Essays on Inequality of Opportunity in Health and Human Development

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Ph.D. Thesis

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May 2010

Abstract

This thesis comprises four essays on inequality of opportunity in health and human development.

Chapter 2 proposes an empirical implementation of the concept of inequality of opportunity in health and applies it to data from the UK National Child Development Study. Drawing on the distinction between circumstance and effort variables in John Roemer's work on equality of opportunity, circumstances are proxied by parental socio-economic status and childhood health; effort is proxied by health-related lifestyles and educational attainment. Stochastic dominance tests are used to detect inequality of opportunity in the conditional distributions of self-assessed health in adulthood. Alternative measures of inequality of opportunity are proposed. Parametric models are estimated to quantify the triangular relationship between circumstances, effort and health. The results indicate considerable and persistent inequality of opportunity in health. Circumstances affect health in adulthood both directly and through effort factors such as educational attainment, suggesting complementary educational policies may be important for reducing health inequalities.

Chapter 3 specifies a behavioural model of inequality of opportunity in health that integrates John Roemer's framework of inequality of opportunity with the Grossman model of health capital and demand for health. The model generates a recursive system of equations for health and lifestyles, which is jointly estimated by full information maximum likelihood with freely correlated error terms. The analysis innovates by accounting for unobserved heterogeneity, thereby addressing the partial-circumstance problem, and by extending the analysis to health outcomes other than self-assessed health, namely long standing illness, disability and mental health.

Chapter 4 explores the existence of long-term health returns to different qualities of education, and examines the role of quality of schooling as a source of inequality of opportunity in health. It provides corroborative evidence of a statistically significant and economically sizable association between quality of education and a number of health and health-related outcomes that remains valid beyond the effects of measured ability, social development and academic qualifications. The results also establish quality of schooling as a leading source of inequality of opportunity in health.

Chapter 5 exploits a natural experiment provided by the fact that cohort-members attended different types of secondary school, as their schooling lay within the transition period of the comprehensive education reform in England and Wales that commenced in the 1960's. This experiment is used to explore the impact of educational attainment and of school quality on health and health-related behaviour later in life. A combination of matching methods, parametric regressions, and instrumental variable approaches are used to deal with selection effects and to evaluate differences in adult health outcomes and health-related behaviour for cohort members exposed to the old (selective) and to the new (comprehensive) educational systems.

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Acknowledgements

I would like to extend my gratitude to my thesis advisors Andrew Jones, Nigel Rice and Peter Smith for providing outstanding guidance throughout my PhD. I would also like to thank the Centre for Health Economics, especially the members of the Health Econometrics and Data Group for invaluable encouragement and camaraderie. Funding by Fundação para a Ciência e a Tecnologia is gratefully acknowledged.

Very special thanks go to Dimitra for her loving support and understanding.

I dedicate this thesis to my parents.

Declaration

I confirm that the work presented in this thesis is my own, except where co-authorship is explicitly acknowledged.

Chapter 2 has been published as a single authored peer-reviewed research article under the title: Inequality of opportunity in health: evidence from a UK cohort study. *Health Economics* 2009; 18(9):1057-74.

Chapter 3 has also been published as a single authored peer-reviewed research paper under the title: Modelling opportunity in health under partial observability of circumstances. *Health Economics* 2010; 19(3):252-64. During the Seventh World Congress of the International Health Economics Association (iHEA), held in Beijing in July 2009, an earlier version of this paper was awarded the prize of the iHEA student competition "Young Researchers in Health Economics". Candidates were asked to submit full papers, which were judged by a competition committee made up of Alistair McGuire (Chair), Terkel Christiansen, Bruce Hollingsworth, and Hu Shanlian.

Chapter 4 is written in co-authorship with Professor Andrew Jones and Professor Nigel Rice. I am the lead author, having identified the theme of research and the original idea, prepared the data, carried out the empirical analysis and written the first draft.

Chapter 5 is also written in co-authorship with Professor Andrew Jones and Professor Nigel Rice. I contributed to the original research idea and to the choice of methodological approach, prepared the data, performed part of the empirical analysis and contributed towards the elaboration of the first draft. This research paper is currently under review for publication in a peer-reviewed journal.

Preliminary versions of chapters 4 and 5 have been presented at the University of Chicago, University of Lausanne, University of Manchester, University of Paris Descartes, McMaster University, University of Wisconsin-Madison, University of Coimbra and Korea University.

Chapter 1

Introduction

This thesis consists of a collection of four essays on inequality of opportunity. It is motivated by recent advances in the theory of distributive justice and contributes towards an integrated normative analysis of inequalities in health, education and other aspects of human development.

As asserted by Roemer (2005), equality of opportunity is to be contrasted with equality of outcomes. The Achilles' heel of the advocacy of equality of outcomes has traditionally been its failure to hold individuals accountable for their choices. In light of this, the greatest recent progress in the egalitarian theory of justice, as Cohen (1989) puts it, is arguably the co-option of the sharpest idea in the anti–egalitarian arsenal: the notion of *responsibility*. By compensating for the impact of circumstances beyond individual control, yet holding individuals responsible for the consequences of their choices, equality of opportunity is an appealing compromise between strict equality of outcomes and mere equity of formal rights. It has thus attracted growing attention in the economics literature and is being increasingly advocated by policy makers, as is made clear in The World Bank Development Report 2006, *Equity and Development*, which focuses on the inequality issue (World Bank, 2005).

This conceptual progress is the culmination of a series of developments in political philosophy. Rawls' (1971) pioneering work is credited with reinventing egalitarian justice. Together with Amartya Sen's concept of equality of *capabilities*, Rawls' equality of *social primary goods* replaces subjective utility with an objective criterion. Once these goods and capabilities are equally distributed, any residual inequality is deemed a legitimate consequence of individual choice, hence of *individual responsibility*. As Barry (1991) makes clear, between the polar extremes of the *choicist* position, which attributes every individual outcome to free and unconstrained choice, and the *anti-choicist* argument, which views outcomes as the reflection of differences in the circumstances that determine choices, there are infinite intermediate positions. Dworkin (1981; 2000) proposed a solution to this dilemma by treating responsibility as the corner-stone of distributive justice. Like Rawls and Sen before him, Dworkin rejects equality of welfare as a valid criterion since people differ through dissimilar circumstances and handicaps, which determine, at least in part, choices and outcomes. The problem thus becomes one of finding the *distribution of resources* that appropriately compensates individuals for these circumstances and handicaps. This approach leads to Dworkin's widely debated concept of *equality of resources*, which has attracted important criticisms, such as those raised by Arneson (1989) and Cohen (1989) who address the intractable separation between preferences and resources. This debate prompted key progresses in social choice theory, rendering these new ideas operational within the analytical framework known as the equal-opportunity approach.

Equality of opportunity has been given different formal expressions in the social choice literature, such as those of Fleurbaey (1994) and Bossert (1995). These contributions proved too abstract for empirical application, however, hence the vast majority of the applied work on inequality of opportunity is based in the model proposed by Roemer (1996; 1998; 2002). The four essays in this thesis are empirical implementations of this version of the concept of equality of opportunity in the field of health economics.

Arguably, inequality of opportunity is already the implicit equity concept in some earlier contributions in health economics, such as Williams' *fair innings* argument (Williams, 1997) and the Rawlsian approach to the measurement of health inequalities proposed in Bommier and Stecklov (2002). However, this normative crucial shift in emphasis, from outcomes to opportunities, is still very scarcely reflected in the latest empirical work on health inequalities. This thesis contributes towards narrowing this gap in the health economics literature.

The relevance of the analysis of inequality of opportunity in health extends well beyond its normative appeal. At the heart of the inequality of opportunity concept lies the interaction between *circumstances* beyond individual control and *effort* variables, for which individuals are at least partly responsible. In a health context, early childhood circumstances, parental background, cognitive and non-cognitive ability, as well as decisions regarding type and quality of schooling belong to the first category, while lifestyle choices in adulthood belong to the second. The relationship between each of these factors and health has been addressed independently by well-developed strands of research: the literature on the long-lasting impact of early childhood circumstances (e.g. Currie and Stabile (2004), Case et al. (2005) and Lindeboom et al. (2006)), the empirical analysis of the relationship between education and health (e.g. Lleras-Muney (2005), Arendt (2005; 2008), Oreopoulos (2006), Silles (2009) and Van Kippersluis et al. (2009) and Cutler and Lleras-Muney (2010)), the economics of human development (e.g. Heckman and Rubinstein, 2001, Feinstein, 2000; Kuhn and Weinberger, 2005; Heckman et al., 2006; Carneiro et al., 2007) and contributions on the relationship between health and lifestyles (e.g. Mullahy and Portney (1990), Kenkel (1995), Contoyannis and Jones (2004) and Balia and Jones (2008)). By establishing a bridge between these different branches of applied research, the empirical analysis of inequality of opportunity also contributes towards an integrated approach to the determinants of health in a human development context.

Chapter 2 proposes an empirical implementation of the concept of inequality of opportunity in health and applies it to data from a UK cohort study: the National Child Development Study (NCDS). Drawing on the distinction between circumstance and effort variables, circumstances are proxied by rich data on cohort-members' parental background and childhood health. Effort is proxied by a series of health-related lifestyles in adulthood. The analysis innovates by:

- Implementing a series of stochastic dominance testable conditions in order to detect the presence of inequality of opportunity in health amongst the NCDS cohort-members.
- Proposing two alternative measures for the extent of inequality.
- Illuminating, by estimation of parametric models, the direct and indirect channels through which unfair circumstances affect health outcomes later in life.
- Contributing towards a joint analysis of the way childhood circumstances and lifestyles interact, determining health outcomes in adulthood. Each of these types of factors has been separately studied in the health economics literature but little attention has been given to their interaction.

The results indicate the existence of considerable and persistent inequality of opportunity in health among NCDS cohort-members. Part of the effect of childhood circumstances is a direct one and thus only amenable to policy during the early years of life. However, a significant part of this effect is channelled through behavioural choices regarding education and lifestyle. This suggests an important role for complementary policies to reduce health inequalities outside the health care system, in particular, in the education sector.

Chapter 3 specifies and estimates a behavioural model of inequality of opportunity in health in which the exertion of effort is the consequence of utility maximising behaviour subject to constraints. The motivation for this is twofold. First, it narrows the gap between the normative literature on health inequalities and the positive economics research on health capital and demand for health. Second, it proposes an empirical solution to a widely debated structural problem of the equality of opportunity framework: in practice, the full set of circumstances affecting health outcomes is typically only partially observable. This analysis contributes to the existing literature by:

- Integrating John Roemer's framework of inequality of opportunity with the Grossman model of health capital and demand for health, thereby narrowing the gap between the positive and normative dimensions of the relationship between circumstances, effort and health.
- Accounting for the presence of unobserved heterogeneity that simultaneously affects health and each of the effort factors, and hence addressing the problem of partial observability of the set of circumstances.
- Extending the empirical analysis of inequality of opportunity to health outcomes other than self-assessed health, such as the incidence of long standing illness, disability and mental disorder.

The results indicate the presence of unobserved factors that impact simultaneously on health outcomes and effort variables, corroborating the empirical relevance of the theoretical problem of partial observability of circumstances. They also show that different health outcomes in adulthood are affected by different subsets of circumstance factors, suggesting that education[1] and social development in

[1] It should be noted that, from a normative perspective, educational attainment may be treated either as a circumstance or as an effort variable. On the one hand it is strongly influenced by circumstances

childhood have important implications for key lifestyle choices in adulthood, thereby reinforcing the results of Chapter 2. This corroborates the potential for complementary policies in the educational sector as an instrument for the reduction of health inequalities.

Chapters 4 and 5 explore the interaction between education, cognitive skills, social adjustment and health. Chapter 4 exploits well-defined differences in the educational experience of NCDS cohort-members in order to analyse the relationship between quality of schooling and health disparities. While there is a large literature on the association between years of schooling, academic qualifications and health, little is known about the existence of long-term health returns to different qualities of education. This has important policy implications, as evidence of such returns can inform the design of complementary policy interventions linking the education and healthcare sectors. This chapter contributes to the literature by:

- Examining the scarcely studied association between quality of education and various health outcomes and health-related behaviours.
- Investigating the role of a series of potential mediating channels for these relationships.
- Using the stochastic dominance testable conditions proposed in Chapter 1 to assess whether, from a normative standpoint, quality of schooling can be considered a source of inequality of opportunity in health.

