importance to school reputation, and school religion and less importance to school distance tend to invest more in home educational resources. The inverse relationship between the importance attached to school distance and investment in home educational resources can be understood as a willingness to prioritize other school characteristics instead of proximity to home. The positive correlation between the importance attached to school reputation and investment in educational resources is consistent with parents being more interested in their children's academic achievements. In the same vein, there is evidence that suggests that religious schools may outperform secular ones in Chile (McEwan and Carnoy, 2000; Mizala and Torche, 2012), which is consistent with the positive correlation between parents who attach greater importance to school religion and the investment in home educational resources.

Other variables that have a statistically significant positive effect on the home educational resource index are the children's science enjoyment, the children's scientific interest, and the parents' views on science. The fact that parents who attach more importance to science or who attach more importance to school reputation may invest more in home educational resources seems logical. Similarly, it seems plausible that children who like science are influenced by having richer home educational resources.

There are several additional variables that have a statistically significant effect on the children's expected occupation. The results suggest that conditional on the other covariates, the children of parents who expect their child to pursue a science-related career, children who enjoy science, and children with science-oriented epistemological beliefs have a higher (negative) probability of declaring they expect to achieve occupations with higher (lower) income generating capacity. Moreover, the higher the importance that parents attach to school achievement the higher (lower) the marginal effect with respect to the probability of achieving better (worse) paid jobs. By contrast, the importance that parents attach to pedagogy has a statistically significant negative (positive) effect on the probability of children declaring they expect to achieve better (worse) paid occupations. We can think of two hypotheses to explain this result. Parents who prioritise pedagogy may do so because they: i) believe their children face learning difficulties or ii) consider

themselves unable to support their children with their school work at home. Also, the children of parents who attach more importance to the school's distance from home have a lower (higher) probability of expecting a future occupation with a high (low) income-generating capacity. This may be related to the fact that parents who prioritise the school's distance from home over its quality invest less in their children's skill acquisition.

Among the factors linked to school characteristics, attending private-government dependent school or public school have a lower (higher) effect on the probability of children declaring they expect to achieve better (worse) paid occupations, compared to children who attend private schools. This is consistent with the empirical evidence which suggests that private schools in Chile perform better with respect to skill acquisition (Alarcón López and Falabella, 2021). The proportion of teachers who hold a Ph.D. and the proportion of science teachers in the school both have a positive (negative) effect on the probability of expecting a future occupation with high (low) income-generating capacity.

We now turn to the overall effect of the home educational resource index on the children's expected future occupation. This effect can be break-up into two parts: the effect of the covariates in the distribution of C^{P*} and the effect of C^{P*} on the children's beliefs about their future occupation, conditional on covariates.

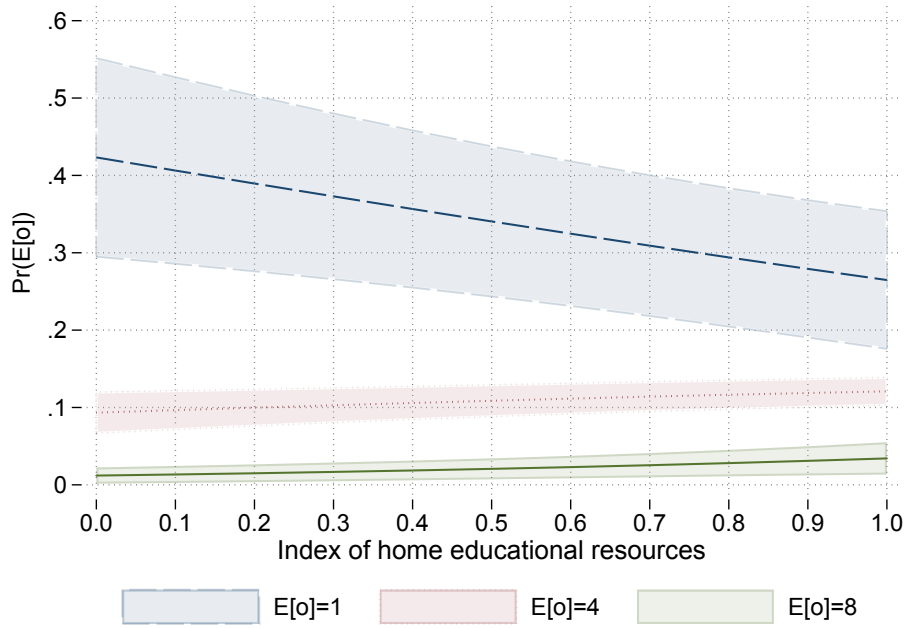
For ease of exposition, we focus on two sub-groups. Sub-group A corresponds to children whose parents have factors that relate to low investment in children's skill acquisition: have low human capital, do not expect them to go into a science-related career, consider school distance as very important, school religion as not important, school reputation as not important, school achievements as not important, school pedagogy as very important, school expenses as very important; while keeping the continuous indexes at the mean. Sub-group B corresponds to children whose parents have factors that relate to high investment in children's skill acquisition: have a high human capital, expect them to go into a science-related career, consider school distance as not important, school religion as very important, school reputation as very important, school achievements as very im-

portant, school pedagogy as not important, low school expenses as not important; while keeping the continuous indexes at the mean.

We computed the expected level of C^{P*} among children in sub-group A and subgroup B and used bootstrap with 10,000 replications to obtain an empirical distribution of these predictions. The 2.5% and 97.5% percentiles of this distribution are used to characterize the uncertainty around the estimations. The results go in the expected direction. The average level of predicted C^{P*} was 0.69 (0.67-0.72) among individuals in sub-group A and 0.91 (0.89-0.93) among individuals in sub-group B.

The results show that C^{P*} has a statistically significant effect on the children's beliefs about their future occupation, controlling for the set of proxies for parents' beliefs and preferences, children's beliefs and preferences, parents' choices and parents' characteristics. According to the normative position that we adopted, this is evidence of IO. Figures 7.3 and 7.4 show the effect of the home educational resource index on the probability of children declaring their future expected occupation being $E[o] = 1$, $E[o] = 4$ and $E[o] = 8$ for sub-groups A and B. Besides the above-mentioned covariates, in sub-group A we fixed the student-teacher ratio, the proportion of teachers who hold a Ph.D. and the proportion of science teachers at the mean, the type of school at public school and all the variables regarding parents' monitoring and involvement on their child's school achievements at 'once a week up to every day'. In sub-group B we fixed the student-teacher ratio, the proportion of teachers who hold a Ph.D. and the proportion of science teachers at the mean, the type of school at private school, and all the variables regarding parents' monitoring and involvement in their child's school achievements at 'never up to twice a year'.

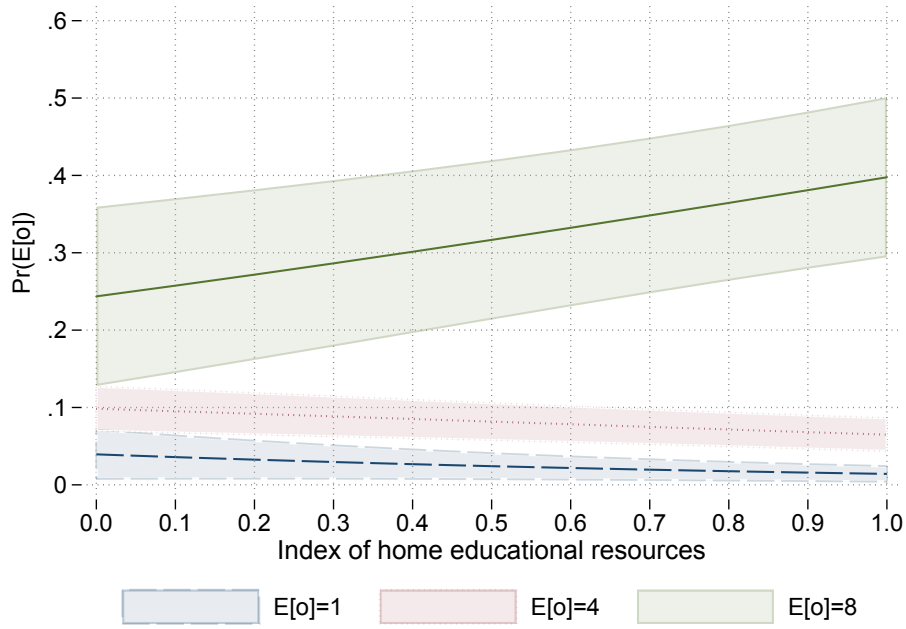
Figure 7.3: *Predicted expected future occupation for each level of C^{P*}, Sub-group A (low investment in children's skill acquisition)*



Notes: Predicted probabilities of expecting low ($E[o] = 1$), intermediate ($E[o] = 4$) or high paid jobs ($E[o] = 8$) for children whose parents have low human capital, do not expect them to go into a science-related career, consider school distance as very important, school religion as not important, school reputation as not important, school achievements as not important, school pedagogy as very important, school expenses as very important, the type of school at public school and all the variables regarding parents' monitoring and involvement on their child's school achievements at 'once a week up to every day'; while keeping the continuous indexes at the mean. The shaded areas correspond to the 95% confidence intervals of the predictions.

The shaded area in the figures corresponds to the 95% confidence interval. As it is shown in the figures, conditional on C^{P*}, children in subgroup A have a lower probability of expecting to work in occupations that are better paid ($E[o] = 8$) and a higher probability of expecting to work in occupations which are worse paid ($E[o] = 1$). The opposite effect is found among children in sub-group B. Furthermore, the access to home educational resources seems to have a strong effect in increasing (decreasing) the proportion of children who believe they will work in better-paid (worse-paid) occupations among children in sub-group A (sub-group B), but little effect on their beliefs about working in high-paid (low-paid) occupations.

Figure 7.4: *Predicted expected future occupation for each level of C^{P*}, Subgroup B (high investment in children's skill acquisition)*



Notes: Predicted probabilities of expecting low ($E[o] = 4$), intermediate ($E[o] = 1$) or high paid jobs ($E[o] = 8$) for children whose parents have a high human capital, expect them to go into a science-related career, consider school distance as not important, school religion as very important, school reputation as very important, school achievements as very important, school pedagogy as not important, low school expenses as not important, the type of school at private school, and all the variables regarding parents' monitoring and involvement in their child's school achievements at 'never up to twice a year'; while keeping the continuous indexes at the mean. The shaded areas correspond to the 95% confidence intervals of the predictions.

Alternative model

Table 7.5 shows the results of the alternative model. Since the sign of the regression coefficients does not give the sign of the marginal effect, for ease of interpretation we report the Average Marginal Effects (AME) of each exogenous variable. The results suggest that the probability of expecting to work in a science-related occupation is positively correlated with children's and parents' science-oriented beliefs and preferences. The children whose epistemological beliefs are more science-oriented have a higher probability of expecting to work in a high-paid science-related job and a lower probability of expecting a low-paid science-related job. Also, children who enjoy science and who are more interested in science have a lower probability of declaring that they expect to work on a non-science related job and a higher probability of expecting a high-paid science job. Similarly, the children of parents who believe that their child will work in a science-related occupation

have a lower probability of expecting to work on a non-science-related job and a higher probability of working on a science-related job. Furthermore, the AME suggests that the magnitude of the effect of parents' beliefs regarding their child's occupation is stronger for high-paid science-related jobs than for low-paid science-related jobs. In the same vein, the results show that the children of parents who do not discuss regularly with them regarding their science-related career options are more likely to expect to work on a non-science-related career.

The results also show that the children of parents who attach more importance to the distance of the school from home are more likely to expect to have a non-science-related job. Although the results are less stronger for school expenses, the results suggest that the children of parents who attach more importance to school expenses tend to have a higher probability of expecting a low-paid science-related job and a lower probability of expecting a high-paid science-related job. As was discussed in the results of the main model, this may suggest that parents who attach more importance to characteristics that are not related to the school's educational performance are less likely to invest in their children's academic skills.

It was also found that the children of parents who attach more importance to school pedagogy tend to have a higher probability of expecting to work in a non-science-related job and a lower probability of expecting to work in a science-related job. As was discussed in the results of the main model, this may be because parents attach more importance to school pedagogy when they perceive that their child has poor skills.

The results of the alternative model show that there is a statistically significant effect of the index of home educational resources on the probability of expecting a science-related job. According to the alternative model, the probability of expecting a low-paid science-related job is 10% lower and the probability of expecting a high-paid science-related job is 13% higher among children who have access to the highest *vis a vis* those with the lowest level of home educational resources. This is consistent with the results of the main model and provides complementary evidence to support the hypothesis that there exists

inequality of opportunity in Chile.

Table 7.5: *Regression results of the alternative model: average marginal effects*

	Non sci. job	**Low-paid sci. job**	**High-paid sci. job**
Children's epistemological beliefs	-0.012	-0.011*	0.023**
	(-0.030;0.006)	(-0.023;0.001)	(0.005;0.041)
Children's science enjoyment	-0.045***	0.013*	0.032***
	(-0.065;-0.026)	(-0.000;0.027)	(0.012;0.052)
Children's science interest	-0.027**	-0.009	0.036***
	(-0.048;-0.005)	(-0.024;0.006)	(0.013;0.058)
Parents' science view	-0.003	0.006	-0.003
	(-0.022;0.015)	(-0.007;0.020)	(-0.022;0.016)
Parents' environmental concern	0.011	-0.003	-0.008
	(-0.012;0.033)	(-0.019;0.013)	(-0.031;0.015)
Exp. child science career: *Yes*	-0.288***	0.063***	0.226***
	(-0.330;-0.247)	(0.035;0.090)	(0.184;0.267)
Imp. school religion, *Baseline: NI*			
Somewhat important	0.020	0.019	-0.039
	(-0.31;0.070)	(-0.017:0.055)	(-0.090;0.012)
Important	-0.001	-0.006	0.007
	(-0.051;0.049)	(-0.039;0.028)	(-0.044;0.058)
Very important	-0.003	0.013	-0.010
	(-0.057;0.050)	(-0.024;0.051)	(-0.064;0.044)
Imp. school reputation, *Baseline: NI/SI*			
Important	-0.030	-0.030	0.060
	(-0.104;0.043)	(-0.083;0.024)	(-0.014;0.134)
Very important	-0.024	-0.022	0.046
	(-0.098;0.049)	(-0.076;0.032)	(-0.027;0.120)
Imp. school low expenses, *Baseline: NI*			

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Table 7.5 – continued from previous page

	Non sci. job	Low-paid sci. job	High-paid sci. job
Somewhat important	0.003	0.049***	-0.052*
	(-0.049;0.056)	(0.013;0.084)	(-0.105;0.000)
Important	0.004	0.024	-0.029
	(-0.049;0.058)	(-0.010;0.059)	(-0.082;0.025)
Very important	-0.037	0.024	0.013
	(-0.096;0.020)	(-0.013;0.061)	(-0.046;0.073)
Imp. school pedagogy, *Baseline: NI/SI*			
Somewhat important	0.053**	-0.029*	-0.024
	(0.004;0.102)	(-0.061;0.003)	(-0.074;0.026)
Important	0.058**	0.016	-0.074***
	(0.009;0.107)	(-0.019;0.051)	(-0.123;-0.024)
Very important	0.048	-0.010	-0.038
	(-0.013;0.110)	(-0.051;0.031)	(-0.100;0.024)
Imp. school achievement, *Baseline: NI/SI*			
Important	-0.026	-0.002	0.028
	(-0.085;0.034)	(-0.044;0.040)	(-0.032;0.088)
Very important	-0.044	-0.011	0.055*
	(-0.106;0.019)	(-0.054;0.033)	(-0.008;0.118)
Imp. school distance, *Baseline: NI*			
Somewhat important	0.058**	-0.025	-0.033
	(0.005;0.110)	(-0.062;0.012)	(-0.086;0.021)
Important	0.074***	-0.032*	-0.042
	(0.023;0.124)	(-0.068;0.003)	(-0.093;0.010)
Very important	0.087***	-0.026	-0.061**
	(0.033;0.140)	(-0.063;0.012)	(-0.115;-0.007)
Parents' human capital, *Baseline: High*			

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Table 7.5 – continued from previous page

	Non sci. job	**Low-paid sci. job**	**High-paid sci. job**
Medium high	0.025	0.009	-0.035
	(-0.029;0.079)	(-0.026;0.045)	(-0.089;0.020)
Medium low	0.001	0.017	-0.018
	(-0.062;0.064)	(-0.025;0.058)	(-0.082; 0.047)
Low	0.083**	0.050**	-0.134***
	(0.017;0.149)	(0.004;0.097)	(-0.200:-0.068)
Type of school, *Baseline: Private*			
Private Government-dependent	0.041	-0.019	-0.022
	(-0.015;0.098)	(-0.057;0.020)	(-0.079;0.034)
Public	0.042	0.008	-0.050
	(-0.018;0.103)	(-0.035;0.051)	(-0.111;0.011)
Student-teacher ratio	0.001	0.000	-0.002
	(-0.002;0.004)	(-0.002;0.003)	(-0.005;0.002)
Proportion teacher Ph.D.	-2.617	-0.049	2.667
	(-6.678;1.443)	(-2.761;2.663)	(-1.368;6.702)
Proportion of science teacher	-0.328	0.053	0.275
	(-0.796;0.140)	(-0.258;0.364)	(-0.196;0.746)
Discuss school perf., *Baseline: Never/2 pa*			
One or two per month	0.062	-0.003	-0.060
	(-0.041;0.166)	(-0.077;0.072)	(-0.169;0.050)
Once a week to everyday	0.084*	-0.008	-0.077
	(-0.007;0.176)	(-0.074;0.058)	(-0.174;0.020)
Help homework, *Baseline: Never/2 pa*			
One or two per month	0.012	0.006	-0.018
	(-0.036;0.061)	(-0.028;0.040)	(-0.067;0.030)
Once a week to everyday	0.007	-0.009	0.002

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Table 7.5 – continued from previous page

	Non sci. job	**Low-paid sci. job**	**High-paid sci. job**
	(-0.041;0.055)	(-0.041;0.023)	(-0.047;0.050)
Discuss science perf., *Baseline: Never/2 pa*			
One or two per month	0.002	-0.005	0.003
	(-0.054;0.058)	(-0.045;0.035)	(-0.054;0.060)
Once a week to everyday	-0.023	-0.007	0.030
	(-0.081;0.034)	(-0.047;0.033)	(-0.028;0.088)
Discuss science career, *Baseline: Never/2 pa*			
One or two per month	-0.041*	0.009	0.031
	(-0.089;0.007)	(-0.022;0.041)	(-0.017;0.079)
Once a week to everyday	-0.077***	0.047**	0.030
	(-0.130;-0.025)	(0.010;0.084)	(-0.022;0.082)
C^{P*}	-0.033	-0.099**	0.132**
	(-0.159;0.093)	(-0.182;-0.016)	(0.002;0.262)
Observations	2431	2431	2431

95% confidence intervals in parentheses, NI: Not important, SI: Somewhat important, pa: per year

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

7.5. Discussion

In this paper, we have discussed the challenge of bringing together the axiomatic and empirical analysis in the measurement of IO. The axiomatic analysis supports different theories of compensation and reward and the parameters that aim to reflect these principles. Importantly, the axiomatic analysis takes as given the existence of three factors: effort, circumstances, and luck. The main challenge faced by the applied literature is how to operationalise these factors with respect to a set of potentially observed data (what circumstances, effort, and luck 'are') and with respect to the set of observed data used in the empirical analysis (how the 'true' circumstances, effort and luck relate to observable variables).

We reviewed two normative approaches about how to locate the responsibility cut: control and preferences. In our view, despite being the most popular approach in the applied literature, the control approach has failed to provide an operational definition of effort. By contrast, the preference approach operationalises effort, but the empirical applications that follow this approach have not been able to specify statistical models that could distinguish between preferences and constraints beyond the individuals' responsibility.

The control approach seems to suggest that accountable effort corresponds to some function of individuals' choices, after 'removing' the effect of circumstances. Moreover, we would argue that such a notion of effort is not compatible with the notion of circumstances as factors beyond the individuals' control. According to the model developed in Section 7.3.1, adults' choices are a function of their characteristics, their preferences, and their epistemological beliefs. At the same time, preferences and epistemological beliefs are the results of a formation process. Individuals are born with certain preferences and beliefs that are shaped during their life as a consequence of their interactions with people or with other sources of information such as mass media and schools. Those interactions are the result of parents' choices and children's own choices. Children's own choices are the result of their preferences and their characteristics, whereas their characteristics are a function

of their previous characteristics, parents' choices, their own choices and luck. Given this model structure, adult choices are a function of a process where the initial conditions are the preferences, beliefs, and endowments we are born with, parents' preferences and beliefs, parents' characteristics, and luck, none of which is a factor under the individuals' control. Therefore, if one is willing to derive normative implications from this model, one should conclude that a notion of effort as a function of individuals' choices and a notion of circumstances as factors beyond the individuals' control are not compatible with each other.

Arguably, assessing IO according to the preference approach would require testing if individuals would have achieved different outcomes in adulthood had they faced different circumstances in childhood while holding them responsible for their preferences and epistemological beliefs after the canonical moment. However, is not possible to compute such a counterfactual. We suggest that looking at children's predictions about their future at the canonical moment constitutes a proxy of such counterfactual. This is based on the assumption that children's choices at the canonical moment depend on their subjective probabilities of achieving different life projects and that adults' outcomes are the result of a dynamic process that depends on previous choices. Therefore, an impact on these subjective probabilities at the canonical moment will affect the individuals' characteristics at any future period of time.

In addition, by focusing the analysis around an age where children just start to be held accountable for their preferences, we avoid the limitation faced by other studies that have adopted the preference approach; namely, that factors considered illegitimate constraints are at the same time a function of the individual's preferences. In our empirical application, the availability of home educational resources is considered an illegitimate constraint with respect to children's expectations regarding future occupations. Moreover, since children are not to be held accountable for their preferences before the canonical moment, even if the children's preferences were to shape their access to home educational resources, such an influence would not be considered legitimate.

The results show that access to home educational resources has a statistically significant effect on the children's expectations regarding their future occupation. If one is willing to draw some conclusions based on these results, it could be inferred that richer access to home educational resources increases the children's subjective probability of achieving better-paid occupations, which we interpret as evidence of inequality of opportunity.

The model proposed in this study may contribute to discussing a potential limitation of the preference approach, related to the fairness of inequalities that arise due to heterogeneous beliefs regarding the consequences of individuals' actions. According to this model, individuals' decision making process involves taking into account the utility they derive from being involved in certain actions at the current period of time as well as the consequences of those actions on their characteristics in the next period of time, and the capacity to engage in a given set of activities in the next period of time, conditional on their characteristics at the time. The subjective probabilities of achieving different future characteristics, conditional on current actions, depend on current characteristics and on the individuals' beliefs. This notion of the decision making process is similar to the one provided by Hausman (2011), where preferences over properties and consequences of alternative actions is distinguished from beliefs over them.

In this regard, if individuals have different epistemological beliefs regarding how their activities in a given period of time will shape their characteristics in subsequent periods, their menus of alternatives will differ even if they share the same characteristics. We are referring here to individuals who have different epistemological beliefs regarding the consequences of their actions, conditional on the same information and the same capacity to process that information. According to the framework proposed by Fleurbaey (2008), it is legitimate that individuals of different types have different preferences. But, what about individuals' beliefs? I would argue that an individual-endorsed epistemology after the canonical moment defines an individual's identity as much as their preferences. Then, for instance, if parents transmit different epistemological beliefs to their children, this should not be considered an illegitimate source of inequalities. Moreover, this entails

that it would be legitimate if individuals face different menus of alternatives due to their personal beliefs. Hence, individuals who have the same effort (same preferences) and the same characteristics may obtain different achievements and this would still be a legitimate inequality. However, this contradicts the main idea of this framework which is that it is illegitimate if individuals who share the same preferences obtain different achievements.

This study has several limitations. The definition of the canonical moment (which in this study is around 15 years) plays a crucial role in the analysis since it allows us to disentangle the effect of illegitimate constraints, namely the effect of parents' choices about home educational resources on children's characteristics, from the effect of children's preferences. If the canonical moment takes place before the age of 15, and parents' investment in education is made after that age, the influence of children's preferences on the distribution of home educational resources would be considered legitimate, and it would not be possible to distinguish the effect of preferences from the effect of illegitimate constraints. On the contrary, if the canonical moment takes place at an older age, 15-year-old children could not be held accountable for their preferences regarding future occupations, making our analysis irrelevant.

Another limitation relates to the effect of unobserved factors. These may impact the results in two ways. First, Equation 7.20 includes a set of proxies for children's preferences and epistemological beliefs. Arguably, the quality of these proxies may be poor. If this is the case, we cannot rule out that home educational resources impact children's expectations about their future occupation *through* their preferences and epistemological beliefs. This is problematic since according to our normative position children should be responsible for their preferences and epistemological beliefs at the canonical moment. Second, assuming that we adequately control for these factors, there may exist other unobserved factors correlated with home educational resources and with children's expectations regarding their future occupation. Although several covariates have been included in the model, we cannot exclude the possibility that the effect of unobserved factors can bias the estimations of the effect of C^{P*} on $E[o]$.