The results of Chapter 4 provide corroborative evidence for a statistically significant and economically sizable association between quality of education and a number of health and health-related outcomes. This association remains valid over and above the effects of cognitive ability, social development and academic qualifications. The results also establish quality of education as a source of inequality of opportunity in

beyond individual control: primary and secondary school quality are examples of such circumstances. On the other, it is reasonable to assume that, while impacted by external factors, educational attainment is also partly within individual control. Two approaches are thus possible. One may consider that, in practice, the influence of external factors overrides individual volition, hence educational attainment should, in the context of inequality of opportunity in health, be a circumstance. This approach is followed in Chapter 3. In contrast, one may postulate that despite the influence of circumstances, there remains an important element of individual free choice that needs to be accounted for. Since effort factors in the Roemer model are variables that are at least partly within individual control (E(C)), it follows that attainment can then be classed as one such variable. This is done in Chapter 2.

health, suggesting that equalising opportunities in health may require not only longer schooling, but also better quality of schooling.

Chapter 4 establishes statistical associations, but these are not necessarily causal. Chapter 5 advances this analysis by exploiting a natural experiment: the schooling years of the NCDS cohort-members lie within the transition period of the comprehensive education reform in England and Wales, which substantially affected their individual educational experiences. A combination of matching methods, parametric models and instrumental variables approaches are used to evaluate differences in adult health-related behaviours and outcomes for the cohort members exposed to the reform and for those unaffected by it. Chapter 5 also innovates by analysing the role of non-cognitive skills and social adjustment, which have received little attention in health economics, but which have been brought to the fore in the recent literature on the economics of education and human development (e.g. Heckman et al., 2006; Carneiro et al., 2007). The analysis addresses four fundamental issues:

- The impact of non-cognitive ability on health outcomes in adulthood.
- The overall effect of educational attainment, captured by a detailed measure of the highest qualification attained and of quality of schooling on adult health and lifestyle.
- The way these impacts change once unobserved factors are taken into account by means of an instrumental variables strategy.
- The existence of heterogeneity in the impact of educational attainment, in particular according to the type of school attended.

The results corroborate key conclusions of recent applied work on human development, showing that non-cognitive ability measured through social adjustment as a child is strongly associated with physical and mental health outcomes in adulthood. They also confirm the existence of a positive effect of educational attainment on health-related behaviours and outcomes. This effect is however heterogeneous: attainment has a much smaller impact on the lifestyles of those who attended academically intensive schools than on the health-related behaviours of those who did not attend them. The asymmetry in the impact of attainment on health outcomes is even more striking, given that positive sizable effects are found only for those who attended the most academically demanding types of schools. Different interpretations of these results are proposed. One possibility is that quality of schooling acts as a catalyst in the relationship between attainment and health. An alternative interpretation is that this asymmetry reflects a non-linearity in health returns of different levels of attainment.

Chapter 6 establishes a nexus between the findings of each chapter, drawing policy implications and identifying avenues for future research.

Chapter 2

Inequality of Opportunity in Health: Evidence from a UK Cohort Study

2.1 Introduction

Much of the attention traditionally given to equality of outcomes has shifted towards equality of opportunities. This change of emphasis is the consequence of the latest developments in political philosophy, inspired by the work of Rawls and Sen, systematised by Dworkin (1981), and subsequently modified by Arneson (1989) and Cohen (1989). In recent years, equality of opportunity prompted a series of applications in different fields of economic research[2] and attracted growing interest of policy makers, as becomes clear in the World Bank Development Report 2006. Within health economics, Rosa Dias and Jones (2007) argued that equality of opportunity is the implicit underlying concept of a broad range of inequality studies published over the last decade. Despite this, the number of empirical applications that explicitly apply this concept to health is still scarce[3]; this paper aims primarily at narrowing this gap.

All conceptions of equal opportunity draw on some distinction between fair and unfair sources of inequality. Environmental factors such as parental income are largely seen as illegitimate sources of health inequalities. On the contrary, the differences in health status that are due to lifestyles, are often seen as ethically justified by individual choice. These contrasting sorts of factors have been studied independently by two well developed strands of research: the literature on the impact of childhood conditions on adult health and that concerned with health and lifestyles. The interaction between the two is much less explored. Furthermore, both strands were developed in relative isolation from the literature on health

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[2] For example Betts and Roemer (2001), Le Grand et al. (2002), Lefranc et al. (2004) and Bourguignon et al. (2005).

[3] Zheng (2006) and Devaux et al. (2008) are two of the very few papers focused on inequality of opportunity in health.

inequalities. Establishing a bridge between all these branches of research is the second purpose of this paper.

This paper is grounded on the framework proposed by Roemer (1998, 2002); this is then augmented with a set of testable conditions defined in Lefranc et al. (2004, 2008a). The data used are from the UK National Child Development Study (NCDS).

2.2 Background

2.2.1 Equality of Opportunity: the Roemer model

The empirical analysis developed in this paper is explicitly grounded on the theoretical framework of the Roemer model (1998, 2002). It starts by sorting all factors influencing individual attainment between a category of *effort factors*, for which individuals should be held responsible and a category of *circumstance factors*, which, being beyond individual control, are the only source of illegitimate differences in outcomes. The outcome of interest is health as an adult (*H*). A health production function $H(C, E(C))$ is defined, where C denotes individual circumstances and E denotes effort.

The Roemer model does not specify which causal factors constitute circumstances and effort[4]. In the case of inequality of opportunity in health, this dilemma is facilitated by the existence of medical and economic evidence on the main determinants of health in adulthood. There is a branch of economic literature

[4] Within the responsibility-sensitive egalitarian literature, as made clear by Fleurbaey (2008, p. 247 – 248), there are two main positions regarding what should constitute circumstances (hence causes of illegitimate inequality). The first, often named "control approach" and defended by authors such as Cohen, Arneson and Roemer, asserts that individuals should be held responsible only for what lies within their control; grounded on the Roemer model, this thesis is in accord with this perspective. The second, known as the "preference approach" is proposed by authors such as Rawls, Dworkin and Van Parijs and specifies that individuals should only be made responsible for their preferences; but this includes preferences that were not chosen (as it can be the case of subjective time-discount rates) and which cannot be changed (such as genetic traits). These two approaches yield very different conclusions in cases in which individuals suffer disadvantages due to preferences (inborn or otherwise), which are beyond individual control. This thesis is explicitly grounded on the Roemer model, hence on the "control approach". It is also believed that treating genetic disadvantages as circumstances is in line with the ethos professed by health systems and, more generally, public services in developed countries.

devoted to the impact of childhood circumstances on health outcomes: Currie and Stabile (2004), Case et al. (2005) and Lindeboom et al. (2006) are recent examples. Using different datasets, these studies appraise conflicting theories about the channels by which childhood conditions influence long-term health. The most prominent among these theories are: the *fetal-origins hypothesis* (Barker (1995), Raveli et al (1998)) according to which parental socioeconomic characteristics influence the *in utero* conditions for fetal growth which, in turn, condition long term health; the *life course models* (Kuh and Wadsworth (1993)) which emphasise the impact of deprivation in childhood on adult health and longevity; the *pathways models* (Marmot et al. (2001)) which suggest that health in early life is important mainly because it will condition the socioeconomic position in early adulthood, which explains disease risk later in life.

This paper follows this strand of research: it considers as circumstances the parental socioeconomic characteristics, spells of financial hardship during the cohort members' childhood and adolescence, proxies of congenital endowment such as the prevalence of chronic conditions in the family and birth weight, as well as incidence of acute conditions, chronic illnesses and obesity in childhood and early adolescence. All these factors affect the cohort members before the age of 16, reflecting conditions and choices that are largely beyond individual control.

There is also considerable work done on the relationship between health and lifestyles; examples include Mullahy and Portney (1990), Kenkel (1995), Contoyannis and Jones (2004) and Balia and Jones (2008). Lifestyles, such as cigarette smoking, alcohol consumption, and diet are at least partially within individual control, hence they constitute the primary effort factors. While the literature has established that educational outcomes are impacted very strongly by childhood circumstances, it remains plausible to postulate that a degree of educational attainment lies within individual control. Because of this, and given that it is a potential explanatory factor of health in adulthood, it is also taken here for an effort factor.

The Roemer model defines social types consisting of the individuals who share exposure to the same circumstances. The set of observed individual circumstances allows the specification of these social types in the data. It is assumed that the society has a finite number of T types and that, within each type, there is a continuum of individuals. A fundamental aspect in this setting, is the fact that the distribution of effort within each type (F^t) is itself a characteristic of that type; since this is beyond individual control, it constitutes a circumstance.

In order to make the degree of effort expended by individuals of different types comparable, Roemer proposes the definition of quantiles of the effort distribution (in this case, the number of cigarettes per day or number of units of alcohol consumed per week) within each type: two individuals are deemed to have exerted the same degree of effort if they sit at the same quantile (π) of their type's distribution of effort. When effort is observed, this definition is directly applicable. However, if effort is unobservable, an additional assumption is required: by assuming that the average outcome, health in this case, is monotonically increasing in effort, i. e. that healthy lifestyles are a positive contribution to the health stock, effort becomes the residual determinant of health once types are fixed; therefore, those who sit at the π^{th} quantile of the outcome distribution also sit, on average, at the π^{th} quantile of the distribution of effort within his type.
The definition of equality of opportunity used in this paper also follows from the Roemer model: equality of opportunity in health attains when average health outcomes are identical across types at fixed levels of effort. This means that, on average, all those who adopt identical lifestyles should be entitled to experience a similar health status, irrespective of their circumstances. Such a situation corresponds to a full nullification of the effect of circumstances, keeping untouched the differences in outcome that are caused solely by effort.

When aggregating over different effort levels Roemer (2002) employs the *Mean of Mins* social ordering criterion, as defined by Fleurbaey (2008, p. 201). This criterion consists of maximizing the average (health) outcome of the whole population that would result if each individual outcome were put at the minimum observed in its own responsibility class. The model is nevertheless compatible with many alternative criteria, as clarified in Roemer (2002, p. 459), so the adoption of the *Mean of Mins* is not essential for any of the results in the following sections[5].

2.2.2 Definitions and testable conditions

The definition of equality of opportunity given by Roemer (2002) is more appropriate for the situation in which a public policy is being evaluated rather than for inequality measurement from survey data. A set of alternative definitions was recently proposed by Lefranc et al. (2008a) and Devaux et al (2008): these appeal to the concept of stochastic dominance and are coherent with the rationale of the previous section.

A lottery stochastically dominates another if it yields a higher *expected utility*. Several orders of stochastic dominance may therefore be defined according to the restrictions one is willing to make on the individual utility function. First order stochastic dominance (FSD) holds for the whole class of increasing utility functions (*u'>0*); this corresponds to simply comparing *cdfs* of the earnings paid by alternative lotteries. Second order stochastic dominance (SSD) applies to utility functions which are increasing and concave in income, reflecting the notion of risk aversion (*u'>0* and *u''<0*); SSD evaluates integrals of the *cdfs*. While FSD implies SSD, the converse is clearly not true.

These assumptions define broad classes of utility functions and are therefore applicable to the case of health. The exposure to different circumstances defines alternative lotteries; stochastic dominance allows the comparison of their health-related outcomes under standard assumptions on preferences.

Roemer's notion of inequality of opportunity applies to individuals who, having expended the same effort, achieve different outcomes due to different

[5] Roemer (2002) obtains an indirect outcome function $v^t(\pi,\varphi)$, defined for each type, and solves for the equal-opportunity policy φ that equalises $v^t(\pi,\varphi)$ across types, at fixed levels of effort π, by using the *Mean of Mins* criterion: $\varphi = \arg \max_{\varphi} \int_0^1 \min_t v^t(\pi,\varphi)\, d\pi$. For an account of the numerous alternative criteria, see Van de Gaer (2003) and Vallentyne (2008).

circumstances; inequalities due to effort are deemed acceptable. Denoting by *F(.)* the *cdf* of health, a literal translation of this would mean saying that there is inequality of opportunity whenever: $\forall c \neq c', F(.|c) \neq F(.|c')$.