In our view, the first problem is more important than the second one. If home educational resources impact children's expectations mainly through their preferences and epistemological beliefs, a failure to control for these factors will render our IO assessment strategy invalid. In contrast, provided that we adequately control for children's preferences and epistemological beliefs, a failure to control for unobserved factors may be less problematic. Rather than in providing counterfactual predictions, we are mostly interested in testing whether or not there is a significant effect of C^{P*} on $E[o]$. In this regard, to the extent that the bias of γ is relatively small, it should not change the main conclusions of this study.

Notwithstanding these limitations, this study overcame some of the limitations found in the literature and provide a novel strategy to assess IO according to the preference approach.

Authorship statement

A "CRediT" author statement (Elsevier, 2020) for this paper is as follows:

Nicolas Silva: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing - Original draft, Reviewing and Editing, Project administration.

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Chapter 8: Conclusion

This chapter discusses the thesis as a whole. It features four sections. The first section focuses on the main findings and conclusions regarding the control approach. The second section covers the results related to the preference approach. The third and last section comes back to the idea that inspired this thesis, and examines whether the EO framework could be considered a better strategy to assess health inequalities *vis a vis* the framework of socioeconomic health inequalities. The fourth concludes offering a general reflection on the thesis. This chapter includes some future research ideas, besides those that have already been discussed in each chapter. The main limitations of the empirical studies have already been discussed and are not tackled in detail in this chapter.

8.1. The control approach

8.1.1. Lack of an operational definition of circumstances and effort

One of the central ideas of this thesis is that if circumstances and effort are not operationally defined, the normative exercise of measuring unfair inequalities is not intelligible. Fleurbaey and Schokkaert (2009) suggest that some variables may influence outcomes trough several channels, and that there may be different normative positions regarding the fairness of each pathway. Thus, they conclude that researchers measuring unfair inequalities should build structural models in order to make explicit the mechanisms by which different factors impact outcomes. Similarly, regarding the influence of parents on their children's income, Roemer (2004) argues that one may have different normative positions for each of the following pathways: i) provision of social connections, ii) formation of beliefs and skills, iii) genetic transmission of ability and iv) formation of preferences and

aspirations. Following Fleurbaey and Schokkaert, it could be argued that is not feasible to disentangle these mechanisms and thus their normative implications unless structural models are specified to make these pathways explicit.

However, by far the most common approach in empirical applications is to find some variables that are considered to be beyond the individuals' control because they were not chosen by the individuals (e.g. parents' occupation, sex, region of birth) and use reduced-form equations where a given outcome, such as income, is regressed against these circumstances. Since there will always be unobserved circumstances, the studies relying on this empirical strategy claim that they provide a lower bound of IO. There are two shortcomings regarding this empirical strategy. First, it implicitly assumes that all the causal pathways that link these variables with a given outcome are illegitimate. Second, even if one is willing to argue that all the mechanisms that link a variable such as parents' occupation with children's income are unfair, one still needs to define which factors (even if these cannot be observed) are within the individuals' control. Otherwise, how we can be sure that we do not live in a deterministic world and that all the inequalities are linked in one way or another to factors that were not chosen by the individuals? In other words, how we can be sure that fair inequalities exist? As it was discussed in Section 7.2.1, since there will always be unobserved circumstances there have been studies aiming to provide upper bounds of IO (Hufe et al., 2022), but the assumptions made by them are not without problems. In this regard, a better method to compute upper bounds of IO could be to build a model where an outcome is regressed against one or more effort factors and assume that all the unexplained variability is due to circumstances. However, this has not been implemented in the literature, perhaps because effort has never been operationally defined.

This is closely linked with the aim of Chapter 4, which is to explore an operational definition of accountable effort that fits with Roemer's framework. Roemer's idea about accountable effort corresponds to a set of ordered inputs, conditional on individuals' circumstances, where this order is defined by the productivity of each combination of factors with respect to a given outcome. In this regard, if the achievement of a given outcome is a function of circumstances and effort, and Roemer's identification assumption holds (see

Chapter 4), it is possible to identify accountable effort without the need of providing an operational definition of effort. However, as Roemer admits (Roemer et al., 2003), once the effect of luck is take into account, this strategy fails to identify accountable effort. Consider the following example. Assume that the productivity of individuals with respect to a given outcome is a function of innate ability and the numbers of hours at work. In this case, conditional on the same innate ability, working more hours involves more effort. However, if there are two workers who share the same innate ability and work the same number of hours, but one of them is more productive due to luck, we can no longer identify effort just by comparing how productive they are. Alternatively, we could still identify effort by defining an order of inputs that is not linked to productivity, but to how 'costly' it is for the individuals to engage in the activities that are required for achieving a given outcome. Therefore, if we agree that working more hours is more costly, given the same innate ability, two individuals who work the same number of hours exert the same effort, irrespective of their final productivity. This seems to be the underlying idea behind Roemer's notion of effort when he declares that EO involves that "those who expend (costly) effort deserve to be rewarded" (Roemer, 2012, p. 178). In addition, this appears to be the concept behind the operational definition of effort proposed by Lefranc and Trannoy (2017). This notion of effort as costly activities requires that individuals agree with respect to which combination of activities are more or less costly. Chapter 4 shows that this assumption does not hold empirically with respect to health-related lifestyles, so that is not possible to affirm that healthy lifestyles are more costly than unhealthy lifestyles.

Now, even if it were possible to provide a basis to define an order of activities that could be used to defend this conceptualisation of effort, how could such a notion be made compatible with the control approach? In Chapter 7 it was argued that, according to the theoretical model provided in that chapter, individuals' choices can be understood as the result of a dynamic process which is entirely explained by factors beyond the control of the individual. If one is willing to derive normative implications from this model, one should conclude that a notion of effort as an ordered set of choices and a notion of circumstances as factors beyond the individuals' control are not compatible with each other.

8.1.2. Compensating for the indirect effect of circumstances

Most empirical applications assume that both the direct and indirect effects of circumstances on effort are illegitimate sources of inequality. Despite being the most popular normative perspective in the literature, the issue of how to compensate for the indirect effect of circumstances has not receive much attention. Chapter 5 shows that when there is an unequal distribution of effort across types, an ex-post approach to compensation aiming to correct for the indirect effect of circumstances will violate the principle of equal treatment of equals (ETE). A violation of ETE entails that there will be an unequal treatment (in terms of transfers) among individuals who belong to the same type and exert the same effort. It was shown that this incompatibility does not occur in Roemer's model due to the assumptions made about the distribution of effort.

Assuming that effort corresponds to individuals' preferences, since the 'responsible effort' (i.e. the counterfactual effort that individuals would have exerted had they belonged to a different type) of individuals is not observable, in practice the violation of ETE entails a discriminatory practice. Consider for instance the example used in the empirical study of Chapter 5. A compensation strategy aimed to correct for the indirect effect of parents' smoking habits should allocate transfers based on the responsible effort of individuals. However, among individuals who belong to the same type (children of smoking parents) and exert the same effort (smokers) it is not feasible to distinguish who would have been non-smoker had their parents been non-smokers. Therefore, in practice a strategy that allocates different transfers (or offer different health benefits) among the smokers who are children of smoking parents will be a discriminatory policy.

An alternative (ex-ante) compensation strategy involves allocating higher transfers to individuals who belong to the type with worse opportunities (in this case, the children of smoking parents). Nonetheless, as it was discussed in Chapter 5, such an allocation strategy may create an inequality conditional on smoking: the smokers (non-smokers) who are children of non-smoking parents will receive higher transfers than the smokers (non-

smokers) of smoking parents. From a policy perspective, this would require a differential treatment among individuals who have the same lifestyle, based on information about their childhood, which may be hard to implement. In this respect, the alternative compensation principle proposed in Chapter 5 may be an attractive policy since it allows to reduce ex-ante inequalities due to the indirect effect of circumstances and i) does not violate ETE and ii) does not require treating differently individuals who exert the same effort.

8.2. The preference approach

In Chapter 6, it is argued that, in contrast to the control approach, the preference approach may be more suitable to provide an operational definition of effort and circumstances. Under this approach, one may have a deterministic view about how preferences are formed and still hold individuals responsible for their preferences (after a certain age) because preferences define our identity and it will be disrespectful to interfere in it. In this section I will discuss the main topics that were found in this thesis related to the preference approach.

8.2.1. Liberal reward and the use of equivalent health to decompose inequalities

Chapter 6 discusses the use of equivalent health to assess how favourable a given menu of alternatives is with respect to different kinds of preferences. This approach provides a normative argument to reduce inequalities among individuals with the same circumstances, as opposed to liberal reward, which suggests a neutral allocation that does not interfere with inequalities among individuals of the same type. The assessment of individuals' life situations according to the health equivalent approach (as well as the equivalent income approach) depends on two factors: the kinds of preferences involve and the category used as the reference. The empirical study presented in Chapter 6 examined the extent to which members of the public support an allocation of resources compatible with a scenario where the reference category corresponds to the most preferred health-related lifestyle, conditional on a given set of preferences. As it was discussed, the results suggest that respondents do not necessarily take into account the information about preferences that was provided in the survey and that their attitudes towards inequalities are explained

by their prior beliefs regarding the kinds of preferences of individuals who adopt healthy and unhealthy lifestyles. In addition, the survey did not explore the implicit reference categories used by the respondents. As discussed in Chapter 6, it would be interesting to contrast the attitudes of members of the public towards health inequalities, controlling for their beliefs about the preferences of individuals who adopt healthy and unhealthy lifestyles, and their implicit reference categories.

Another possible extension of this study is the use of the equivalent income approach to assess the attitudes of members of the public towards inequalities of different kinds. To explain this, I will introduce the following notation. The life situations of individuals i will be characterized by their income Y_i and a set of other factors $\mathbf{Z}_i$. Additionally, a menu of alternatives θ corresponds to the combination of income and other life dimensions available to each individual and R_i to the preferences of each individual with respect to $(Y, \mathbf{Z})$. Therefore, the current life situation of individuals, conditional on the menu of alternatives available to them can be characterized by $(Y_i, \mathbf{Z}_i; \theta)$. The wellbeing of individuals, given their life situations will be denoted by $W(Y_i, \mathbf{Z}_i; \theta)$. Let Y_i^* denote the equivalent income of each individual, or the equivalent amount of income that combined with their most preferred factors $\overline{\mathbf{Z}}_i$ will make them as happy as they are now. Then, we have that $W(Y_i, \mathbf{Z}_i; \theta) = W(Y_i^*, \overline{\mathbf{Z}}_i; \theta)$.

Hence, the inequality in terms of wellbeing between two individuals i and j who face different choice sets can be decomposed as follows:

$$\begin{aligned} W(Y_i, \mathbf{Z}_i; \theta) - W(Y_j, \mathbf{Z}_j; \theta') &= \underbrace{\left(W(\overline{Y_j}, \mathbf{Z}_j^*; \theta) - W(\overline{Y_j}, \mathbf{Z}_j^*; \theta')\right)}_{\triangle_1} \\ &+ \underbrace{\left(W(\overline{Y_i}, \mathbf{Z}_i^*; \theta) - W(\overline{Y_j}, \mathbf{Z}_j^*; \theta)\right)}_{\triangle_2} \\ &= \underbrace{\left((Y_j^*, \overline{\mathbf{Z}}_j; \theta) - (Y_j^*, \overline{\mathbf{Z}}_j; \theta')\right)}_{\triangle_1} \\ &+ \underbrace{\left((Y_i^*, \overline{\mathbf{Z}}_i; \theta) - (Y_j^*, \overline{\mathbf{Z}}_j; \theta)\right)}_{\triangle_2} \end{aligned} \tag{8.1}$$

The first term in brackets on the right-hand side of Equation 8.1, $\triangle_1$, corresponds to the difference between the equivalent income of individual j had she been faced with the menu of alternatives available to individual i and the equivalent income of individual j given her current menu of alternatives. Assuming that individuals i and j face different menus of alternatives due to circumstances beyond their control, this inequality can be conceived as IO. The second term, $\triangle_2$, equals the difference in equivalent income between i and j had both of them faced the menu of alternatives θ. This corresponds to the inequality in terms of equivalent income that is strictly due to preferences heterogeneity, which was the focus of Chapter 6.

Additionally, $\triangle_1$ can be decomposed into $\triangle_{1a}$ and $\triangle_{1b}$ as it is shown in Equation 8.2. In this case, $\triangle_{1a}$ corresponds to the inequality in wellbeing for individual j under two life situations: i) a life situation where individual j has an income equal to her equivalent income when she faces the menu of alternatives available to individual i, combined with $\overline{\mathbf{Z}}_j$ and ii) a life situation that combines the income of individual j given the menu of alternatives θ' and $\overline{\mathbf{Z}}_j$. Alternatively, $\triangle_{1b}$ corresponds to the difference in wellbeing of individual j under the following life situations: i) a life situation where the income of individual j corresponds to the income she obtains given the menu of alternatives θ' combined with $\overline{\mathbf{Z}}_j$, and ii) the life situation that individual j obtains given the menu of alternatives θ': $\overline{\mathbf{Z}}_j$ [1]. The inequality captured by $\triangle_{1a}$ can be interpreted as an inequality in wellbeing that is strictly due to income, conditional on $\overline{\mathbf{Z}}_j$, whereas $\triangle_{1b}$ could be interpreted as an inequality strictly due to non-income dimensions, conditional on $Y_j; \theta$. Based on this decomposition, it would be interesting to assess the attitudes of members of the public towards inequalities due to: i) IO, expressed in terms of income, conditional on the best non-income profile, ii) IO, expressed in terms of inequality in the non-income dimensions, conditional on the same income, and iii) income inequality due to preference heterogeneity.

[1] Note that $\triangle_{1b}$ is equivalent to $\big(W(Y_j; \theta', \overline{\mathbf{Z}}_j) - W(Y_j^*, \overline{\mathbf{Z}}_j; \theta')\big)$.

$$
\begin{aligned}
W(Y_i, \mathbf{Z}_i; \theta) - W(Y_j, \mathbf{Z}_j; \theta') = & \underbrace{\left(W(Y_j^*, \overline{\mathbf{Z}}_j; \theta) - W(Y_j; \theta', \overline{\mathbf{Z}}_j)\right)}_{\triangle_{1a}} \\
& + \underbrace{\left(W(Y_j; \theta', \overline{\mathbf{Z}}_j) - W(Y_j, \mathbf{Z}_j; \theta')\right)}_{\triangle_{1b}} \\
& + \underbrace{\left(W(Y_i^*, \overline{\mathbf{Z}}_i; \theta) - W(Y_j^*, \overline{\mathbf{Z}}_j; \theta)\right)}_{\triangle_2}
\end{aligned} \tag{8.2}
$$

8.2.2. The assessment of IO according to the preference approach

Chapter 7 argues that an empirical assessment of IO in adulthood according to the preference approach requires an estimation of what would have been the counterfactual achievements of individuals had they faced different circumstances, while holding them responsible for their preferences and epistemological beliefs from the canonical moment onward. However, obtaining such a counterfactual is not feasible. Alternatively, the empirical application provided in Chapter 7 aimed to assess IO by testing if circumstances (i.e. parents' choices regarding home educational resources) have a statistically significant effect on the subjective probability of achieving different life projects, conditional on preferences and epistemological beliefs at the canonical moment. It is reasonable to assume that the subjective probabilities of achieving different life projects will influence the children's choices after the canonical moment, which in turn will shape their characteristics in the future. Therefore, the evidence of circumstances shaping the subjective probabilities of achieving different life projects can be used to infer that circumstances will have an impact on children's outcomes in adulthood. In this regard, I would argue that the assessment of the influence of circumstances on children's beliefs at the canonical moment may offer a good strategy for further explorations of IO according to the preference approach.

8.3. EO and Socioeconomic inequalities

Chapter 3 aimed to provide, for the first time, evidence on the temporal trends of socioeconomic inequalities in life expectancy in Chile. As it was acknowledged in the discussion

section of Chapter 3, the main limitation of this study is that it uses different sources of information regarding the education of the population at risk (census) and the mortality records (information provided by the next of kin of the deceased person), which may introduce bias in an unknown direction. Currently, there exist alternative databases to obtain data of better quality in Chile. Since the mortality database has information on the personal identification number of each deceased person, it should be possible to link this database with reliable information about income at the individual and household level, available in the databases administered by the Ministry of Welfare (Ministerio de Desarrollo Social y Familia) and the Ministry of Finance (Ministerio de Hacienda). During this thesis, I applied twice to a research call from the Ministry of Welfare, with the aim of obtaining better quality of data for this empirical application. Unfortunately, both applications were unsuccessful. This study can serve as a vehicle to highlight the importance of monitoring the changes in health inequalities through time and to find better sources of information.

As it was mentioned in Chapter 1, it may be argued that the EO framework provides several advantages compared to the assessment of socioeconomic health inequalities. One of such advantages is that, while the framework of socioeconomic inequalities adopts a relational egalitarian perspective, EO is rooted in luck egalitarianism. This means that, while the framework of socioeconomic health inequalities considers that inequalities that cannot be avoided or that are not anybody's fault should not be regarded as illegitimate, EO suggests that the fact that some inequalities cannot be avoided or do not originate in human actions, does not lead to the conclusion that these inequalities are fair. However, in the literature review it was found that the studies assessing IO in health do not provide much clarity on this matter. For instance, age and sex are two factors that the framework of socioeconomic health inequalities categorise as fair sources of inequalities because their genetic or biological effects on health cannot be modified. Instead, in the literature review covered in Chapter 2, it was found that most studies categorised sex and age as 'neutral' variables, which are not effort neither circumstances. Section 2.4.2 in that chapter discusses in more detail why categorising sex and age as normatively neutral seems inappropriate.

Similarly, according to the framework of socioeconomic health inequalities, health differences that are not systematically related to socioeconomic position, such as random factors or 'luck' should not be judged as unfair causes of inequalities. In contrast, one of the most powerful ideas of luck-egalitarianism is that 'brute luck', or events which probability of occurrence cannot be influenced by the individuals, are unfair. Although ways to articulate the concept of luck with the reward and compensation principles have been explored (Lefranc et al., 2009; Lefranc and Trannoy, 2017), an operational definition of luck has not yet been provided in the literature and no empirical applications to measure it has been attempted. In this regard, compared to the socioeconomic health inequalities approach, the framework of EO has not given much clarity about how to account for inequalities that arise in factors which effects cannot be modified or which occurrence is not systematically related to individuals' characteristics.

Another potential advantage of the theory of EO is that it aims to provide a more clear direction about when individuals' choices can be considered fair drivers of inequalities. Whitehead (1992), in her seminal paper about health inequities, seems to suggest that the extent to which choices can be considered legitimate sources of inequality depends on the degree of control that individuals have over those choices, a notion closely related to the normative position adopted by the control approach. However, Whitehead does not define under what conditions it could be said that individuals exert control over their choices. In this regard, the theory of EO seems better equipped to define when individuals' choices could be considered beyond the individuals' control. Conversely, as it has been argued in this thesis, the control approach lacks an operational definition of effort and circumstances that could shed light on this matter.

Compared to the study of income inequality, where there has been a shift from assessing total inequality to the assessment of unfair inequalities, the study of health inequalities has always focused on assessing unfair inequalities, without providing a definition of what constitutes 'total health inequalities' for binary outcomes, such as mortality and other health measures. The literature review presented in Chapter 2 showed that stud-

ies assessing IO in health also fail to provide such a definition. Many studies assessing income-related EO compute relative measures of IO where IO is computed as a fraction of total inequality. In contrast, most studies that assessed health-related EO were not able to obtain these kinds of estimators since it is not feasible to compute total health inequality for binary outcomes because when using nonlinear models the variance of the error term cannot be identified.

The use of categorical variables in health is widespread. Consider for instance: mortality, the occurrence of some disease and the presence or absence of some disability. I would argue that the concept of total inequality for categorical variables differs depending on the alleged data generating process of these outcomes. This can be linked to an old debate about the nature of categorical outcomes, or what has been called the Pearson-Yule debate (Hagenaars, 2015). While Yule argued that categorical variables are inherently discrete in nature, Pearson sustained that categorical variables correspond to the realizations of underlying normally-distributed continuous variables. Consider for instance the analysis of total inequality with respect to the occurrence of some disease. A measure of total inequality that accounts for the inherently discrete nature of this variable could be the probability 'at the individual level' of experiencing a given disease in a given period of time. Imagine that for each individual the probability of experiencing a given disease is a function of a set of observable factors, such as socioeconomic position, health-related lifestyles, among other observed factors, and a set of unobserved factors. Hence, a measure of total inequality in the probability of experiencing the disease will result from applying some inequality function to the 'true' probability of experiencing the disease at the individual level [2] However, even the most comprehensive dataset will only include a subset of the true explanatory factors, so it is only feasible to compute a lower bound of the true total inequality in terms of the probability of experiencing a disease. In contrast, the occurrence of some disease can be represented by a latent-variable model, where there exists a continuous latent variable which is a function of a set of explanatory factors and some random component. Given this data generating process, total inequality corresponds

[2] A similar notion of health inequalities at the individual level has been proposed by Gakidou et al. (2000). So far, this kind of measure has not yet been implemented.

to inequality in terms of the latent variable. Moreover, in this case it is not feasible to compute total inequality either, because the distribution of the latent variable cannot be observed. In this regard, it is hard to imagine that the estimation of total health inequalities (and in consequence, of relative measures of IO) for categorical outcomes is possible.

These are a few challenges in relation to the assessment of IO in health. In summary, I would argue that despite being an attractive alternative to assess unfair health inequalities, the framework of EO does not provide good answers on how to deal with some of the limitations found in the framework of socioeconomic health inequalities.

8.4. Reflections on this thesis as a whole

This thesis aims to reflect on how unfair inequalities in health can be measured. It focuses on two different frameworks to assess unfair inequalities, the framework of socioeconomic health inequalities and the framework of EO. The thesis argues that the framework of socioeconomic health inequalities has several limitations and that the EO framework has not provided much clarity on how to deal with these limitations.

Probably, the most significant contribution of this thesis is to highlight that there are many challenges in the way EO has been implemented and to suggests alternative proposals to move the debate forward. I would argue that the progress made by the theoretical and the empirical literature on the control approach to EO will reach a dead end, unless a clear description of what circumstances, effort and luck 'are' in the real world. In this regard, the preference approach and the notion of equivalent income seems to be better suited to assess unfair inequalities. Hopefully, some of the ideas contained in this thesis could have some impact on the research community interested on assessing unfair inequalities.

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Appendices

Appendix for Chapter 2: Inequality of opportunity in health: a review and critique of the literature

Table A.3.1.

Comparative assessment of the studies included in the review

Authors, year, country	*Data*	*Variables*				*Normative perspective*	*Approach used to define effort and model specification*	*Estimation*	*Inequality measurement*	*Assessment of IO (a description of methods to obtain $\widehat{H'}$ is provided in the next Appendix section)*
		Health outcome(H)	*Circumstances (C)*	*Effort(E)*	*Neutral (D)*					
Rosa Dias, 2009 Great Britain	National Child Development Study (Great Britain longitudinal survey) – Data for 2004.	SAH (ordinal) 4 categories in all waves but last. 1 to 5 in the last wave (the one they use). Measured at age 46.	Grandparents' socioeconomic characteristics, parents' socioeconomic characteristics, social conditions during childhood and adolescence, congenital health endowments, whether mother smoke during pregnancy, whether child was breastfed, morbidity during childhood, parents' health status, obesity in childhood and early adolescence and parent's lifestyles during children 's childhood.	Cigarette smoking, alcohol consumption, diet, socioeconomic position: education	Age, sex	Genuine control approach	$H_i^{lb} = h(C, D, \zeta)$ $I(\widehat{H}_i^{lb})$: (inequality in the predictions of H_i^{lb}) $H_i^{ub} = h(C, E, D, \zeta)$ $I(\widehat{H}_i^{ub})$: (inequality in the predictions of H_i^{ub}) The author refers to $I(\widehat{H}_i^{lb})$ as a "lower bound of inequality of opportunity" and to $I(\widehat{H}_i^{ub})$ as an "upper bound of inequality of opportunity"	Ordered probit models.	Outcome used in the analysis: not defined Inequality index: Gini-opportunity index, pseudo-Gini index. Methods of decomposition: no decomposition was performed, $\theta_{r,p}^{IOP}$ is measured dividing $I(\widehat{H}_i^{lb})$ over $I(\widehat{H}_i^{ub})$	Explicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$ Method used to obtain $\widehat{H'}$: Ex-ante, type-based counterfactual.
Jusot et al. 2010 Europe	First wave of SHARELIFE (Survey of Health, Ageing and Retirement in Europe; 2004 cross sectional survey)	SAH (ordinal) 1 to 5. Measured at age 50 or older. Treated as binary: good or very good health vs. others.	Parents' socioeconomic characteristics, social conditions during childhood, parents' longevity, parents' lifestyles during children 's childhood.	Socioeconomic position: education and occupation. These were used only to disentangle the direct and the mediated effect of circumstances.	Age, sex	Genuine control approach	$H_i = h(C, D, \zeta)$	Logistic regression.	Outcome used in the analysis: predicted probability of reporting at least good SAH Inequality index: Gini	Explicit normative strategy: θ_a^{IO} Method used to obtain $\widehat{H'}$: Ex-ante, type-based counterfactual.
Bricard et al. 2013 Europe (13 countries)	Third wave of SHARELIFE (Survey of Health, Ageing and Retirement in Europe; 2008/09 cross-sectional survey)	SAH (ordinal). 1 to 5. Measured at age 50 or older. Treated as binary: good or very good health vs. others.	Parents' socioeconomic characteristics, social conditions during childhood, parents' longevity, parents' lifestyles during children 's childhood.	Smoking (E_1), sedentary lifestyle (E_2), obesity (E_3).	Age, sex	Choice approach (in the paper referred to as Barry's position) Genuine control approach (in the paper referred to as Roemer's position)	Choice approach $H_i = h(C, E, D, \zeta)$ Genuine control approach $E_{1,i} = e_1(C, D, \varepsilon_1)$ $E_{2,i} = e_2(C, D, \varepsilon_2)$ $E_{3,i} = e_3(C, D, \varepsilon_3)$ $H_i = h(C, \varepsilon_1, \varepsilon_2, \varepsilon_3, D, \zeta)$	Linear probability models.	Outcome used in the analysis: predicted probability of reporting at least good SAH Inequality index: Variance Method of	Assessment of IO; Implicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$