This condition is however too stringent to be useful in empirical work. Lefranc et al. (2008a) consider that the data are consistent with the hypothesis of inequality of opportunity if the social advantage provided by different circumstances can be unequivocally ranked by SSD[6], i.e. if the distributions of health conditional on different circumstances can be ordered according to *expected utility*:

$$\forall c \neq c', F(.|c) \succ_{SSD} F(.|c').$$

In this paper the main outcome of interest is self-assessed health, which is inherently ordinal. This fact dictates the need of redefining this condition in terms of FSD:

$$\forall c \neq c', F(.|c) \succ_{FSD} F(.|c').$$

Since FSD implies SSD, this is a stronger condition, which necessarily satisfies the requirements set by Lefranc et al. (2008a). This condition is statistically testable and therefore it is used to assess the existence of inequality of opportunity[7].

2.2.3 Measures of inequality of opportunity

The stochastic dominance conditions are testable, but do not provide a measure of inequality of opportunity in health. For this purpose, this paper uses two alternative measures. The first is the Gini-opportunity index, first put forward by Lefranc et al. (2008b). It quantifies the health inequality between different social types, defined by the researcher according to the exposure to particular circumstances. The second is a measure that avoids the subjective definition of a discrete number of types, inspired in the *conditional equality* approach proposed by Fleurbaey and Schokkaert (2009).

[6] SSD with equal means is equivalent to the Lorenz curve dominance criterion, which is widely used in health economics.

[7] The *cdf* approach and FSD procedure do not hinge on the *Mean of Mins* criterion or any other aggregation method, as discussed by Fleurbaey (2008: p.218) and illustrated in Lefranc et al. (2004).

2.2.3.1 The Gini-opportunity index

The area underneath the generalised Lorenz curve (*A*) relates to the Gini coefficient according to $A = \int GL(p)dp = \frac{1}{2}\mu(1-G)$, where *GL* stands for the generalised Lorenz curve, μ for the mean outcome and *G* for the Gini coefficient. The double of *A*, i.e. the expression $\mu(1-G)$, is known as the *Sen evaluation function*[8], and constitutes the primary measure of social welfare when only the mean level of outcome and the Gini coefficient are known.

In this context, Bensaid and Fleurbaey (2003) interpret the area underneath the generalised Lorenz curve as a cardinal measure of opportunity: for example, the area underneath the generalised Lorenz curve of one given type is a measure of that type's opportunity set. Following this line of thought, Lefranc et al. (2008b) propose using a modified Gini coefficient to quantify the inequality between the different types' opportunity sets: ranking types (not individuals) according to their respective values of $A_j = \mu_j(1-G_j)$ and starting from the smallest one, the *Gini-Opportunity index* is defined as: $G-Opp = \frac{1}{\mu}\sum_{i}^{k}\sum_{i<j} p_i p_j \left[\mu_j\left(1-G_j\right)-\mu_i\left(1-G_i\right)\right]$.

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One advantage of basing the inequality measurement on differences in the Sen evaluation functions, rather than on mean differences, is that it is particularly meaningful in terms of social welfare. Several welfare interpretations have been proposed for it in the literature.

The first is the original interpretation proposed by Sen (1973). Newberry (1970) had shown that the Gini coefficient alone cannot order distributions in the same way as any additive group welfare function, assuming concave individual utility functions. Sen proposed an alternative on non-individualistic welfare grounds: $A(\mu, G)=\mu(1-G)$. As made clear in Sen (1973, pg 33) the rationale for this is analogous to Rawls' maxmin, but applied pairwise: *suppose the welfare level of any pair of individuals is equated to the welfare of the worse-off person in the two. Then, if the total welfare of the group is identified with the sum of the welfare of all pairs, we get the welfare function underlying the Gini coefficient.*

A second interpretation of this evaluation function has acquired a central role in the theory of relative deprivation. In his seminal work on relative deprivation and the Gni coefficient, Yitzhaki (1979) shows that the social evaluation of the deprivation inherent in a person's not having X is an increasing function the proportion of those who have, hence social deprivation can be represented by μG . Consequently, $\mu(1-G)$ is a measure of the satisfaction in the society.

Other interpretations have been proposed in the literature such as Layard's use of generalised Sen evaluation functions to introduce the idea of altruism in the social welfare theory. But, in the context of the measurement of inequality of opportunity, Bensaid and Fleurbaey (2003) and Lefranc et al (2008b) have shown that the area underneath a types generalised Lorenz curve, hence the value of its Sen evaluation function, constitutes a cardinal measure of this types opportunity set.

This index, gives the weighted average of the differences between the types' opportunity sets in which the weights are the sample weights of the different types $\left(p_{i,j}\right)$. It increases in the number of types, therefore depending on the subjective definition of these by the researcher[9].

In the specific case of health, a potential limitation of this index concerns the fact that the Gini coefficient, hence also the Gini-opportunity index, is not invariant to the scale on which the health variable is measured. This is a well known fact, but the use of mean based indices, such as Gini coefficients and concentration indices, as well as of regression models that assume a particular scale of the health variable is widespread: **t**his is for example the approach used by Wagstaff et al. (1991), Contoyannis et al. (2004) and Van Doorslaer and Koolman (2004) in the field of health inequalities, and also the methodology implemented in many other papers concerned with different aspects of health economics such as Case et al. (2005). Resolving this limitation is therefore beyond the scope of this paper[10]. However, to mitigate its impact and to ensure the robustness of the results, sensitivity analysis was undertaken regarding the latent scale of the self-assessed health variable[11].

2.2.3.2 An alternative approach

In some situations, the definition of social types has a clear intuitive appeal; in others, however, it may be hard to justify. In order to avoid this downside, one may treat each individual as a type: by assuming that the number of social types equals the number of individuals, the Gini-opportunity index equals, by construction, the conventional Gini coefficient.

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[9] The Gini-opportunity index also satisfies all the fundamental properties required by the indices of relative inequality: within type anonymity; between-type Pigou-Dalton principle of transfers; normalisation (if cdfs are equal, the index is equal to zero); homogeneity of degree zero; invariance to a replication of the population. For details see Lefranc et al. (2008b) and references therein.

[10] A series of different possibilities to deal with this problem was recently proposed by Erreygers (2009).

[11] A summary robustness check has been performed in order to assess the sensitivity of the inequality measures computed in the paper to different self-assessed health scales. This was carried-out using the McMaster Health Utility Index Mark III which is a truly cardinal health measure and has been used to cardinalise ordinal self-assessed health indices as shown in Van Doorslaer and Jones (2003). The McMaster Health Utility Index Mark III indicates lower and upper bounds for the health variable: in a five-point scale these are respectively [0; 0.428; 0 .756; 0.897; 0.947] and [0.428; 0.756; 0.897; 0.947; 1]. As a robustness check, the inequality measures computed in the chapter were recomputed using these alternative scales; the results were reassuring, showing that the reported measures are not significantly sensitive the use of these different health scales.

Fleurbaey and Schokkaert (2009) propose a range of different approaches to the measurement of health inequalities that do not require the definition of a discrete number of types. The measure used in this paper is inspired in one of them, the *conditional equality*, and is computed as follows. After running $h_i = \alpha + \beta C_i + \varepsilon_i$ one computes $\hat{h}_i = \hat{\beta} C_i = h_i - \hat{\varepsilon}_i$. The pseudo-Gini coefficient[12] is then applied directly to $\hat{h}_i$, in order to measure the overall health inequality that is due to circumstances, hence the extent of inequality of opportunity.

This approach diverges from Fleurbaey and Schokkaert (2009): the first stage regression implemented in this paper omits all the effort variables; as pointed-out by Gravelle (2003), this might lead to biased estimates, for the partial correlations between circumstances and effort are not taken into account. However, in the context of the Roemer model, these partial correlations should also be treated as circumstances for they embody the indirect effect of the unjust circumstances on health that is channelled through effort. This omission is therefore deliberate.

The value of this measure is directly comparable with that of the health pseudo-Gini[13] coefficient $G(h_i)$. The health pseudo-Gini coefficient has been used in the literature to measure inequality of outcomes. It implicitly treats as circumstances all the sources of variation in health and, therefore, the value of $G(h_i)$ constitutes an upper bound for inequality of opportunity. In turn, $G(\hat{h}_i)$ treats as circumstances only the sources of unfair inequality that are labelled as such by the researcher; it is therefore a lower bound for the extent of inequality of opportunity in health.

It is important to stress that these measures of inequality of opportunity are inherently different and therefore do not necessarily bring about the same ranking of social states. The Gini-opportunity index measures the inequality between a discrete number of social types subjectively defined by the researcher. $G(\hat{h}_i)$ also

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[12] The outcome of interest in this paper is self-assessed health, measured in a discrete ordinal scale. Because of this, individuals cannot be simply ranked by health: grouped data is therefore used and *pseudo-Lorenz curves* and *pseudo-Gini coefficients* defined.

[13] In this paper, $G(h_i)$ denotes the pseudo-Gini coefficient.

requires a normative cut between circumstances and effort, but it respects the continuous nature of these variables; it quantifies the overall contribution of circumstances to the observed (health) outcome inequality. Finally, the pseudo-Gini index is the standard tool for the measurement of pure health inequalities; it implicitly assumes that all causes of inequality of opportunity are circumstances.

2.3. Data

2.3.1 The National Child Development Study (NCDS)

The NCDS follows the cohort of nearly 17,000 individuals born in Great Britain in the week of 3rd March 1958. Individuals are followed from birth to the age of 46. Parents were interviewed for the first time in 1958; extensive medical data on children were collected together with comprehensive information about the socioeconomic characteristics and educational achievements of their parents. Posterior interviews were conducted in 1965, 1969, 1974, 1981, 1991, 1999 / 2000 and 2004. Information in the first three waves of the survey was obtained from parents and school teachers. At the age 7 and 11, ability tests were administrated in mathematics and reading. During this period of childhood and adolescence, data on some aspects of parental health was systematically collected, such as incidence of hereditary conditions in the family. Parental occupation and education, exposure to financial difficulties and other socioeconomic characteristics of the household were also recorded in these first three waves of the survey.

Questionnaires from waves 4 to 7 were addressed to cohort members (rather than their parents) and cover a broad range of subjects grouped in the following categories: employment; income; health and health-related behaviour; citizenship and values; relationships; parenting and housing; education and training.

The issue of attrition has been considered both in research papers and in reports produced by the NCDS advisory panel. Attrition does not seem to be associated with socioeconomic status, as shown in Case et al. (2005), and has modest positive correlation with cohort members' spells of unemployment, as reported by Lindeboom et al. (2006). In this paper, a variable addition test was carried-out to investigate whether health-related attrition is a problem: ordered probit regressions were used to determine whether being in subsequent waves of the panel is correlated with health status. No evidence of health-related attrition was found.

2.3.2 Variables: health, circumstances and effort

The main health outcome considered in this paper is self-assessed health (SAH) measured in a four-point scale: excellent, good, fair and poor health[14]. SAH is measured when the cohort members are 23, 33, 42 and 46 years old. SAH is widely used in health economics and was shown to predict mortality and deterioration of health even after controlling for the medical assessment of health conditions: Idler and Kasl (1995) provide an extensive literature review on this issue. In the specific case of the NCDS, the focus on SAH is also corroborated by its high correlation with reported disability and number of hospitalisations[15].

Two sorts of circumstance variables are considered: the parental socioeconomic background of the cohort members and their congenital and childhood health conditions.

The socioeconomic background of the cohort members is characterised by a comprehensive set of variables. The NCDS allows us to trace the social class of the parents and of both grandfathers of the cohort members. This is derived from the respective Registrar General's Social Class in the first three waves of the survey (for parents) and at the time in which parents left school (for the grandfathers). Following the literature on the NCDS, data on wages were not taken directly into account given substantial non-response. Along the lines of Case et al. (2005) and Lindeboom et al. (2006), this was replaced by the incidence of financial difficulties during the childhood of the cohort members. The number of years of schooling of the mother and of the father is also included in the set of circumstances.

[14] In the latest wave of the survey, SAH is however measured in a five-point scale which also includes the category of "very poor health".
[15] See Case et al. (2005, pp. 370).

The proxies for health endowment used in this paper have all been cited in the literature as systematic determinants of adult health. Birthweight is taken as the main indicator of health at birth; dummy variables for whether the mother smoked after the fourth month of pregnancy and for whether the child was breastfed are included as controls. The NCDS provides information about a comprehensive set of morbidities experienced by the child up until the age of 16. Measures of morbidity, which aggregate 12 categories of health conditions, are constructed according to Power and Peckham (1987) and treated as circumstances. Dummy variables for the occurrence of chronic diseases in the parents and for the incidence of hereditary conditions such as diabetes and epilepsy in parents, brothers and sisters of the cohort members complement the information on health endowments. Dummy variables for whether the child was obese at age 16 and for whether both parents were smokers in 1974 are also treated as circumstances.

The effort factors considered in the paper are health-related lifestyles such as cigarette smoking, alcohol consumption, consumption of fried food and educational attainment: these are strongly constrained by circumstances, but also reflect individual choices.

All the variables used to proxy lifestyles are based on self-reported information. The variable for cigarette smoking is the self-reported number of cigarettes smoked per day. Alcohol consumption is measured by the number of units of alcohol consumed on average per week: NCDS respondents are asked about their weekly consumption of a wide range of alcoholic drinks (glasses of wine, pints of beer and so forth). These were then converted to units of alcohol using the UK National Health Service official guidelines[16]. Educational attainment is measured by the highest academic qualification awarded to cohort members[17]. The summary statistics of the main variables used in the paper is shown in Table 1.

[16] These are publicly available at:
http://www.nhsdirect.nhs.uk/magazine/interactive/drinking/index.aspx .

[17] O-level (Ordinary levels) were a secondary education qualification corresponding, typically, to 11 years of education; A-levels (Advanced levels) are a qualification which corresponds to 13 years of education. Completion of A-levels is a prerequisite for university admission.

2.4 Testing and measuring inequality of opportunity in health

The existence of inequality of opportunity in health can be tested using the set of conditions defined in Section 2.2.2. As explained above, the data are consistent with inequality of opportunity if $\forall C \neq C', F(H|C) \succ_{FSD} F(H|C')$. In order to illustrate the application of this condition to the NCDS data, three social types are defined on the sole basis of the social class of the cohort members' father in 1974: a top class including professional and managerial workers, a middle class including partially skilled non-manual and skilled manual workers, and a bottom class including unskilled manual and unemployed workers.

The outcome of interest is self-assessed health at age 46, measured in a five-point scale. Given the existence of a common discrete support, Kolmogorov-Smirnov test procedures were carried-out to test for first degree stochastic dominance between types; this approach was previously used in the literature by Lefranc et al. (2004) and Devaux et al. (2008). Table 2 shows the results of these tests: the distribution of health in the top social class dominates at first degree that of the middle class which, in turn, dominates, also at first degree, the outcome distribution of the bottom social type at the 5% significance level. These results establish the existence of inequality of opportunity between types.

Two approaches to the measurement of inequality of opportunity were presented in Section 2.2.3. The first of them, the Gini-opportunity index, is implemented using the social types defined for testing for stochastic dominance, and its values tabulated for the four latest waves of the NCDS in the first column of Table 3. This index measures the extent of inequality of opportunity between the three social types when the cohort members were 23, 33, 42 and 46 years old. To allow for sampling error, the standard errors of the Gini-opportunity indices are bootstrapped in each wave, with independent re-sampling within each of the three types.

The second column of Table 3 presents the values of the pseudo-Gini coefficient $G\left(\hat{h}_i\right)$, which measures the overall inequality that is attributable to circumstances, avoiding the subjective definition of social types. It is computed as described in Section 2.2.3. The circumstances used in the regression are the following[18]: gender, regional dummies, socioeconomic status of the father and of both grandfathers, number of years of education of the father and of the mother, indicators for whether the father and the mother were smokers in 1974, birthweight, incidence of physical and mental impairments during childhood and adolescence, exposure to financial hardship at age 11 and at age 16, indicators for the prevalence of diabetes, epilepsy and other (unspecified) chronic conditions in the family and a dummy variable for whether the cohort member was obese at age 16. This equation is the same for all the waves, making the values of $G\left(\hat{h}_i\right)$ directly comparable.

The third column of Table 3 displays the values of the health pseudo-Gini coefficient $G\left(h_i\right)$. As seen in Section 2.2.3, this measure treats all the sources of variation in health as circumstances, equating inequality of opportunity and inequality of outcomes; $G\left(h_i\right)$ is therefore an upper bound to the extent of inequality of opportunity.

The Gini-opportunity index, exhibits a remarkable persistence over the time: it does not change significantly over the last three waves of the survey. This suggests that the long term association between parental socioeconomic status and the cohort members' health is far from being restricted to childhood and adolescence. The values of $G\left(\hat{h}_i\right)$ and $G\left(h_i\right)$ show an increasing trend, as the 1958 cohort ages and the prevalence of illness mounts[19].

[18] As explained above, this procedure is in line with van Doorslaer et al. (2004), in the sense that only circumstance variables are used in the first stage regression.

[19] It must be stressed that there is no theoretical reason ensuring that the three indices depict the same trend. For example, Lefranc et al. (2008b: p.539-540) use a dataset of 9 countries to compare the extent of income inequality (measured by the Gini coefficient) with that of the inequality of opportunity for the acquisition of income (measured by the Gini-opportunity index). Their results show that the correlation between the values of these two measures can be negative in practice.

The fourth column of Table 3 displays the ratio $G\left(\hat{h}_i\right) / G\left(h_i\right)$; this corresponds to the proportion of total health inequality that is due to inequality of opportunity (i.e. due to the direct and indirect effect of the observed circumstances). The weight of inequality of opportunity in the total health inequality is relatively steady across the four waves, assuming values between 21% and 26%. Since these circumstances affect the cohort members before age 16, at least 21% of the health inequalities observed in adulthood are due to factors which are only amenable to policy interventions early in life.

2.5 Estimation results

So far the analysis has been focused on identifying and measuring inequality of opportunity in health. The attention is now turned to explaining it. On a first stage, a model of association between self-assessed health (SAH) at age 46 and a comprehensive set of circumstances is estimated; this allows an assessment of the global impact of circumstances on health. These estimates are then contrasted with those of an alternative model, which controls for effort variables; this compares the relative importance of the pathway of circumstance through effort, with its direct effect. The estimates of the effort factors must however be seen as associations that do not necessarily reflect causality. Finally, in order to illuminate further the triangular relationship between circumstances, effort and health, a set of univariate equations is estimated for each of the effort variables.

2.5.1 Adult health and early life circumstances: direct and indirect effects

Table 4 shows the results of the ordered probit regression of SAH at age 46 on circumstances. A general-to-simple *kitchen sink* approach was followed, starting with a large number of regressors, all of them potential circumstances. These circumstance variables are also the ones used to compute $G\left(\hat{h}_i\right)$ in Table 3. The reported marginal effects are computed by averaging across all the individual marginal effects in the sample, and by taking *excellent health* as the reference category.

The estimated coefficients for the social class of the cohort member's father are positive and statistically significant. Compared with the bottom social class, individuals whose father or male head of household is in the top occupational category are 5.7 percentage points more likely to report excellent health. This partial effect is of 4.1 percentage points for the middle social class. These facts are striking given the large number of controls used and mirror the results of the stochastic dominance analysis, confirming the existence of inequality of opportunity in health.
The number of years of education of the mother is significantly associated with good health in adulthood; paternal education is however statistically insignificant after controlling for paternal social class. This is in line with Case et al. (2005, pp 377); it is also a statistically significant result for women, but not for men.

Financial difficulties at age 16, are a statistically significant determinant of health deterioration in adulthood, especially for men: spells of bad household finances at age 16 are associated with a 13.4 percentage points lower probability of reporting excellent health at age 46. Propper et al. (2004) show that spells of low income in early years affect health in childhood and adolescence; the results in Table 4 make clear that this association persists in adulthood.

Health endowments are also crucial: the incidence of illness in adolescence is significantly correlated with a worsening of self-reported health at age 46. Marginal effects are identical for men and women, corresponding to a nearly 2 percentage points lower probability of reporting excellent health. The prevalence of obesity at age 16 is also highly correlated with a deterioration of adult health. This effect is statistically significant for women (but not for men) and accounts for a reduction of around 8.4% in the probability of reporting excellent health in adulthood.

Table 4 accounts for the global impact of circumstances on SAH at age 46, but it omits important determinants of health, namely effort factors. These are added to the model in Table 5.

After controlling for many of the factors that individuals partially control, and including among them educational attainment and even own social class at age 33, most of the circumstances preserve their statistical significance. However, the size of the marginal effects[20] of circumstances such as parental social class and bad finances at age 16 are strongly reduced. This indicates that only a fraction of the effect of circumstances is a direct one: effort factors now capture part of their impact on health.

The health endowment circumstances that were statistically significant in Table 4 remain significant in Table 5; their marginal effects are also reduced. Particularly striking is the fact that obesity at age 16 remains statistically significant after controlling for a series of lifestyles and dietary choices, carrying a negative partial effect of nearly 4 percentage points. Although this is statistically significant only for women, it suggests that childhood obesity has an important direct effect on adult health, therefore amenable only to early policy interventions.

Amongst effort factors, the detrimental effect of cigarette smoking on SAH is prominent. This is in line with most of the literature: Power and Peckham (1987), Marmot et al. (2001), Contoyannis and Jones (2004) and Balia and Jones (2008) report similar results. The avoidance of fried food is the only dietary choice that shows a statistically significant positive impact on SAH at age 46.

After controlling for own social class in adulthood and for a commonly used proxy of intellectual ability (maths test scores at age 11), the attainment of A-levels or higher academic qualifications shows to be statistically significant: compared with those with no secondary education, individuals attaining at least A-levels have an approximately 1.3 percentage points higher probability of reporting excellent health[21]. Finally, the effect of (own) social class is also statistically significant: compared to the bottom social category, individuals in the top and middle classes have a nearly 1.5 percentage points higher probability of reporting excellent health at age 46. However, it must be noted that these results encase important gender differences. The association between academic qualifications and self-assessed health at age 46 is sizable and statistically significant for men, but not for women. Also, the estimated marginal effect of own social class in adulthood is substantial

[20] The marginal effects in Table 5 are also for the probability of reporting excellent health.
[21] This makes clear that there is an association between educational attainment and self-assessed health at age 46 over and above the effect of professional occupation in adulthood. This would not occur if education were a pure job marketing signalling device.

for men but practically null for women. This is consistent with the existence of marked differences in labour market opportunities between male and female cohort-members, which may partly explain the observed gender-asymmetric health returns by educational qualifications.

2.5.2 Circumstances and effort: primary pathways

In order to illuminate further the effect of circumstances on effort, single equations for each of the most important effort variables are estimated in Table 6.

The first and second equations of the table concern cigarette smoking. The number of cigarettes smoked per day shows a spike at zero, which is typical of cigarette smoking data. In order to take this into account, two equations are estimated: the first is a probit model, estimated for the whole sample, for whether an individual is a smoker or a non-smoker; the second, features the logarithm of the number of cigarettes smoked as the dependent variable and is estimated only for smokers.

Parental smoking, bad household finances at age 16 and the prevalence of hereditary conditions in the family are chief determinants of cigarette smoking at age 33. Parental smoking accounts for a statistically significant increase in the probability of smoking of 3.6 percentage points, in the case of the father, and of around 2.4 percentage points in the case of the mother. The partial effect of financial difficulties in adolescence is even larger: 9.2 percentage points. Conversely, the prevalence of chronic diseases in the family, other than diabetes and epilepsy, has a statistically significant negative partial effect of 9.8 percentage points. This corroborates the thesis that perceived physical frailty leads to the adoption of healthy lifestyles to offset health risks.

Finally, the results suggest the existence of a socioeconomic and educational gradient in the probability of smoking: those with higher qualifications are less likely to smoke, even after controlling for own and parental socioeconomic status. Although the estimates of academic qualifications should not be seen as causal effects, this backs the idea that complementary educational policies may be crucial to reduce inequality of opportunity in health.

The evidence concerning the number of cigarettes smoked per day is mixed: there is neither a clear socioeconomic gradient nor an educational gradient. This is in accord with papers such as Jones (1989): education and social status reduce the probability of an individual becoming a smoker; however, for those who are already smokers, tobacco is a normal good.

The third equation in Table 6 is an ordered probit with degrees of avoidance of fried food as the dependent variable. The results suggest that males are less likely to avoid fried food than females. Those hit by financial hardship at age 16 are approximately 6.3 percentage points less likely to be in the highest category of fried food avoidance. Education matters once more: individuals reporting at least O-levels bear a positive and statistically significant association with the avoidance of fried food. Of special interest, however, is the positive and statistically significant effect of obesity at age 16; this corresponds to an estimated partial effect of approximately 7 percentage points. This is once again in line with the rationale of risk offsetting in face of perceived frailty, and confirms that the harmful impact of child obesity on adult health is largely a direct one that needs to be tackled early in life.