									decomposition: Shorrock's variance decomposition	
García-Gomez et al. 2013, García-Gomez et al. 2015 The Netherlands (Description based on García-Gomez et al. 2015)	Three cross-sectional surveys from the Netherlands on living conditions (HSLC) linked to two administrative databases: cause of death registry, national medical registry. Surveys: 1998, 1999, 2000. Adm. Data: 10-year survival data.	Mortality (M). Data for individuals aged 40 or older.	The study aims to compare measures of health inequalities according to different normative positions. The cut between legitimate and illegitimate regressors varies according to each normative approach. Variables: age, sex, socioeconomic position, marital status, geographical region of residence, urban/rural, religion and whether there are children in the household, lifestyles (smoking, exercise, body weight).			Normative approaches (there were four other normative positions that we do not cover here): 1. Choice (referred to as 'preference approach' in the study) Legitimate: lifestyles Illegitimate variables for health status and mortality: age, gender, marital status, children, religion, region, urbanization and home ownership 2. Genuine control (referred to as 'control approach' in the study) Legitimate variables: Marital status, children, religion, region, urbanization and home ownership Illegitimate variables: age, gender, education 3. Authentic preferences: Legitimate variables for lifestyles: all but education Illegitimate variables for lifestyles: education Illegitimate variables for health status and mortality: all	$M_i = m(H, X, L, \zeta)$ $H_i = h(X, L, \varepsilon_2)$ $L_i = l(X, R, \varepsilon_1)$ H: hospitalization (6 equations) L: lifestyles (3 equations) X: vector of covariates (E and C) Ri : instrumental variables for lifestyles (region of residence, urban/rural and religion)	Recursive system of equations: Probit models.	Outcome used in the analysis: predicted probability of dying within 7 years Inequality index: Absolute Gini, variance, concentration index.	Explicit normative strategy: θ_a^{IO} Method used to obtain $\widehat{H'}$: 1) Ex-post, direct unfairness; 2) Ex-post, fairness gap.
Jusot et al. 2013 France	French Health, Health Care and Insurance Survey (cross-sectional survey), 2006 survey.	SAH (ordinal) 1 to 5. Treated as binary: good and very good health vs. others	Parents' socioeconomic characteristics (C_1), social conditions during childhood (C_2), parents' longevity (C_3), parents' health (C_4), parents' lifestyles during children 's childhood (C_5).	Smoking (E_1), diet (E_2), obesity (E_3).	Age, sex	Choice approach (in the paper referred to as Barry's position) Genuine control approach (in the paper referred to as Roemer's position) Family's effort	Choice approach $H_i = h(C, E, D, \zeta)$ Genuine control approach $E_{1,i} = e_1(C, D, \varepsilon_1)$ $E_{2,i} = e_2(C, D, \varepsilon_2)$ $E_{3,i} = e_3(C, D, \varepsilon_3)$ $H_i = h(C, \varepsilon_1, \varepsilon_2, \varepsilon_3, D, \zeta)$	Probit models (generalized residuals were estimated).	Outcome used in the analysis: predicted probability of reporting at least good SAH Inequality index:	Implicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$

						approach (in the paper referred to as the Swift's approach).	Family's effort approach $C_{1,i} = e_1(E, D, \varepsilon_1)$ ... $C_{5,i} = e_3(E, D, \varepsilon_5)$ $H_i = h(E, \varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4, \varepsilon_5, D, \zeta)$		Variance Method of decomposition: Shorrock's variance decomposition	
Lazar et al. 2013 Israel	Israeli Social Survey 2003 (cross-sectional survey)	SAH (ordinal). 1 to 4.	Sex, parents' socioeconomic characteristics, father's place of birth, religion, respondents' place of birth.	Socioeconomic position: education (E_1), occupation (E_2); and smoking (E_3).	Age, sex	*Genuine control approach*	$E_{1,i} = e_1(C, D, \varepsilon_1)$ $E_{2,i} = e_2(C, D, \varepsilon_2)$ $E_{3,i} = e_3(C, D, \varepsilon_3)$ $H_i = h(C, \varepsilon_1, \varepsilon_2, \varepsilon_3, D, \zeta)$	Logit models (generalized residuals were estimated) for the effort equations. Ordered logit model for the health outcome equation.	Outcome used in the analysis: the predicted latent variable was standardized between 1 and 0: $(\widehat{H}_i$-min$(\widehat{H}_i))/($max$(\widehat{H}_i)$-min$(\widehat{H}_i))$ Inequality index: Mean logarithmic deviation (MLD) Method of decomposition: path-independent multiplicative decomposition	Explicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$ Method used to obtain $\widehat{H'}$: Ex-ante, type-based counterfactual; Ex-post, tranche-based counterfactual.
Li Donni et al. 2014 UK	BHPS (British Household Panel Survey; longitudinal survey) 2000-2005	SAH (ordinal). 1 to 5, collapsed into four categories by grouping very poor with poor. Individuals older than 55 years between 2000 and 2005.	Parents' socioeconomic characteristics, ethnicity and respondents' place of birth, accident indicator.	Socioeconomic position: education (E_1), occupation (E_2); and smoking (E_3).	Age, sex	*Genuine control approach*	$E_{1,i} = e_1(C, D, \varepsilon_1)$ $E_{2,i} = e_2(C, D, \varepsilon_2)$ $E_{3,i} = e_3(C, D, \varepsilon_3)$ $H_i = h(C, \varepsilon_1, \varepsilon_2, \varepsilon_3, D, \zeta)$	Probit models (generalized residuals were estimated) for the effort equations. Ordered logit model for the health outcome equation.	Outcome used in the analysis: predicted probability of reporting at least good SAH Inequality index: Atkinson Method of decomposition: path-independent multiplicative decomposition	Assessment of IO; Explicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$ Method used to obtain $\widehat{H'}$: Ex-ante, type-based counterfactual; Ex-post, tranche-based counterfactual.
Jusot et al. 2014 Indonesia	Indonesia Family Life Survey (IFLS; longitudinal survey), fourth wave (2007)	SAH (ordinal), 1 to 4, for household members aged 40 or over	Parents' socioeconomic characteristics, religion, language, parents' longevity, place of residence, marital status, being migrant. Socioeconomic position (SEP): education, occupation.	NA	Age (birth cohort), sex. marital status (socioeconomic position, marital status were also considered as circumstances in an alternative scenario)	*Genuine control approach*	SAH is regressed on objective measures of health status using ordinal logit models. The predicted probability of reporting very good health ($\widehat{H}_i$) is used for the analysis. Model 1 $\widehat{H}_i = h(C, D, \zeta)$ Model 2 $\widehat{H}_i = h(C, SEP, D, \zeta)$	Ordered logit model to compute $\widehat{H}_i$. Linear model for the health outcome equation.	Outcome used in the analysis: predicted probability of reporting very good health Inequality index: Variance	Implicit normative strategy: $\theta_{r,o}^{IO}$

							The differences in the coefficient associated with C between model 1 and model 2 is interpreted as the indirect effect of circumstances through socioeconomic status		Method of decomposition: Shorrock's variance decomposition (Decomposition of the inequality explained by each circumstance over total inequality).	
Øvrum and Rickertsen, 2015 Norway	Norwegian Monitor Survey (cross sectional), 2005 to 2011.	Health: SAH (ordinal, 1 to 5), obesity Lifestyles (L): physical activity, diet, individuals aged 25-75.	Parents' socioeconomic characteristics, social conditions during childhood. Socioeconomic position (SEP): education, income, occupation.	'Psychological traits': like to pay in instalments, life insurance, self-control	Age, sex, children, marital status	*Choice approach*	$H_i = h(C, D, E, \varepsilon_1)$ $L_i = l(C, D, E, \varepsilon_2)$	Probit models for health and lifestyle equation.	Outcome used in the analysis: the predicted latent variable of several outcomes (at least good SAH, BMI<30 and a binary variable for the frequency of physical activity, consumption of fish, and consumption of fish and vegetables) Inequality index: Gini index, concentration index Method of decomposition: Gini decomposition, decomposition of concentration index.	Implicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$
Fajardo-Gonzalez 2016 Colombia	Colombian Living Standard and Social Mobility Survey (cross-sectional survey), 2010 survey.	SAH (ordinal), 1 to 4.	Parents' socioeconomic characteristics, social conditions during childhood, ethnicity, place of birth.	Socioeconomic position: education	Age, sex	*Choice approach* *Genuine control approach*	*Choice approach* $H_i = h(C, E, \zeta)$ *Genuine control approach* $E_i = e(C, D, \varepsilon)$ $H_i = h(C, D, \varepsilon, \zeta)$	Linear model for the effort equation. Logit model for the health outcome equation.	Outcome used in the analysis: predicted probability of reporting at least good SAH Inequality index: Dissimilarity index, Gini opportunity index Method of decomposition (only for the dissimilarity index):	Implicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$

									Shapley-value decomposition	
Pasqualini et al. 2017 Europe (21 countries)	SHARE (Survey of Health, Ageing and Retirement in Europe; cross-sectional), waves 2, 3 and 4 (2006, 2008/9 and 2010). ELSA (English Longitudinal Study of Ageing; longitudinal survey), 2005, 2007 and 2008 waves.	SAH (ordinal, 1 to 5, collapsed to binary), Body Mass Index (BMI), number of chronic conditions. Individuals aged 50 or more.	Country (j) level variables (C): average income per country, income inequality (Gini index) per country Parents' socioeconomic characteristics (ChSEP) and social conditions during childhood (ChSEP).	NA	NA	*Genuine control approach*	$H_j^{\pi(y)} = h(C_j, ChSEP_j^{\pi(y)}, ChSEP_j)$ $\pi(y)$: is the πth percentile of the income distribution in country *j* $H_j^{\pi(y)}$: is the average health outcome among individuals in the πth percentile of the income distribution in a given country j $ChSEP_j^{\pi(y)}$:is the average level of a given parent socioeconomic characteristic in that country	*Linear model.*	Outcome used in the analysis: BMI, probability of reporting at least fair SAH, probability of reporting poor health Inequality index: R squared Method of decomposition: R squared (Decomposition of the inequality explained by each circumstance over explained inequality).	Implicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$
Rivera 2017 Colombia	Colombian Longitudinal Survey Cross setional survey (ELCA; cross sectional survey), 2010 data.	SAH (Visual Analogue Scale - VAS, 1 to 100) Adjusted VAS EQ5D*	Parents' socioeconomic characteristics, place of residence, place of birth, parents' health status during childhood, household structure, ethnicity.	Preventive use of health services, socioeconomic position (SEP): education, occupation, household wealth.	Birth cohort, sex	*Choice approach (in the paper referred to as Barry's position)* *Genuine control approach (in the paper referred to as Roemer's position)*	*Adjusted VAS was obtained from predictions of a linear regression of VAS against health conditions.* *Choice approach:* $H_i^B = h(C, E, D, \zeta)$ *Genuine control approach:* $E_i = e(C, D, \varepsilon_1)$ $H_i^R = h(C, \varepsilon_1, D, \zeta)$	*Linear models.*	Outcome used in the analysis: unadjusted VAS, adjusted VAS,, and EQ5D-based measure Inequality index: Variance Method of decomposition: Shorrock's variance decomposition	Implicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$
Carrieri and Jones 2018 England	Health survey for England (cross-sectional survey). 10 waves, from 2003 to 2012.	Biomarkers: cholesterol and glycated hemoglobin, fibrinogen. Composite index of all the above measures.	Birth cohort, sex, socioeconomic position (education, deprivation score of area of residence)	Cigarette smoking, alcohol consumption, diet	NA	*Genuine control approac .*	$\mathrm{H_{i,\tau}} = \mathrm{h(E, \zeta)}$ τ: types (unique combination of circumstances, when circumstance variables are categorical)	*Linear models (one model for each type).*	Outcome used in the analysis: observed levels of biomarkers. Inequality index: Gini and variance. Method of decomposition: Gini index decomposition by Jones and	Explicit normative strategy: θ_a^{IO} and $\theta_{r,o}^{IO}$