Given the substantial influence of education on other effort variables and on health, a final note concerns the estimates of the impact of circumstances on the probability of attaining each educational level. The last three columns of Table 6 give probit estimates for three levels of education: academic degree or equivalent, A-levels or higher and O-levels or higher.

Women are more likely to report having at least O-levels; however, men are more likely to attain a university degree. Ill health in childhood and obesity at age 16, bear a negative but statistically insignificant association with the educational outcomes. These are largely sensitive to the social position of the parents: parental education has a positive and statistically significant impact on all levels of educational attainment and bad finances at age 16 accounts for a statistically significant reduction of roughly 4.6 percentage points of the probability of reporting O-levels or a higher qualification. This suggests that equality of opportunity in education may a key factor to reduce inequality of opportunity in health, highlighting the potential for complementary policies between the educational and health care sectors.

2.6 Conclusions

This paper proposes two approaches to measuring inequality of opportunity in heath and finds evidence of such inequality among NCDS cohort members. The results suggest that at least 21% of the health inequalities observed in adulthood are due to inequality of opportunity.

Econometric models are used to identify the most influential circumstances beyond individual control and to quantify their impact. Accounting for a comprehensive set of controls, parental socioeconomic status is a crucial explanatory factor of self assessed health in adulthood. The education of the mother (but not of the father) is also crucial, but mostly for women. Spells of financial difficulties during childhood and adolescence are particularly detrimental to men: alone, these are associated to a 13.4 percentage points reduction in the probability of reporting excellent health at age 46. In terms of health endowments, ill health during childhood is negatively associated with SAH at age 46, affecting both men and women. Obesity in childhood and adolescence is negatively associated with health at age 46, and is mainly detrimental to women.

Once effort factors, such as lifestyles and educational attainment, are added to the model, most of the circumstances remain statistically significant, although their marginal effects are reduced. This suggests that, although part of their effect is channelled through effort, an important part of it is a direct one.

Separate equations are estimated for each of the effort factors, to illuminate the indirect pathways of the effect of circumstances through effort. The results show that the influence of circumstances on effort factors can be paramount, as for example in the cases of cigarette smoking and educational attainment. They also suggest that inequality of opportunity in the educational sector may exacerbate health inequalities via the influence that education exerts on lifestyles.

Policy implications are inferred. Some unjust circumstances are only amenable to policy during childhood. Moreover, given that parental characteristics are among the most influential circumstances, policy interventions aimed at young adults, and namely at young parents, may be crucial to prevent inequality of opportunity from carrying over from one generation to the next. Finally, since the influence of circumstances on health is often channelled through effort, key complementary policies to reduce health inequalities may need to be implemented outside the health care system and, in particular, in the educational sector.

Appendix A

Table 1: Summary statistics

	Full sample			
Variable	Mean	Std. Dev.	Min	Max
Self-assessed health, age 46	3.987719	0.9302554	1	5
Male	0.5171652	0.4997187	0	1
Parental socioeconomic status at birth: high	0.2727015	0.4453612	0	1
Parental socioeconomic status at birth: middle	0.49983	0.5000141	0	1
Paternal grandfather's socioeconomic status	1.975576	0.7470104	1	3
Maternal grandfather's socioeconomic status	2.04248	0.7366398	1	3
Years of education: father	9.904075	1.621967	7	16
Years of education: mother	9.916638	1.376012	7	16
Indicator: mother smoker, age 16	0.7865378	1.010508	0	4
Indicator: father smoker, age 16	1.119048	1.136957	0	4
Indicator: maternal smoking after 4th month of pregnancy	0.3364165	0.472497	0	1
Indicator: breastfead	0.6421394	0.4793864	0	1
Birthweight	128.3177	72.43585	11	509
Physical / mental impairments, age 16	2.236591	1.541278	0	10
Indicator: financial hardship, age 11	0.0714425	0.2575708	0	1
Indicator: financial hardship, age 16	0.0789546	0.269677	0	1
Indicator: diabetes in parents, brothers or sisters	0.0212642	0.1442684	0	1
Indicator: epilepsy in parents, brothers or sisters	0.073906	0.2616263	0	1
Indicator: other hereditary chronic condition	0.025154	0.1565977	0	1
Indicator: chronic conditions in cohort member's mother, age 16	0.0477003	0.2131386	0	1
Indicator: obesity, age 16	0.0324388	0.1771673	0	1
Indicator: university degree or equivalent	0.2313824	0.4217384	0	1
Indicator: A-levels or higher qualification	0.3206419	0.4667478	0	1
Indicator: O-levels, or higher qualification	0.8212712	0.3831451	0	1
Mathematics test score, age 11 (scores range from 0 to 40)	15.23885	11.01308	0	40
Indicator : smoker, age 33	0.3197992	0.4664195	0	1
Number of cigarettes per day	5.543246	9.519264	0	70
Arguments with parents about risks of smoking	0.0913892	0.2881695	0	1
Avoidance of fried food in diet: weekly frequency (1 to 6), age 33	4.538137	0.9861445	1	6
Weekly consumption of vegetables, age 33	0.6580174	0.638489	0	2
Weekly alcohol consumption, age 33	2.453389	1.619937	0	4
Sweets consumption: weekly frequency, age33	4.152178	1.667634	1	9
Socioeconomic status: high (age 33)	0.5977131	0.4903824	0	1
Socioeconomic status: middle (age 33)	0.2081837	0.4060281	0	1

Table 2: Tests for stochastic dominance between types

Null hypothesis	Corrected P value
Null: Type 1 FSD type 2	0.999
Null: Type 1 FSD type 3	0.999
Null: Type 2 FSD type 3	0.959

Figure 1: SAH (age 46) by parental socioeconomic group

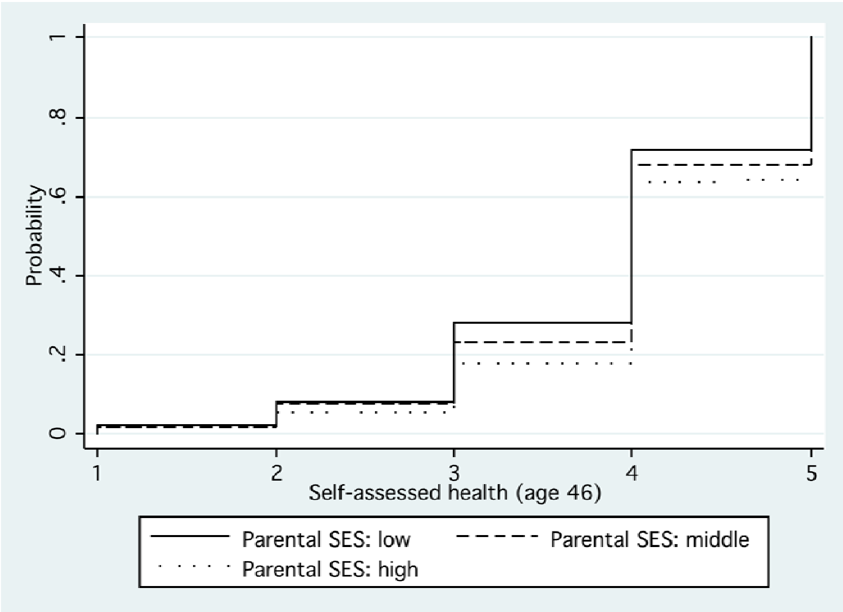

Table 3: Measures of inequality of opportunity				
NCDS wave	**Gini-opportunity index**	$G\left(\hat{h}_i\right)$	**Health Pseudo-Gini:** $G(h_i)$	**Ratio:** $\frac{G\left(\hat{h}_i\right)}{G(h_i)}$
Wave 4: 1981 (age 23)	0.0088496 (0.0017707)	0.02205	0.10257	0.21497
Wave 5: 1991 (age 33)	0.0165535 (0.0015658)	0.02976	0.11304	0.26326
Wave 6: 1999/2000 (age 42)	0.018381 (0.0018364)	0.03257	0.12765	0.25515
Wave 7: 2004 (age 46)	0.0178522 (0.0026443)	0.0338	0.15405	0.2194

Note: Bootstrapped standard errors in parentheses, with independent re-sampling within each of the three types.

Table 4: Adult health and circumstances*. Ordered probit estimates

Dependent variable:	**Full sample**		**Women**		**Men**	
Self-assessed health (age 46)	Coefficient	Marginal Eff.†	Coefficient	Marginal Eff.†	Coefficient	Marginal Eff.†
Parental SES at birth: High	0.202***	0.0574	0.239***	0.0401	0.163*	0.0616
	(0.0615)		(0.0855)		(0.0897)	
Parental SES at birth: Middle	0.142***	0.0414	0.185***	0.0330	0.104	0.0394
	(0.0459)		(0.0633)		(0.0676)	
Paternal grandfather SES	-0.0287	-0.00836	-0.0374	-0.00665	-0.0137	-0.00520
	(0.0293)		(0.0409)		(0.0424)	
Maternal grandfather SES	-0.0171	-0.00498	0.00123	0.000220	-0.0392	-0.0149
	(0.0247)		(0.0345)		(0.0356)	
Years of education: Father	-0.0116	-0.00338	-0.00838	-0.00149	-0.0185	-0.00704
	(0.0130)		(0.0184)		(0.0186)	
Years of education: Mother	0.0282*	0.00823	0.0378*	0.00672	0.0183	0.00697
	(0.0148)		(0.0203)		(0.0218)	
Mother smoker (age 16)	-0.0491**	-0.0143	-0.0489	-0.00871	-0.0439	-0.0167
	(0.0221)		(0.0307)		(0.0321)	
Father smoker (age 16)	-0.0158	-0.00462	-0.0228	-0.00405	-0.0144	-0.00548
	(0.0158)		(0.0218)		(0.0230)	
Maternal smoking during pregnancy	0.0132	0.00384	0.0229	0.00406	-0.00707	-0.00269
	(0.0450)		(0.0622)		(0.0656)	
Breastfed	0.0541	0.0159	0.0845	0.0154	0.0181	0.00688
	(0.0371)		(0.0523)		(0.0529)	
Birthweight	0.000377	0.000110	0.000987**	0.000176	-0.000115	-4.37e-05
	(0.000258)		(0.000400)		(0.000342)	
Mathematics test score: age 11	0.00455***	0.00133	0.00475**	0.000846	0.00468**	0.00178
	(0.00164)		(0.00237)		(0.00231)	
Physical / mental impairments (age 16)	-0.0760***	-0.0222	-0.0846***	-0.0151	-0.0647***	-0.0246
	(0.0109)		(0.0150)		(0.0162)	
Financial hardship (age 11)	-0.0653	-0.0195	-0.216**	-0.0431	0.134	0.0502
	(0.0802)		(0.110)		(0.119)	
Financial hardship (age 16)	-0.201**	-0.0627	-0.0825	-0.0153	-0.346***	-0.134
	(0.0791)		(0.113)		(0.112)	
Diabetes in parents or siblings	-0.0680	-0.0203	0.160	0.0260	-0.353**	-0.137
	(0.110)		(0.149)		(0.164)	
Epilepsy in parents or siblings	-0.0856	-0.0256	0.00330	0.000587	-0.178*	-0.0685
	(0.0640)				(0.0910)	
Other hereditary chronic condition	-0.0685	-0.0205	-0.0483	-0.00884	-0.0566	-0.0216
	(0.107)		(0.152)		(0.152)	
Chronic condition: Mother (age 16)	-0.0880	-0.0264	-0.114	-0.0215	-0.0619	-0.0237
	(0.0801)		(0.113)		(0.115)	
Obesity (age 16)	-0.268***	-0.0848	-0.341***	-0.0724	-0.173	-0.0668
	(0.0788)		(0.108)		(0.116)	
Number of observations	4408		2220		2188	

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Coefficients and marginal effects for regional variables are suppressed here (due to statistical insignifiance) but available upon request.

*The same circumstances used to compute $G(\hat{h}_i)$ in Table 3.

† Marginal effects for the probability of reporting excellent health .

Table 5: Adult health, circumstances and effort
Ordered probit estimates

Dep. Variable:	**Full sample**		**Women**		**Men**	
SAH (age 46)	Coefficient	Marginal Eff.*	Coefficient	Marginal Eff.*	Coefficient	Marginal Eff.*
Circumstance variables						
Parental SES at birth: High	0.222***	0.0274	0.315***	0.00922	0.126	0.0336
	(0.0696)		(0.0957)		(0.103)	
Parental SES at birth: Middle	0.104**	0.0137	0.150**	0.00518	0.0571	0.0154
	(0.0523)		(0.0711)		(0.0780)	
Paternal grandfather SES	0.0178	0.00233	0.0282	0.000958	0.0220	0.00595
	(0.0333)		(0.0458)		(0.0491)	
Maternal grandfather SES	-0.0123	-0.00161	0.0106	0.000359	-0.0463	-0.0125
	(0.0278)		(0.0383)		(0.0411)	
Years of education: Father	-0.00986	-0.00129	-0.0214	-0.000727	0.000520	0.000140
	(0.0144)		(0.0203)		(0.0207)	
Years of education: Mother	0.0254	0.00332	0.0438*	0.00149	0.00861	0.00233
	(0.0166)		(0.0229)		(0.0245)	
Mother smoker (age 16)	-0.0432*	-0.00567	-0.0605*	-0.00206	-0.0183	-0.00493
	(0.0253)		(0.0346)		(0.0379)	
Father smoker (age 16)	-0.00738	-0.000967	-0.0250	-0.000847	0.00699	0.00189
	(0.0179)		(0.0246)		(0.0265)	
Maternal smoking during pregnancy	0.0355	0.00461	0.0808	0.00268	-0.0379	-0.0103
	(0.0512)		(0.0700)		(0.0765)	
Breastfed	0.0630	0.00841	0.0833	0.00291	0.0542	0.0148
	(0.0420)		(0.0585)		(0.0611)	
Birthweight	0.000645**	8.45e-05	0.000773*	2.62e-05	0.000430	0.000116
	(0.000308)		(0.000450)		(0.000428)	
Physical / mental impairments (age 16)	-0.0733***	-0.00962	-0.0660***	-0.00224	-0.0827***	-0.0223
	(0.0123)		(0.0169)		(0.0185)	
Financial hardship (age 11)	-0.0350	-0.00469	-0.185	-0.00742	0.185	0.0465
	(0.0923)		(0.124)		(0.140)	
Financial hardship (age 16)	-0.156*	-0.0225	-0.0624	-0.00224	-0.292**	-0.0870
	(0.0911)		(0.129)		(0.131)	
Diabetes in parents or siblings	-0.0832	-0.0115	0.108	0.00330	-0.341*	-0.103
	(0.123)		(0.166)		(0.187)	
Epilepsy in parents or siblings	-0.0651	-0.00886	-0.0436	-0.00154	-0.105	-0.0293
	(0.0741)		(0.103)		(0.109)	
Other hereditary chronic condition	-0.103	-0.0144	-0.0377	-0.00133	-0.142	-0.0402
	(0.122)		(0.170)		(0.179)	
Chronic condition: Mother (age 16)	-0.130	-0.0185	-0.135	-0.00516	-0.142	-0.0402
	(0.0942)		(0.129)		(0.141)	
Mathematics test score: age 11	0.000855	0.000112	0.000727	2.46e-05	0.00133	0.000359
	(0.00203)		(0.00283)		(0.00295)	
Obesity (age 16)	-0.268***	-0.0414	-0.393***	-0.0190	-0.119	-0.0336
	(0.0877)		(0.119)		(0.132)	
Effort variables						
University degree or equivalent	-0.0619	-0.00832	-0.0361	-0.00126	-0.126	-0.0347
	(0.0700)		(0.0948)		(0.105)	
A-levels or higher qualification	0.104*	0.0132	0.0421	0.00140	0.192*	0.0508
	(0.1102)		(0.0892)		(0.103)	
O-levels or higher qualification	0.0452	0.00606	0.141	0.00530	-0.0249	-0.00667
	(0.0631)		(0.0924)		(0.0876)	
Indicator(smoker)*Log(cigarettes/day)[T]	-0.124***	-0.0163	-0.104***	-0.00352	-0.145***	-0.0392
	(0.0159)		(0.0224)		(0.0231)	
Fried food avoidance: frequency[T]	0.0549***	0.00720	0.0782**	0.00266	0.0425	0.0115
	(0.0206)		(0.0311)		(0.0291)	
Weekly vegetables consumption[T]	-0.0224	-0.00293	-0.0476	-0.00162	0.0340	0.00917
	(0.0302)		(0.0411)		(0.0463)	
Weekly alcohol consumption[T]	0.00296	0.000388	0.00127	4.30e-05	-0.00881	-0.00238
	(0.0145)		(0.0239)		(0.0200)	
Sweets consumption: frequency[T]	0.00347	0.000455	0.00118	4.00e-05	0.00480	0.00130
	(0.0117)		(0.0161)		(0.0172)	
Own socioeconomic status: High[T]	0.111**	0.0149	0.110	0.00385	0.0964	0.0262
	(0.0550)		(0.0685)		(0.0945)	
Own socioeconomic status: Middle[T]	0.128**	0.0159	0.0984	0.00307	0.115	0.0305
	(0.0633)		(0.112)		(0.0919)	
Number of observations	3535		1833		1702	

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Coefficients and marginal effects for regional variables are suppressed here (due to statistical insignifiance) but available upon request.
*Marginal effects for the probability of reporting excellent health .
[T] denotes 'at age 33'.

Table 6: The impact of circumstances on effort

	Dep. Variable Indicator: Smoker (Probit estimates)		Dep. Variable Cigarettes / day (OLS estimates)		Dep. Variable Fried food (Ordered probit estimates)		Dep. Variable University degree[‡] (Probit estimates)		Dep. Variable A-levels or higher (Probit estimates)		Dep. Variable O-levels or higher (Probit estimates)	
	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.
Male	-0.0326	-0.0101	0.0655	0.0655	-0.573***	-0.222	0.0859*	0.0214	0.0399	0.0107	-0.179***	-0.0283
	(0.0492)		(0.0475)		(0.0381)		(0.0517)		(0.0505)		(0.0660)	
Parental SES at birth: High	-0.0878	-0.0269	-0.0324	-0.0324	-0.0459	-0.0171	0.0507	0.0127	0.0965	0.0262	-0.0366	-0.00581
	(0.0852)		(0.0792)		(0.0665)		(0.0976)		(0.0931)		(0.111)	
Parental SES at birth: Middle	-0.0384	-0.0119	-0.0521	-0.0521	-0.0320	-0.0120	0.0152	0.00377	0.0633	0.0169	0.0473	0.00747
	(0.0637)		(0.0581)		(0.0504)		(0.0780)		(0.0735)		(0.0772)	
Paternal grandfather SES	-0.0278	-0.00858	0.0696*	0.0696	-0.0523*	-0.0196	-0.0887*	-0.0220	-0.119***	-0.0317	-0.0936*	-0.0148
	(0.0411)		(0.0395)		(0.0317)		(0.0457)		(0.0435)		(0.0536)	
Maternal grandfather SES	0.0276	0.00853	0.0131	0.0131	-0.0217	-0.00811	0.000487	0.000121	-0.0121	-0.00323	0.0136	0.00214
	(0.0344)		(0.0331)		(0.0263)		(0.0374)		(0.0361)		(0.0451)	
Years of education: Father	0.0323*	0.00999	-0.0107	-0.0107	-0.00219	-0.000818	0.0435**	0.0108	0.0487***	0.0130	0.0195	0.00308
	(0.0180)		(0.0167)		(0.0137)		(0.0176)		(0.0181)		(0.0294)	
Years of education: Mother	0.0597***	0.0184	-0.0164	-0.0164	-0.0375**	-0.0140	0.131***	0.0326	0.164***	0.0438	0.101***	0.0159
	(0.0206)		(0.0195)		(0.0157)		(0.0201)		(0.0209)		(0.0343)	
Mother smoker (age 16)	0.0791***	0.0244	0.0372	0.0372	-0.0222	-0.00832	0.00256	0.000636	-0.0414	-0.0111	-0.0782**	-0.0123
	(0.0303)		(0.0268)		(0.0241)		(0.0350)		(0.0339)		(0.0382)	
Father smoker (age 16)	0.120***	0.0369	0.0571***	0.0571	-0.00447	-0.00167	-0.0493**	-0.0122	-0.0633***	-0.0169	-0.0920***	-0.0145
	(0.0216)		(0.0198)		(0.0170)		(0.0247)		(0.0236)		(0.0276)	
Maternal smoking during pregnancy	-0.0586	-0.0179	0.0810	0.0810	0.0491	0.0183	0.00978	0.00244	-0.0253	-0.00677	-0.00255	-0.000402
	(0.0622)		(0.0569)		(0.0486)		(0.0705)		(0.0683)		(0.0793)	
Breastfed	0.00416	0.00128	-0.00747	-0.00747	-0.000747	-0.000279	0.0391	0.00969	-0.0266	-0.00712	0.0260	0.00412
	(0.0517)		(0.0488)		(0.0398)		(0.0576)		(0.0553)		(0.0664)	
Birthweight	-0.000152	-4.70e-05	0.000313	0.000313	0.000367	0.000137	-0.000178	-4.43e-05	0.000250	6.70e-05	0.00117*	0.000184
	(0.000367)		(0.000362)		(0.000280)		(0.000405)		(0.000389)		(0.000545)	
Physical/mental impairments (age 16)	0.00579	0.00179	0.00740	0.00740	0.00202	0.000756	-0.0114	-0.00283	-0.00889	-0.00238	0.00696	0.00110
	(0.0152)		(0.0143)		(0.0117)		(0.0167)		(0.0162)		(0.0200)	
Financial hardship (age 11)	0.280***	0.0925	0.0913	0.0913	-0.171**	-0.0637	-0.0267	-0.00660	-0.0734	-0.0195	-0.262**	-0.0461
	(0.106)		(0.0855)		(0.0868)		(0.150)		(0.141)		(0.120)	
Financial hardship (age 16)	0.100	0.0318	-0.141	-0.141	0.0286	0.0107	-0.173	-0.0411	-0.112	-0.0295	-0.350***	-0.0638
	(0.110)		(0.0905)		(0.0888)		(0.162)		(0.148)		(0.119)	
Diabetes in parents or siblings	0.0747	0.0235	0.0929	0.0929	-0.00731	-0.00273	0.116	0.0297	0.0756	0.0204	-0.0461	-0.00741
	(0.155)		(0.143)		(0.121)		(0.170)		(0.168)		(0.201)	
Epilepsy in parents or siblings	0.00600	0.00186	-0.0762	-0.0762	-0.0103	-0.00386	-0.0412	-0.0102	0.120	0.0327	0.243	0.0345
	(0.0905)		(0.0838)		(0.0703)		(0.105)		(0.0980)		(0.122)	
Other hereditary chronic condition	-0.358**	-0.0989	0.0540	0.0540	-0.0429	-0.0160	-0.224	-0.0524	-0.264	-0.0680	-0.0146	-0.00231
	(0.163)		(0.169)		(0.117)		(0.188)		(0.179)		(0.189)	
Chronic condition: Mother (age 16)	-0.0866	-0.0261	-0.0388	-0.0388	-0.0584	-0.0218	0.105	0.0267	0.126	0.0341	-0.0403	-0.00646
	(0.119)		(0.113)		(0.0903)		(0.129)		(0.126)		(0.146)	
Obesity (age 16)	-0.120	-0.0360	0.0525	0.0525	0.188**	0.0697	-0.157	-0.0374	-0.0570	-0.0151	0.00271	0.000427
	(0.110)		(0.108)		(0.0851)		(0.130)		(0.121)		(0.135)	
Mathematics test score: age 11	-0.00341	-0.00105	-0.000888	-0.000888	-0.00108	-0.000403	0.0317***	0.00789	0.0409***	0.0109	0.0358***	0.00564
	(0.00251)		(0.00247)		(0.00191)		(0.00255)		(0.00248)		(0.00339)	
University degree or equivalent	-0.189**	-0.0570	-0.151	-0.151	0.0853	0.0319	—	—	—	—	—	—
	(0.0910)		(0.0980)		(0.0659)		—	—	—	—	—	—
A-levels or higher qualification	-0.192**	-0.0586	-0.101	-0.101	0.0868	0.0325	—	—	—	—	—	—
	(0.0848)		(0.0882)		(0.0633)		—	—	—	—	—	—
O-levels or higher qualification	-0.377***	-0.127	0.0167	0.0167	0.186***	0.0698	—	—	—	—	—	—
	(0.0728)		(0.0611)		(0.0598)		—	—	—	—	—	—
Own socioeconomic status: High[†]	-0.234***	-0.0746	-0.108*	-0.108	0.107**	0.0403	0.634***	0.150	0.737***	0.201	0.648***	0.110
	(0.0656)		(0.0596)		(0.0527)		(0.0854)		(0.0781)		(0.0766)	
Own socioeconomic status: Middle[†]	-0.0302	-0.00927	-0.0214	-0.0214	-0.129**	-0.0486	-0.223*	-0.0534	-0.213**	-0.0566	0.270***	0.0398
	(0.0767)		(0.0673)		(0.0617)		(0.114)		(0.103)		(0.0873)	
Constant	-1.025***		2.674***				-3.520***		-3.629***		-0.462	
	(0.296)		(0.290)				(0.312)		(0.315)		(0.441)	
Number of observations	3660		994		3727		3738		3738		3738	

Notes: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Coefficients and marginal effects for regional variables are suppressed here (due to statistical insignificance) but available upon request.
[†] at age 33.
[‡] or equivalent.