									Lopez-Nicolas (2006), and Shorrock's variance decomposition. The study also decomposed IO into the direct and the indirect (through effort) effect of circumstances.	
Deutsch et al. 2018 Luxembourg	Panel Socio-Economique Liewen zu Letzebuerg (PSELL-3; panel survey). Focus on 2008 (wave 6) with 2005 and 2007 (waves 3 and 5).	SAH (ordinal, 1 to 5, also treated as binary, with top 2 versus the other 3). Individuals aged 25-65.	Parents' socioeconomic characteristics, social conditions during childhood, father's country of birth, respondent's country of birth, year of immigration.	Socioeconomic position: education (E_1), smoking (E_2) and physical activity (E_3).	Age, age squared, sex	*Genuine control approach.*	$E_{1,i} = e_1(C, D, \varepsilon_1)$ $E_{2,i} = e_2(C, D, \varepsilon_1, \varepsilon_2)$ $E_{3,i} = e_3(C, D, \varepsilon_1, \varepsilon_2, \varepsilon_3)$ $H_i = h(C, D, \varepsilon_1, \varepsilon_2, \varepsilon_3, \zeta)$	*Logit models for the effort equations (no information about how the residuals were estimated).* *Logit and ordered logit models for the health outcome equation.*	Outcome used in the analysis: probability of reporting at least good SAH and 5-category ordered logit Inequality index: Variance Method of decomposition: Shapley-value decomposition	Implicit normative strategy: θ_a^{IO} and $\theta_{r,p}^{IO}$
Davillas and Jones, 2020 UK	Understanding Society (UKHLS; longitudinal survey). 2010-11 data (wave 2)	Physical measurements and biomarkers (waist-to-height ratio, systolic blood pressure, ratio of total cholesterol over high-density lipoprotein, glycated haemoglobin, C-reactive protein. Composite index of all the above measures.	Age, sex, childhood language, parents' socioeconomic characteristics, education.	NA	Age, sex (the study explored the effect of age and sex as circumstances and as neutral variables)	*Genuine control approach.*	(1) $H_i = h(C, D, \zeta)$ (2) $H_{i,\pi} = h(C, D, \zeta)$ π: quantiles	(1) Linear regression. (2) Quantile regression.	Outcome used in the analysis: physical measurements and biomarkers. Inequality index: Mean logarithmic deviation. This study also estimated the contribution of each circumstance variable at each quantile to IO using the Shapley-value decomposition.	Explicit normative strategy: θ_a^{IO} and $\theta_{r,o}^{IO}$ Method used to obtain $\widehat{H'}$: Ex-ante, type-based counterfactual. .
Carrieri et al. 2020 UK	Understanding Society (UKHLS; longitudinal survey). 2010-11 data (wave 2)	Allostatic load (index that combines biomarkers for adiposity, blood pressure,	Age, sex, race, parents' socioeconomic characteristics.	Cigarette smoking, alcohol consumption, diet. Socioeconomic position: education, household income and	NA	*Genuine control approach.*	$\mathrm{H_{i,\tau}} = \mathrm{h(E, \zeta)}$ τ: types (unique combination of circumstances, when circumstance variables are categorical)	*Linear models (one model for each type).* *Types were defined using a*	Outcome used in the analysis: observed levels of allostatic load Inequality index:	Explicit normative strategy: θ_a^{IO} and $\theta_{r,o}^{IO}$ Method used to obtain $\widehat{H'}$: the decomposition

		inflammation, blood sugar levels and cholesterol)		marital status (these were included only in the sensitivity analysis).				*latent-class approach (finite mixture model).*	variance Method of decomposition: decomposition strategy by Jones and Lopez-Nicolas (2006) and Carrieri and Jones (2018) The study also decomposed IO into the direct and the indirect (through effort) effect of circumstances.	method used allow to obtain an explicit normative measure of IO without needing to rely on estimating $\widetilde{H}^{\prime}$.
Chen et al. 2020 Yan et al. 2020 China and USA	China: China Health and Retirement Longitudinal Study (CHARLS), 2013 and 2015 waves, linked to the CHARLS Life History Survey (longitudinal survey) for 2014. USA: Health and Retirement Study (HRS) 2015	SAH (ordinal, 1 to 5), physical health (short physical performance battery and frailty score), mental health (Center for Epidemiological Studies Depression Scale), mortality. The paper by Yan et al. also includes cognitive ability (word recall, math score and Wscore).	Born in war or crisis period, place of birth, parents' socioeconomic characteristics, social conditions during childhood, health status in childhood, place of birth, parents' health status during children 's childhood, parents' health-related behaviours during children 's childhood, relationship with parents in childhood, friendship in childhood, access to health care in childhood.	NA	NA	*Genuine control approach.*	$H_i = h(C, \zeta)$	*Linear model.*	Outcome used in the analysis: observed levels of health outcomes (is not reported how 'total observed' inequality was assessed for categorical outcomes). Inequality index: Mean logarithmic deviation This study also estimated the contribution of each circumstance variable to IO using the Shapley-value decomposition.	Explicit normative strategy: $\theta^{IO}_{r,o}$
Trannoy et al. 2010 France	French part of SHARELIFE (Survey of Health, Ageing and Retirement in Europe; cross-sectional survey). 2004 wave.	SAH (ordinal, 1 to 5), grouped . Individuals aged 49 or older.	Parents' socioeconomic characteristics, parents' longevity.	Socioeconomic position: Education (E_1), occupation (E_2).	Age, sex	*Genuine control approach.*	$E_{1,i} = e_1(C, D, \varepsilon_1)$ $E_{2,i} = e_2(C, D, \varepsilon_1, \varepsilon_2)$ $H_i = h(C, D, \varepsilon_1, \varepsilon_2, \zeta)$ *Ordered logit model* $H_i = h(C, D, \varepsilon_1, \varepsilon_2, \zeta)$	*Probit models (generalized residuals were estimated)*	Outcome used in the analysis: predicted probability of reporting at least good SAH Inequality index: Gini, Eyrregers	Improvements due to IO reduction: AAI, CAI, RIR
Balia and Jones, 2011 UK	British Health and Lifestyle Survey (HALS; cross-	Lifespan, survival	Parents' lifestyles during children 's childhood (smoking).	Cigarrete smoking	Age, sex, socioeconomic position,	*Genuine control approach.*	$E_i = e(C, E, \varepsilon_1)$ $H_i = h(C, \varepsilon_1, D, \zeta)$	*Simultaneous hazard model: probit model for*	Outcome used in the analysis: predicted median	Improvements due to IO reduction: AAI, CAI, RIR

	sectional survey). Data from 1984 up to 2005.				employment status, rural/urban, household size, marital status.			*smoking habit, duration model for initiation and quit smoking, duration model for mortality.*	survival, predicted lifespan Inequality index: Gini, Sen's welfare index (inequality-adjusted average outcome.)	
Chen 2015 USA	National Longitudinal Survey of Young 1979 NLSY79 (longitudinal survey)	SAH (ordinal, 1 to 5), Health status index: a physical and a mental scores	Sex, ethnicity, parents' socioeconomic characteristics.	Socieconomic position (SEP): income , cigarrete smoking, education.	Sex	*Genuine control approach.*	$F^{\tau}(H) = \frac{1}{n^{\tau}} \sum_{L,SEP} F^{L,SEP}(H) \sum_{E} \pi^{E,\tau}(L,SEP) n^{\tau}(E)$ τ: type (combination of circumstances) $F^{\tau}(H)$: distribution function of health by type n^{τ}: number of individuals per type $F^{L,SEP}(H)$: cumulative distribution function of health of the group of individuals of a given socioeconomic group who have a lifestyle L (L, SEP): denote a lifestyle-socioeconomic group pair (i.e. individuals that share the same lifestyle and belong to the same socioeconomic group) $\pi^{E,\tau}(L,SEP)$: denote the proportion of individuals of a given type with educational level E who achieve a lifestyle-socioeconomic group pair (L, SEP) $n^{\tau}(E)$: number of individuals of a given type that achieve an educational level E	*Non parametric.*	Outcome used in the analysis: average SAH, average physical and mental health scores. Decomposes the distribution to account for the influence of 'channels' (income and education). It creates counterfactual distribution that remove one or the other channel.	Improvements due to IO reduction: AAI EO measured through a EO welfare function equal to the sum of the health status of the worse off type, across the effort distribution.
Asada et al. 2015, Asada et al. 2014 Canada (2014) and United States (2015 study)	2002–03 Joint Canada/United States Survey of Health (JCUSH). Data for 2002-03.	Preference-based measure: Health Utilities Index Mark 3 (HUI)	The aim of the study of (2014) was to compare measures of health inequalities according to different normative positions. In each normative position, the cut between legitimate and illegitimate regressors varies. Variables (categories as defined by the authors): – Health endowments: age – Individual preferences: smoking, BMI, physical activity – Available information: education – Social background: sex, income, income x smoking, race, country of birth, marital status – Basic health care coverage – Health care supply: quality of health care			*Choice approach*	$H_i = h(X, \zeta)$ X: vector of covariates (E and C)	*Linear model*	1. Outcome used in the analysis: observed levels of HUI and FI Inequality index: Gini 2. Outcome used in the analysis: predicted VAS, adjusted VAS and EQ5D-based measure Inequality index: Variance Method of decomposition:	1. Assessment of IO; Explicit normative strategy: θ_a^{IO} Method used to obtain $\widehat{H^{\tau}}$: 1) Ex-post, direct unfairness; 2) Ex-post, fairness gap. 2. Assessment of IO; Implicit normative strategy: $\theta_{r,o}^{IO}$

									Shorrock's variance decomposition	
Jones et al. 2014 UK	NCDS (the National Child Development Study, longitudinal survey). 1958 cohort, with focus on age 46 (2004).	SAH (ordinal, 1 to 5), index of mental health, prevalence of self-reported long-standing illness	Parents' socioeconomic characteristics, cognitive ability, and political tone of a cohort member's local area before the introduction of the reform.	Cigarette smoking, educational attainment, socioeconomic position (SEP): occupation.	NA	*Genuine control approach.*	$F^{\tau}(H) = \frac{1}{n^{\tau}} \sum_{L,SEP} F^{L,SEP,\tau}(H) \sum_{E} \pi^{E,\tau}(L,SEP) n^{\tau}(E)$ τ: type (combination of circumstances) $F^{\tau}(H)$: distribution function of health by type n^{τ}: number of individuals per type $F^{L,SEP,\tau}(H)$: cumulative distribution function of health of the group of individuals of a given socioeconomic group, who have a lifestyle L and belong to a type τ (L,SEP): denote a lifestyle-socioeconomic group pair (i.e. individuals that share the same lifestyle and belong to the same socioeconomic group) $\pi^{E,\tau}(L,SEP)$: denote the proportion of individuals of a given type with educational level E who achieve a lifestyle-socioeconomic group pair (L,SEP) $n^{\tau}(E)$: number of individuals of a given type that achieve an educational level E	*Genuine control approach.*	1 . Outcome used in the analysis: predicted probability of reporting at least good SAH Inequality index: Dissimilarity index 2. Outcome used in the analysis: average SAH, prevalence of chronic illness and disability being absent, average mental health score Decomposes the distribution to account for the influence of 'channels' (income and education). It creates counterfactual distribution that remove one or the other channel.	1. Assessment of IO; Explicit normative strategy: θ_a^{IO} 2. Improvements due to IO reduction: AAI EO measured through a EO welfare function equal to the sum of the health status of the worse off type, across the effort distribution.
Carranza and Hojman, 2015 Chile	Social Protection Survey (longitudinal survey). All waves (2002, 2004, 2006, 2009) with focus on the last one.	SAH (ordinal, 1 to 5). Individuals aged 50 or older.	Parents' socioeconomic characteristics, social conditions during childhood, cognitive ability (numeracy skills (Q)).	Cigarrete smoking (E_1), obesity (E_2), sports (E_3), socioeconomic position: education (E_4).	Age, sex	*Genuine control approach.*	$Q_i = q(C,D,\xi)$ $E_{1,i} = e(C,D,\varepsilon_1)$ $E_{2,i} = e(C,D,\varepsilon_2)$ $E_{3,i} = e(C,D,\varepsilon_3)$ $E_{4,i} = e(C,D,\varepsilon_4)$ $H_i = h(C,D,\varepsilon_1,\varepsilon_2,\varepsilon_3,\varepsilon_4,\xi,\zeta)$	*Linear model for the numercay skills equation.* *Probit models for the effort equations.*(generalized residuals were estimated) Linear probability model for health outcome	1. Outcome used in the analysis: predicted probability of reporting at least good SAH, or at least very good SAH Inequality index: Variance Method of decomposition: Shorrock's variance decomposition 2. Outcome used in the analysis:	1. Assessment of IO; Implicit normative strategy: $\theta_{a,o}^{IO}$ and $\theta_{r,o}^{IO}$ 2. Improvements due to IO reduction: AIR, RIR