Chapter 3

Modelling Opportunity in Health under Partial Observability of Circumstances

3.1 Introduction

Recent empirical papers, such as Trannoy et al. (2009) and Rosa Dias (2009), provide evidence of substantial and persistent inequality of opportunity in health in European countries. They also suggest that unjust circumstances affect health through a network of indirect effects whose causal nexus is often ambiguous. This has lead authors such as Fleurbaey and Schokkaert (2009) to propose that such complex interactions be clarified through the specification of a structural model of unfair inequalities; this paper follows this line of research.

This paper is grounded on the framework of Roemer (1998, 2002), which draws a distinction between *circumstance* and *effort* variables: the outcome of interest is health as an adult; *circumstances* (beyond individual control) are proxied by parental socioeconomic status and childhood health, while *effort* is proxied by factors that are at least partly within individual control, such as health-related lifestyles and educational attainment. This framework is then embedded in a structural model, along the lines of Fleurbaey and Schokkaert (2009). Since the outcome of interest in this paper is health, the model is a normative interpretation of Grossman's (1972) model of health capital and demand for health; this closes the gap between the literature on the production of health and the normative literature on health inequalities[22].

This structural model generates the demand for health and for each of the effort factors. These define a recursive system of equations that is estimated jointly by full information maximum likelihood (FIML), allowing the system error terms to be freely correlated so as to account for unobserved common factors, such as unobserved or unmeasured circumstances, that impact simultaneously on health and effort factors. The purpose of this approach is twofold. First, it sheds light on

[22] Other applications of the Grossman model to the analysis of health inequalities can be found in Dardanoni and Wagstaff (1987) and Contoyannis and Forster (1999).

the relationship between circumstances, effort and health. Second, it addresses the problem posed by the partial observability of the relevant set of circumstances, referred to in the literature as the *partial-circumstance problem*. The model is estimated using data from the National Child Development Study (NCDS) which follows the cohort of individuals born in the week of 3rd March 1958 up to age 46.

3.2 Equality of opportunity: the Roemer model in the context of health

The Roemer model (1998, 2002) partitions all factors influencing individual attainment into a category of *effort factors*, for which individuals should be held partly responsible and a category of *circumstance factors*, which, being beyond individual control, are the only source of illegitimate differences in outcomes. In this paper the outcome of interest is health as an adult (*H*), which results from a health production function, $H\left(C, E(C), \mu_H\right)$, where *C* denotes individual circumstances, *E* denotes effort, and in which it is explicitly recognised that effort can be shaped by circumstances. μ_H reflects unobserved factors affecting the health production.

The specification of the causal factors that constitute circumstances in a health context follows the vast published literature on the impact of childhood circumstances on health outcomes in adulthood: for example, Kuh and Wadsworth (1993), Barker (1995), Marmot et al. (2001), Case et al. (2005) and Lindeboom et al. (2006) are key references. Following this strand of research, this paper treats as circumstances parental socioeconomic characteristics, spells of financial hardship during the cohort members' childhood and adolescence, proxies of congenital endowment such as the prevalence of chronic conditions in the family, and the incidence of acute and chronic illnesses and obesity in childhood and early adolescence. All these factors affect people before the age of 16, reflecting conditions and behaviours that are largely beyond individual control. Since cognitive ability, social development in childhood and educational attainment are likely to be decisively influenced by parental and environmental factors, they are also considered a circumstance in terms of its influence on health in adulthood.

The choice of the effort factors is also guided by the literature, namely by work done on the relationship between health and lifestyles, such as Mullahy and Portney (1990), Kenkel (1995), Contoyannis and Jones (2004) and Balia and Jones (2008). This paper treats as effort a set of lifestyles, such as cigarette smoking, alcohol consumption and dietary choices that are, at least partly, within individual control.

The Roemer model defines social types consisting of individuals who share exposure to the same circumstances. The set of observed individual circumstances allows the specification of these social types in the data. A fundamental aspect in this setting, is the fact that the distribution of effort within each type (F^t) is itself a characteristic of that type; since this is beyond individual control, it constitutes a circumstance.

In order for the degree of effort expended by individuals of different types to be comparable, Roemer proposes the definition of quantiles of the effort distribution (in this case, for example the number of cigarettes per day or number of units of alcohol consumed per week) within each type: two individuals are deemed to have exerted the same degree of effort if they sit at the same π^{th} quantile of their type's distribution of effort. When effort is observed, this definition is directly applicable. However, if effort is unobservable, an additional assumption is required: by assuming that the average outcome, health in this case, is monotonically increasing in effort, i.e. that healthy lifestyles are a positive contribution to the health stock, effort becomes the residual determinant of health once types are fixed; therefore, those who sit at the π^{th} quantile of the outcome distribution also sit, on average, at the π^{th} quantile of the distribution of effort within their type.

The definition of equality of opportunity used in the paper also follows from the Roemer model: equality of opportunity in health attains when average health outcomes are identical across types, at fixed levels of effort. This means that, on average, all those who adopt identical lifestyles should be entitled to experience a similar health status, irrespective of their circumstances. Such a situation corresponds to a full nullification of the effect of circumstances, keeping untouched the differences in health outcomes that are caused solely by effort.

3.3 Outline of the structural model

Economists typically assume that levels of effort are the consequence of utility maximisation subject to constraints, yet the determination of effort levels is omitted by the Roemer model. Fleurbaey and Schokkaert (2009) propose the formulation of a behavioural model to explain the interaction between legitimate and illegitimate sources of inequality and hence the channels by which circumstances affect health outcomes. The nature of the data used here also permits such a model to link the literature on childhood circumstances to the research on health and lifestyles; these have evolved in relative isolation. The structural model put forward in this paper is a normative interpretation of Grossman's (1972) seminal model, which also draws on more recent variants of this specification, such as Lechene and Adda (2001), Contoyannis and Jones (2004) and Balia and Jones (2008).

Following Grossman (1972), it is assumed that health is a fundamental commodity[23] produced by inputs that are labelled either circumstances or effort by the researcher. The production of health at date *t* is given by production function, $f\left(E_t, C_t, \mu_H\right)$, where E_t denotes observed effort expended at date *t*, C_t denotes observed circumstances at date *t* and μ_H reflects unobserved factors affecting the production of health. As in the original Grossman model, the health production function is assumed to be increasing and concave in effort.

The health stock at any date *t+1* is given by the production of health at date *t+1* and the depreciated health stock from the previous time period (*t*), where the depreciation rate (δ) is positive and smaller than unity. The law of motion of the health stock can thus be expressed by:

$$H_{t+1} = f(E_t, C_t, \mu_H) + \left(1 - \delta_t\right) H_t \qquad (1)$$

[23] Two aspects deserve clarification. First, health constitutes a *fundamental commodity* in the sense that it is an argument of the (direct) utility function; no ethical judgment is attached to this assumption. Second, the literature encompasses more refined versions of the Grossman model than the one presented here: Dardanoni and Wagstaff (1987) and Forster (2001) explore modelling health as an investment good; Carbone et al. (2005) allow for individual adaptation to an anchoring health state. Also, the original Grossman model features specific details, such as the treatment of sickness time, which are left-out of our behavioural model. All these are not essential in this analysis, hence excluded for parsimony.

Effort factors are choice variables, by definition, and their marginal product is assumed to be known to the individuals. Each individual chooses demand for a vector of effort commodities and health to maximise lifetime utility, subject to income and time constraints, as well as uncertainty regarding the time of death. This uncertainty takes the form of a known hazard rate, $\sigma_t(H_t)$, which denotes the probability of surviving from date *t* to date *t+1* and depends on the value of the health stock at date t.

In each time period, instantaneous utility $U(.)$ depends on observed effort, observed circumstances, the health state variable and, given only partially observable circumstances, on factors that are unobserved by the researcher (although arguably known to the individual), μ_U. For example, genetic propensities are circumstances that may condition effort responses aimed at offsetting the risk of illness, but which are hidden to the researcher. Instantaneous utility is discounted by a subjective discount factor, β, which lies between 0 and 1, and the probability of survival until the next period, $\sigma_t(H_t)$. Each individual's maximisation problem can thus be described by:

$$\max_{E,H} \sum_{t=0}^{\infty} \beta^t \sigma_t\left(H_t\right) U\left(E_t, H_t; C_t, \mu_t\right) \tag{2}$$

Total expenditure at time *t* on commodities belonging to the effort vector, $p_{jt}E_{jt}$, needs to be met by exogenous income (y_t) and labour income (w_tL_t), where p_{jt} denotes the price of commodity *j*, w_t denotes the hourly wage and L_t denotes labour supply. The amount of time required to consume a unit of commodity E_{jt} is denoted τ_{jt}; the total time available (*T*) net of working hours (L_t) therefore needs to equal the time required for consumption. Hence, individuals maximise (2) subject to the following within-period income and time constraints:

$$\begin{aligned} &\sum_{j=1}^{J} p_{jt}E_{jt} \leq y_t + w_tL_t \\ &\sum_{j=1}^{J} \tau_{jt}E_{jt} = T - L_t,\ j = 1,\dots,J \end{aligned} \tag{3}$$

Since $L_t = T - \sum_{j=1}^{J} \tau_{jt} E_{jt}$ the two constraints may be combined and expressed in terms of full prices and income:

$$\sum_{j=1}^{J} \left(p_{jt} + w_t \tau_{jt} \right) E_{jt} \leq y_t + w_t T \qquad (4)$$

The transition equation (1) ensures the recursive nature for this maximisation problem whose Bellman equation is[24]:

$$V\left(H_t\right) = \max_{E_t} \left\{ U_t\left(E_t, H_t\right) + \beta \mathrm{E}_t \left[V\left(H_{t+1}\right) \right] \right\} \qquad (5)$$

The solution of the individuals' optimisation problem, given by (5), consists of the demand for health (*1* x *t* vector *H*) and demands for effort factors (*j* x *t* matrix *E*), where demands are expressed as functions of observed circumstances and the vector of unobservable factors, μ, where $\mu = \left[\mu_U, \mu_H \right]$:

$$H = g_H\left(C, \mu\right)$$
$$E = g_E\left(C, \mu\right) \qquad (6)$$

Roemer's assumption that health outcomes are monotonically increasing in effort remains sensible in this behavioural framework: healthy lifestyles and education in general are believed to improve health; however, individual preferences and probabilities of survival may dictate a utility maximising behaviour that diverges from the simple intertemporal maximisation of the health stock.

This paper estimates an empirical version of the system of equations (6) to illuminate the triangular relationship between circumstances, effort and health, accounting for the effect of unobserved factors, such as unmeasured circumstances, present in the μ terms[25].

3.4 Data

The National Child Development Study (NCDS) follows a cohort of 17,000 individuals born in Great Britain during the week of 3rd March 1958, from birth up

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24 E_t denotes expected value at time *t*. It is assumed that individuals are alive at period *t*, hence the mathematical expectation E_t is taken over the uncertain future survival reflected by σ_t.

25 The μ terms in the system of equations may reflect any possible type of unobserved factors, and not exclusively unobserved circumstances.

until age 46. The cohort members' parents were interviewed for the first time in 1958 and extensive medical data on the children were collected; comprehensive information about the cohort-members' parental background, childhood health and educational achievement was compiled during the first three waves of the study. From wave four onwards, the NCDS questionnaires were addressed to the cohort members and cover a broad range of subjects encompassing employment, health and health-related behaviour, education, citizenship and values, parenting and housing[26].