									predicted probability of reporting at least good SAH, or at least very good SAH Inequality index: Gini, Theil, Atkinson	
Asada et al. 2018 Canada	Canadian Health Measures Survey (cross-sectional survey). Cycle 2 (2009-10).	Preference-based measure: Health Utilities Index (HUI) Health status index: Frailty Index (FI)	Biological endowment: sex (for FI), family medical history Social background: sex or 'gender' (for HUI), visible minority status, immigrant status, geographical area of residence, socioeconomic position (education, income). Social support: sense of community belonging, leisure activity.	Biological endowment: age Health behaviour: recreational drug use, sleep, sexually transmitted disease, alcohol consumption, BMI, sedentary activity, physical activity.	NA	*Choice approach*	$H_i = h(C, E, \zeta)$	*Linear model*	1. Outcome used in the analysis: observed levels of HUI and FI Inequality index: Gini 2. Outcome used in the analysis: predicted VAS, adjusted VAS and EQ5D-based measure Inequality index: Variance Method of decomposition: Shorrock's variance decomposition.	1. Assessment of IO; Explicit normative strategy: θ_a^{IO} Method used to obtain $\widehat{H'}$: 1) Ex-post, fairness gap. 2. Assessment of IO; Implicit normative strategy: $\theta_{a,o}^{IO}$ and $\theta_{r,o}^{IO}$
Ding et al. 2020 China	CHARLS (longitudinal survey). (2015, 2014 and 2011)	Physical measurements and biomarkers (waist-to-height ratio, systolic blood pressure, triglycerids, ratio of total cholesterol over high-density lipoprotein, glycated haemoglobin, creatinine, C-reactive protein, white blood cells count). Composite index of all the above	Age, sex, region, being born during war period, parents' health status during children 's childhood, parent's lifestyles during children's childhood, social conditions during childhood, health during childhood, parents' socioeconomic characteristics, access to healthcare in childhood.	NA	NA	*Genuine control approach.*	(1) $H_i = h(C, D, \zeta)$ (2) $H_{i,\pi} = h(C, D, \zeta)$ π: quantiles	(1) Linear regression. (2) Quantile regression.	Outcome used in the analysis: physical measurements and biomarkers. Inequality index: Mean logarithmic deviation. This study also estimated the contribution of each circumstance variable at each quantile to IO using the Shapley pley-value decomposition.	Explicit normative strategy: θ_a^{IO} and $\theta_{r,o}^{IO}$ Method used to obtain $\widehat{H'}$: Ex-ante, type-based counterfactual. .

		measures.								
Brunori et al. 2021 Europe (31 countries)	European Union Statistics on Income and Living Conditions (EU - SILC) 2011 (repeated cross-sectional survey)	SAH (ordinal, 1 to 5)	Sex, parent's country of birth and citizenship, parents' socioeconomic characteristics	NA	NA	*Genuine control approach.*	$H_i = h(C, \zeta)$	*Non parametric.* The influence of age on SAH is removed using fixed effects.	Outcome used in the analysis: probability of reporting at least good SAH Inequality index: Dissimilarity index	Explicit normative strategy: θ_a^{IO} Method used to obtain $\widehat{H'}$: Ex-ante, type-based counterfactual.

*The author stated that a cardinal measure of health was obtained from information of EQ5D, however there is no information about how the valuation of health states was obtained.

NA: not available

$H_i = h(C, E, D, \zeta)$ refers to a model were H_i is the observed health outcome of individuals in the sample; h is a function of health production; C, E, D are vectors of circumstances, effort and demographic or neutral variables, respectively, and ζ is random variability. We use ε to denote random errors in effort-related equations. Any aditional notation is explained in the table.

Methods used to obtain $\widehat{\mathbf{H}'}$

Ex-ante type-based counterfactual

$\widehat{H}_i$ corresponds to the average of predicted health status among people with the same level of circumstance regressors. Given an inequality measure I, θ_a^{IO} can be computed according to:

$$\theta_a^{IO} = I\left(\frac{1}{N_C}\sum_{i\epsilon N_C}\widehat{H}_i\right),$$

where N_C corresponds to the number of individuals in each type, and types are mutually exclusive combinations of circumstances.

When path-independent multiplicative inequality index are used, explained inequality can be decomposed into inequality due to circumstances θ_a^{IO} and inequality due to effort θ_a^E.

Inequality due to effort is obtained by scaling the predicted health status of each individual by the ratio of the average health status in the sample and θ_a^{IO}.

$$\theta_a^E = I\left(\widehat{H}_i\frac{\frac{1}{N}\sum_i\widehat{H}_i}{\theta_a^{IO}}\right).$$

Ex-post type-based counterfactual

Inequality due to effort corresponds to the average of predicted health status among people with the same level of effort, according to:

$$\theta_a^E = I\left(\frac{1}{N_E}\sum_{i\epsilon N_E}\widehat{H}_i\right),$$

where N_E corresponds to the number of individuals in each `tranche', and tranches are to mutually exclusive combinations of efforts.

When path-independent multiplicative inequality index are used, explained inequality can be decomposed into inequality due to circumstances θ_a^{IO} and inequality due to effort θ_a^E.

IO is obtained by scaling the predicted health status of each individual by the ratio of the average health status in the sample and θ_a^E.

$$\theta_a^{IO} = I\left(\widehat{H}_i\frac{\frac{1}{N}\sum_i\widehat{H}_i}{\theta_a^{IO}}\right).$$

Direct unfairness

$\widehat{H}_i$ corresponds to the predictions of a model that includes circumstance and effort regressors with effort variables fixed at a reference value: $\widehat{H}\{C_i, \bar{E}\}$.

Fairness gap

$\widehat{H}_i$ corresponds to the predicted health for each individual minus the predictions of a model that includes circumstance and effort regressors with circumstances variables fixed at a reference value: $\widehat{H}\{C_i, E_i\}$ - $\widehat{H}\{\overline{C}, E_i\}$.

Appendix for Chapter 3: Trends in socioeconomic inequalities in life expectancy and lifespan variation in Chile

Information available about education attainment

The type of information and level of disaggregation by years of education and age varies between sources of information. The distribution by years of education for each year relies on information from censuses and a repeated cross-sectional survey (CASEN) which is representative of the Chilean population. Microdata was available for census and population surveys from 1990 onwards, whereas before the year 1990, census information was only available as aggregated data (.pdf files). The census of 1920, 1930, 1940 and 1952 contain abridged data by educational categories. The distribution by years of education for these years was extrapolated relying on information from the closest adjacent year for which disaggregated information was available. Table A.2.1 shows the information available by year and source of information, and the extrapolation method used (if applicable). The last column shows the age group for which the distribution by years of education was computed.

Table A.2.1. Information about education contained in census and population surveys

Year	*Source of information*	*Age group*	*Educational categories available in each census*	*Extrapolation method*	*Age group*
1920	Census	25 to 29 years	Number of individuals by literacy.	The proportion of individuals by educational category for categories different from no education was assumed to be equal to the distribution observed in 1940. The proportion of individuals by years of education within each educational category was assumed to be equal to the distribution observed in 1960.	25 to 29 years
1930	Census	20 to 29 years	Number of individuals by literacy.	The proportion of individuals by educational category for categories different from no education was assumed to be equal to the distribution observed in 1940. The proportion of individuals by years of education within each educational category was assumed to be equal to the distribution observed in 1960.	20 to 29 years

1940	Census	Disaggregated	Number of individuals by years of education for primary education. Number of individuals by educational category for other categories.	The proportion of individuals by years of education within each educational category for categories different from primary school was assumed to be equal to the distribution observed in 1960.	25 to 30 years
1952	Census	25 to 29 years	Number of individuals by educational category.	The proportion of individuals by years of education within each educational category was assumed to be equal to the distribution observed in 1960.	25 to 29 years
1960	Census	20 to 24 years and 25 or more	Number of individuals by years of education in the highest attained educational category for school education. Number of individuals by educational category for other categories.	A weighted average of the number of individuals by level of education in the two age groups available (20 to 24 years and 25 or more) was computed. The total number of individuals in each educational categories was equally distributed within categories (e.g. the number of individuals with 7 years of graduate education equals the number of individuals with graduate education divided by 6).	Weighted average of age groups: 20 to 24 years and 25 or more
1970	Census	25 to 34 years	Number of individuals by abridged years of education in the highest attained educational category (e.g. 7 or 8 years of Graduate education).	The total number of individuals in each educational categories was equally distributed within categories (e.g. the number of individuals with 7 years of graduate education equals the number of individuals with 7-8 years of graduate education divided by 2).	25 to 34 years
1982	Census	25 to 29 years	Number of individuals by abridged years of education (e.g: 7 or 8 years of education).	The total number of individuals in each educational category was equally distributed within	25 to 29 years

				categories (e.g. the number of individuals with 7 years of education equals the number of individuals with 7-8 years of education divided by 2).	
1990	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
1992	Census	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
1994	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
1996	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
1998	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
2000	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
2002	Census	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
2006	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
2009	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
2011	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years
2015	CASEN survey	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years

2017	Census	Disaggregated	Number of individuals by years of education in the highest attained educational category.	NA	26 to 30 years

Definition of years of education

The censuses, population surveys and deaths records contain infromation about the last attained educational category and the lasta ttained years of education within each category. Table A.2.2 shows the mapping from this information to the variable 'years of education'. The table incorporates also the corresponding ISCED-2011 (International Standard Classification of Education) codes for each educational category.

Table A.2.2 Mapping of educational categories to years of education

Category (in Spanish)	*Name in English*	*ISCED 2011 code*	*Years of education*
No formal education or illiteracy			0
Educación parvularia	Pre-primary Education	010, 020	0
Preparatoria (1st to 6th years) Enseñanza Básica (1st to 6th years)	Primary education	100	1 to 6
Humanidades (1st to 2nd years)	Lower secondary education	244	7 to 8
Humanidades (3rd to 6th years)	a) Genereal upper secondary education.	344	9 to 12
Educación básica (7th and 8th years)	Lower secondary education	244	7 to 8
Educación media: a) humanista-científico, b) técnico profesional o c) artística	a) General upper secondary education, b) Technical upper secondary education, and c) Artistic upper secondary education.	344 and 354	9 to 12
Comercial, Industrial, Agricola, Técnico femenina, Normalista	Technical upper secondary education	354	9 to 12
Educación técnica de nivel superior	Higher technical education	554	13 to 15
Bachillerato, Licenciatura y Carrera profesional	Bachelors and Professional title	645, 646, 647, 657, 747, 748, 757, 844	13 to 19
Magíster o Doctorado	Master or Doctorate	747, 748, 844	18 to 20

Groups of diseases used in the analysis

Death records from 1991 categorises the main causes of death using ICD-9 (International classification of diseases) codes, whereas databases of 2002 and 2017 codifies causes of death according to ICD-10 codes. Table A.2.3 shows the codes used to categorise the groups of diseases used in the analysis.

Table A.2.3. Definition of groups of diseases

Group of diseases	***ICD-9***	***ICD-10***
Cancer	140-239,273.1,289.8	C00-D48
Cardiovascular	390-459 (except 427.5, 435, 446, 459)	I00-I99
Digestive	520-579	K00-K93
Infectious diseases	001-139,279.5,795.8	A00-B99,R75
Mental and behavioural	290-329	F00-F99
Respiratory	460-519, 786.0	J00-J99
Other	All but the above	All but the above

Definition of educational categories

Tables A.2.4 and A.2.5 show the distribution by years of education for different years. Cells in light yellow (green) indetify the years of education that fit into the first quintile (tenth decile). Cells in dark yellow (green) show the years of education that fit into two adjacent ranks.

Table A.2.4. Distribution of education among men age 26-30 years old, by year

	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2017
0	0.29	0.19	0.25	0.16	0.14	0.06	0.02	0.02	0.02	0.02	0.00
1	0.31	0.21	0.28	0.18	0.16	0.09	0.03	0.02	0.03	0.02	0.00
2	0.37	0.28	0.38	0.26	0.22	0.17	0.06	0.03	0.03	0.02	0.00
3	0.47	0.39	0.52	0.38	0.34	0.25	0.09	0.06	0.04	0.03	0.01
4	0.58	0.51	0.64	0.50	0.45	0.33	0.15	0.08	0.05	0.03	0.01
5	0.64	0.59	0.70	0.58	0.52	0.46	0.22	0.11	0.07	0.04	0.02
6	0.81	0.78	0.79	0.76	0.70	0.60	0.28	0.17	0.11	0.05	0.03
7	0.84	0.81	0.82	0.80	0.75	0.63	0.36	0.21	0.13	0.06	0.03
8	0.87	0.84	0.86	0.84	0.80	0.67	0.45	0.34	0.24	0.13	0.09
9	0.89	0.88	0.89	0.87	0.84	0.72	0.54	0.40	0.31	0.15	0.11
10	0.92	0.91	0.91	0.90	0.89	0.76	0.64	0.48	0.37	0.20	0.16
11	0.94	0.93	0.93	0.93	0.92	0.86	0.75	0.54	0.41	0.23	0.18
12	0.97	0.97	0.97	0.97	0.97	0.93	0.87	0.81	0.69	0.61	0.55
13	0.98	0.97	0.97	0.97	0.97	0.94	0.89	0.83	0.77	0.64	0.58
14	0.98	0.98	0.98	0.98	0.98	0.95	0.91	0.87	0.81	0.70	0.65
15	0.99	0.98	0.98	0.98	0.98	0.96	0.93	0.91	0.89	0.78	0.72
16	0.99	0.99	0.99	0.99	0.99	0.97	0.96	0.93	0.92	0.84	0.80
17	1.00	0.99	0.99	0.99	0.99	0.98	0.97	0.97	0.97	0.95	0.92
18	1.00	1.00	1.00	1.00	1.00	0.99	0.98	0.99	0.99	0.98	0.96
19	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	0.98	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table A.2.5. Distribution of education among women age 26-30 years old, by year

	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010	2017
0	0.34	0.22	0.29	0.17	0.19	0.02	0.03	0.01	0.01	0.01	0.00
1	0.36	0.24	0.31	0.19	0.21	0.03	0.04	0.02	0.02	0.01	0.00
2	0.41	0.30	0.41	0.26	0.28	0.06	0.08	0.03	0.03	0.02	0.00
3	0.51	0.42	0.54	0.38	0.39	0.09	0.12	0.04	0.03	0.02	0.00
4	0.61	0.54	0.66	0.50	0.51	0.15	0.19	0.08	0.04	0.02	0.01
5	0.67	0.61	0.72	0.57	0.57	0.22	0.27	0.12	0.06	0.03	0.01
6	0.82	0.79	0.81	0.77	0.75	0.28	0.35	0.19	0.10	0.04	0.02
7	0.85	0.83	0.84	0.80	0.78	0.36	0.42	0.24	0.13	0.06	0.03
8	0.88	0.86	0.87	0.84	0.82	0.45	0.49	0.37	0.22	0.12	0.06
9	0.91	0.89	0.90	0.88	0.87	0.54	0.57	0.43	0.29	0.14	0.08
10	0.93	0.92	0.93	0.91	0.92	0.64	0.64	0.52	0.37	0.19	0.12
11	0.95	0.94	0.95	0.94	0.94	0.75	0.77	0.58	0.41	0.21	0.14
12	0.98	0.98	0.98	0.98	0.98	0.87	0.89	0.85	0.68	0.61	0.49
13	0.99	0.98	0.99	0.99	0.99	0.89	0.91	0.87	0.77	0.63	0.51
14	0.99	0.99	0.99	0.99	0.99	0.91	0.93	0.90	0.82	0.69	0.59
15	0.99	0.99	0.99	0.99	0.99	0.93	0.95	0.94	0.90	0.77	0.68
16	0.99	0.99	0.99	0.99	1.00	0.96	0.97	0.96	0.92	0.82	0.76
17	1.00	1.00	1.00	1.00	1.00	0.97	0.98	0.99	0.98	0.95	0.93
18	1.00	1.00	1.00	1.00	1.00	0.98	0.99	0.99	0.99	0.97	0.96
19	1.00	1.00	1.00	1.00	1.00	0.99	0.99	1.00	1.00	0.98	1.00
20	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Appendix for Chapter 5: Compensation and the indirect effect of circumstances

Proof of proposition 2

Let a distribution Y^1 be composed of two types and two effort τ, τ', e, e', such that,

$$U^1(e', c_\tau) = U^1(e, c_\tau) + 10 \ , \ U^1(e, c_{\tau'}) = U^1(e, c_\tau) + 2 \ , \ U^1(e', c_{\tau'}) = U^1(e, c_{\tau'}) + 10 \ ,$$

$$n^{e',c_\tau} = 2 \ , \ n^{e,c_\tau} = 1 \ , \ n^{e',c_{\tau'}} = 1 \ , \ n^{e,c_{\tau'}} = 2 \ .$$

In the distribution Y^1, the opportunities are better for individuals of type τ than those of type τ' according to according to $\phi(O(\tau))$ as defined in Equation 5.4.

Consider a transfer policy such that $T(e', c_\tau) = +1$, $T(e, c_\tau) = +1$, $T(e', c_{\tau'}) = -1$, $T(e, c_{\tau'}) = -1$, which originates the following distribution Y^2:

$$U^2(e', c_\tau) = U^2(e, c_\tau) + 10 \ , \ U^2(e', c_\tau) = U^2(e', c_{\tau'}) \ , \ U^2(e, c_\tau) = U^2(e, c_{\tau'}) \ .$$

According to A-EAC, $Y^1 \succ Y^2$ and according to EPC $Y^2 \succ Y^1$. We have a contradiction.

Figures used to describe the Programmes in the survey (in Spanish)

PROGRAMA A

100 fumadores que son hijos de padres fumadores

2 años más de vida

50 fumadores que son hijos de padres no fumadores

2 años más de vida

50 no fumadores que son hijos de padres fumadores

100 no fumadores que son hijos de padres no fumadores

PROGRAMA B

100 fumadores que son hijos de padres fumadores

2 años más de vida

50 no fumadores que son hijos de padres fumadores

2 años más de vida

50 fumadores que son hijos de padres no fumadores

100 no fumadores que son hijos de padres no fumadores

PROGRAMA C

100 fumadores que son hijos de padres fumadores

50 fumadores que son hijos de padres no fumadores

50 no fumadores que son hijos de padres fumadores

2 años más de vida

100 no fumadores que son hijos de padres no fumadores

2 años más de vida

PROGRAMA D

100 fumadores que son hijos de padres fumadores

1 año más de vida

50 fumadores que son hijos de padres no fumadores

1 año más de vida

50 no fumadores que son hijos de padres fumadores

1 año más de vida

100 no fumadores que son hijos de padres no fumadores

1 año más de vida

Appendix for Chapter 6: Liberal reward and healthy lifestyles: A questionnaire-experimental study

Table A.6.1. The four kinds of preferences in the hypothetical scenarios in Exercise 2 (original text in Spanish)

Preferences	*The description shown in the questionnaire to the respondents*
R^1	Those who smoke know about the negative health consequences of smoking, and they are not happy about it. They have a hard time without smoking. The best scenario for them would be to smoke without this having adverse consequences on their health.
R^2	Those who do not smoke enjoy smoking. They have a hard time without smoking. They do not smoke because they want to have a long life and are not willing to die prematurely because of smoking. All of them will smoke if smoking had no adverse effects on health.
R^3	Those who do not smoke have tried cigarettes in the past or have smoked for short periods. They do not enjoy smoking too much, and they do not have a hard time without smoking. They want to have a long life and are not willing to die prematurely because of smoking. Some of them will smoke if smoking had no adverse effects on health.
R^4	Those who do not smoke have tried cigarettes in the past, but they never enjoyed it. They do not smoke because they do not like smoking and not because they would like to avoid the negative health consequences of smoking. Moreover, even if smoking had no adverse effects on health, they would not smoke.

Table A.6.2. The four kinds of preferences in the hypothetical scenarios in Exercise 3 (original text in Spanish)

Preferences	*The description shown in the questionnaire to the respondents*
R^1	Those who engage in unhealthy lifestyles know about the negative health consequences of these habits and they are not happy about it. They have a hard time trying to engage in healthy lifestyles. The best scenario for them would be to keep with their current lifestyles without this having adverse consequences on their health.
R^2	Those who adopt healthy behaviours have a hard time engaging in these lifestyles. They chose these lifestyles because they want to have a long life and are not willing to die prematurely due to unhealthy lifestyles. All of them will exercise less and eat more unhealthy food if this has no negative impact on their health.
R^3	Those who engage in healthy lifestyles do not have a hard time exercising and eating a healthy diet. They chose these lifestyles because they want to have a long life and are not willing to die prematurely due to unhealthy lifestyles. Some of them will exercise less and eat more unhealthy food provided that this has no negative impact on their health.
R^4	Those who engage in healthy lifestyles enjoy exercising and eating a healthy diet. They chose these lifestyles because they enjoy it and not because they would like to improve their health. Moreover, even if they could stay healthy and engage in unhealthy lifestyles they will not do so.

Appendix for Chapter 7: Preferences vs unfair constraints

Average Marginal Effects of the main model

	E[o]=1	**E[o]=4**	**E[o]=8**
Children's epistemological beliefs	-0.009***	-0.004***	0.011**
	(-0.027;-0.012)	(-0.005;-0.002)	(0.002;0.021)
Children's science enjoyment	-0.019***	0.025***	(0.032)***
	(-0.065;-0.026)	(-0.005;-0.002)	(0.015;0.035)
Exp. child science career: *Yes*	-0.077***	-0.016***	0.101***
	(-0.093;-0.061)	(-0.021;-0.012)	(0.081;0.122)
Imp. school pedagogy, *Baseline: NI/SI*			
Somewhat important	-0.000	-0.000	0.000
	(-0.018;0.018)	(-0.004;0.004)	(-0.026;0.026)
Important	0.024**	0.004**	-0.030**
	(0.005;0.043)	(0.001;0.008)	(-0.054;-0.006)
Very important	0.006	0.001	-0.009
	(-0.016;0.029)	(-0.003;0.006)	(-0.040;0.022)
Imp. school achievement, *Baseline: NI/SI*			
Important	-0.011	-0.002	0.013
	(-0.036;0.014)	(-0.005;0.002)	(-0.015;0.040)
Very important	-0.027**	-0.005**	0.034**
	(-0.052;-0.001)	(-0.009;-0.001)	(0.004;0.063)
Imp. school distance, *Baseline: NI*			
Somewhat important	0.001	0.002	-0.013
	(-0.010;0.028)	(-0.002;0.006)	(-0.040;0.015)
Important	0.016*	-0.003*	-0.023*
	(-0.002;0.035)	(-0.000;0.007)	(-0.048;0.003))
Very important	0.022**	0.004**	-0.029**
	(0.001;0.042)	(0.000;0.008)	(-0.056;-0.002)
Parents' human capital, *Baseline: High*			
Medium high	0.019**	0.005**	-0.030**
	(0.001;0.037)	(0.000;0.010)	(-0.060;-0.001)
Medium low	0.017	0.005	-0.027
	(-0.004;0.038)	(-0.025;0.058)	(-0.061; 0.007)
Low	0.064***	0.011***	-0.078***
	(0.037;0.090)	(0.006;0.016)	(-0.110:-0.046)

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	E[o]=1	**E[o]=4**	**E[o]=8**
Type of school, *Baseline: Private*			
Private Government-dependent	0.026***	0.006**	-0.038**
	(0.006;0.045)	(0.001;0.012)	(-0.068;-0.008)
Public	0.047***	0.009***	-0.063***
	(0.024;0.071)	(0.004;0.014)	(-0.092;-0.032)
Proportion teacher Ph.D.	-1.669**	-0.32**	2.192**
	(-3.213;-0.126)	(-0.621;-0.022)	(0.171;4.213)
Proportion of science teacher	-0.248***	-0.048***	0.326***
	(-0.427;-0.069)	(-0.082;-0.013)	(0.091;0.560)
C^{P*}	-0.073***	-0.0914***	0.096***
	(-0.122;-0.025)	(-0.024;-0.004)	(0.033;0.032)
Observations	2431	2431	2431

Only statistically significant effects are reported.

E[o]: expected occupation (job ordinal scale).

95% confidence interval in parenthesis, NI: Not important, SI: Somewhat important

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$