Three separate health outcomes are used in the paper. The first is self-assessed health (SAH) at age 46, measured on a five-point scale: excellent, good, fair, poor and very poor health. SAH is widely used in health economics and has been shown to predict mortality and deterioration of health even after controlling for the medical assessment of health conditions; Idler and Kasl (1995) provide an extensive literature review on this issue. In the specific case of the NCDS, the use of SAH is also corroborated by its high correlation with reported disability and number of hospitalisations[27]. The second health outcome is an indicator variable for whether the individuals report to suffer from a long standing illness or disability at age 46. The third health outcome used in the paper is an index of mental illness: respondents answer a series of questions from the Cornell Medical Index Questionnaire, each targeting a particular mental ailment; the number of positive answers given at age 42 is then used as a malaise score, along the lines of Carneiro et al. (2007).

Three main categories of circumstance variables are used in the paper: parental socioeconomic background; congenital and childhood health of the cohort members; cognitive ability, social development in childhood and educational achievement. In terms of parental background, the NCDS contains rich information

[26] The issue of attrition has been considered both in research papers and in reports produced by the NCDS advisory panel. Attrition does not appear to be associated with socioeconomic status, as shown in Case et al. (2005), and has modest positive correlation with cohort members' unemployment as reported by Lindeboom et al. (2006). In this paper, a variable addition test was carried-out to investigate whether health-related attrition is a problem: ordered probit regressions were used to ascribe whether being in subsequent waves of the panel is a determinant of health status. The results show that, after controlling for a rich set of regressors, the fact that an individual is observed in subsequent waves of the NCDS is not significantly associated with their self-assessed health.

[27] See Case et al. (2005, pp. 370).

that allows tracing the social class and years of schooling of the parents and of both grandfathers of cohort members. Along the lines of Case et al. (2005) and Lindeboom et al. (2006), this information is complemented by data on the incidence of financial difficulties during cohort members' childhood.

Cohort members' childhood health is characterised by a set of morbidity measures, aggregating twelve categories of acute and chronic health conditions, constructed according to Power and Peckham (1987). Indicator variables for the occurrence of diabetes, epilepsy and chronic heart conditions in parents and siblings are also included in order to account for the incidence of hereditary conditions. Finally, obesity at age 16 and parental smoking during the cohort members' childhood and adolescence are also treated as circumstances.

Recent research has provided evidence of a long term direct effect of cognitive ability and social development in childhood on a wide range of behaviours in adulthood with potential impacts on health[28]. These factors are largely beyond individual control, hence can be regarded as circumstances. Scores of ability tests taken at age 11 are used as proxies of cognitive ability, covering three fundamental dimensions: mathematics, reading, and general ability. These test scores are highly correlated at the individual level, leading to multicolllinearity in the econometric models. To avoid this problem, the paper follows the approach of Galindo-Rueda et al. (2005), using principal components analysis of the test scores to construct a single measure of cognitive ability based on the first principal component.

To measure social development in childhood the paper uses scores of the Bristol Social Adjustment Guide (BSAG), following Carneiro et al. (2007). These are used as measures of social maladjustment at age 11: teachers are asked whether the child has problems in twelve behavioural domains such as hostility towards children and adults, anxiety, withdrawal, 'writing off' adults, unforthcomingness, depression, restlessness, acceptance by adults, inconsequential behaviour and miscellaneous psychological and nervous symptoms. One point is attributed to each positive answer; the points are then summed to obtain the BASG social maladjustment score.

[28] See Heckman et al. (2006), Carneiro et al. (2007) and references therein.

The paper also treats as circumstances the highest educational qualifications attained by the cohort members, since these are likely to be decisively influenced by parental and environmental factors[29]. Cumulative indicator variables are used to categorise the highest educational qualifications obtained: no formal qualifications; Certificates of Secondary Education (CSE), O-levels or higher qualification; A-levels or higher qualification; university degree or equivalent[30].

The effort factors considered in the paper are health-related lifestyles. These may be constrained by circumstances, but also reflect individual choices. The paper uses self -reported individual data on cigarette smoking and on the consumption of alcohol and fried food. Cigarette smoking is proxied by an indicator variable for whether the individual is a smoker at age 33. Alcohol consumption is measured by the number of units of alcohol consumed on average per week at age 33. NCDS respondents are asked about their weekly consumption of a wide range of alcoholic drinks (glasses of wine, pints of beer and so forth). These are then converted to units of alcohol using the UK National Health Service (NHS) official guidelines[31]. The consumption of fried food is measured by a categorical variable reflecting its frequency in the individuals' weekly diet at age 33. It should be noted that health outcomes are measure either at age 46 or at age 42, but effort factors are measured at age 33, so as to rule-out reverse causality due to a direct effect of the current health status on behavioural choices.

3.5 Methods

The empirical formulation of the model consists of a one-period version of the system of reduced form equations (6) in which health outcomes and each of the effort factors depend solely on circumstances and unobserved factors. Health is represented by a vector with three components (SAH; long term illness and

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[29] In Chapter 2 the alternative approach is taken: instead of being treated as a circumstance, educational attainment is treated as an effort factor. That approach, is also defendable, since it is possible to postulate that, despite the influence of circumstances, there may remain an important element of individual free choice that needs to be taken into account.

[30] CSEs and O-level (Ordinary levels) were secondary education qualifications corresponding, typically, to 11 years of education. A-levels (Advanced levels) are a qualification which corresponds to 13 years of education. Completion of A-levels is ordinarily a prerequisite for university admission.

[31] These are publicly available at: http://www.nhsdirect.nhs.uk/magazine/interactive/drinking/index.aspx .

disability; mental illness) and effort by a vector composed of three lifestyles (cigarette smoking; weekly consumption of fried food; weekly consumption of alcohol).

This system is estimated by full information maximum likelihood, allowing the system error terms to be freely correlated so as to account for unobserved common factors that impact simultaneously on health and effort factors. This method of dealing with selection on unobservables has been implemented in recent papers such Pudney and Shields (2000), Vera Hernandez (2003), Deb and Trivedi (2006), and Balia and Jones (2008), but not yet in the literature on inequality of opportunity. However, as made clear by Roemer (2004), Lefranc et al.(2009) and Fleurbaey (2008, p.240), accounting for this type of heterogeneity should be important in this context since, in practice, it is often impossible to observe the entire set of relevant circumstances likely to influence the outcome of interest. Although the theoretical bounds for the error incurred through partial observation of circumstances have not been derived, the several types of bias arising from this in the estimation and measurement of inequality of opportunity are known as the *partial-circumstance problem* and extensively discussed in Fleurbaey (2008, p.240-241).

The equations for SAH and for the consumption of fried food are estimated using ordered probit models. The models for the incidence of long standing illness and cigarette smoking are probits, and the equations for mental illness and alcohol consumption are linear regressions. Multivariate normality of the error terms is assumed and, given that the estimation of this system requires computation of multidimensional integrals, a maximum simulated likelihood procedure is implemented using the Geweke-Hajivassiliou-Keane (GHK) simulator[32]. The system is intrinsically non-linear and hence identified by the set of functional assumptions on the error term.

3.6 Results

The importance of unobserved factors, which simultaneously affect both health outcomes and lifestyles choices, can be evaluated by examining the estimates of the

[32] Practical implementation was carried out using the Stata module *cmp*. Full details on this Stata module can be found in Roodman (2009).

correlation coefficients between the error terms of the system equations that are shown in Table 1. The correlation coefficients between the errors of the SAH equation and those of the equations for the incidence of long standing illness and disability and for mental illness are negative and statistically significant; this indicates the existence of unobserved factors that exert a positive effect on SAH and which, simultaneously, reduce the incidence of long standing illness and mental health conditions. The correlation between the error terms of the equation for long standing illness and disability and of the equation for mental illness are positive and statistically significant, due to third factors that favour the occurrence of both types of health problems.

The correlation coefficients between the equation for cigarette smoking and the equations for the consumption of fried food and alcohol are positive and statistically significant. This is in line with evidence that suggests the existence of an individual (genetic or otherwise) propensity for addictive behaviours, affecting simultaneously the three detrimental lifestyles considered in the system. Furthermore, the correlation between the error terms of the equations for SAH and for each of these lifestyles is negative and statistically significant, confirming the presence of unobservables that increase the probability of reporting good health and that, at the same time, reduce the likelihood of individuals smoking, dinking alcohol and consuming fried food. Finally, there are also unobserved factors that jointly increase the incidence of mental illness and the consumption of alcoholic drinks and cigarettes. These estimated correlations corroborate fully the relevance of the partial-circumstance problem put forward in Fleurbaey (2008), highlighting the vital importance of dealing with unobserved heterogeneity in the context of inequality of opportunity. Previous work, such as Trannoy et al. (2009) and Rosa Dias (2009), do not take this into account.

The estimated marginal effects[33] for the one-period version of the system of equations (6) are shown in Table 2. The estimates for the SAH equation are in line with the previous literature that examines inequality of opportunity using self-assessed health as the only proxy for health status in adulthood. After controlling

[33] The marginal effects for the health equation are computed for the probability of reporting excellent health. The marginal effects for the equation for the consumption of fried food correspond to the probability of reporting to “eat fried food every day, more than once per day”.

for social class in adulthood, the cohort-members whose father was in the top occupational category in 1958 are 6.2 percentage points more likely to report excellent health at age 46 than those whose father was in the bottom social class. This partial effect is 4.3 percentage points for those whose father was in the middle social class. The incidence of childhood morbidities and the prevalence of chronic illnesses such as epilepsy in the family have a large negative effect on SAH in adulthood, in line with evidence provided by Case et al. (2005). Also in line with the previous literature, obesity in adolescence is responsible for a 6 percentage points reduction in the probability of reporting excellent health at age 46.

Educational qualifications are also positively associated to the probability of reporting excellent health in adulthood. Conversely, there is a negative and statistically significant effect of social maladjustment at age 11 on SAH at age 46, after controlling for cognitive ability and for the highest academic qualifications attained. Although this circumstance factor has received little attention in the literature on inequality of opportunity, this result is in line with evidence provided by Heckman et al. (2006) on the large impact of non-cognitive skills and social development in childhood on a wide range of outcomes and behaviours in adulthood.

The general pattern of how circumstances influence health outcomes changes considerably once alternative components of the health vector are considered. Contrary to the results obtained for SAH, parental social class, education and household finances do not have a statistically significant effect on the incidence of long standing illness and disability at age 46. This is mainly determined by gender, with males being 5 percentage points more likely to be affected by these conditions, childhood health and by a strong hereditary component: individuals in whose close relatives suffer from epilepsy are 7 percentage points more likely to have developed a chronic illness at age 46; this difference is of roughly 12 percentage points for cohort-members whose close relatives suffer from chronic heart disease. Social maladjustment at age 11 is also positive and statistically significantly associated with the development of chronic illness in adulthood. Finally, the NCDS cohort members who are in the top social class in adulthood are approximately 5 percentage points less likely to suffer from a long standing illness at age 46 than those in the bottom social class.

The estimates for the occurrence of mental illness at age 46 also follow a different pattern of influence to SAH, with parental social class found not to be statistically significant. At age 46, the male cohort-members are less likely to report mental health problems than females. The incidence of these has a positive and statistically significant association with poor childhood health and with the prevalence of chronic conditions in close relatives. Social maladjustment in childhood has a statistically significant positive impact on mental illness in adulthood. Educational attainment has a protective effect: the completion of O-levels or of a higher qualification has a strong and statistically significant negative association with the occurrence of mental health conditions at age 46.

These results show that while the three elements of the health vector are strongly affected by unfair circumstances, each of them responds to a different subset of circumstance factors. In particular, parental socioeconomic status and parental education have a decisive effect on SAH at age 46 but no statistically significant association with the remaining health outcomes.

The remaining three equations of the system concern effort factors. The first of these is a probit model for the probability of an individual being a smoker at age 33. This has a statistically significant association with parental smoking, but not with parental socioeconomic status. Social maladjustment in childhood and differences in educational achievement play a key role in explaining differences in the probability of smoking in adulthood: cohort-members who obtained O-levels or a higher qualification are 9.3 percentage points less likely to smoke at age 46 than those without formal qualifications, after controlling for a wide set of childhood circumstances, ability and social class in adulthood. This corroborates results from the previous literature suggesting that complementary policies in the education sector may be crucial for reducing inequality of opportunity in health. There is also a clear socioeconomic gradient in the probability of smoking: those in the top social class in adulthood are roughly 6 percentage points less likely to be smokers than the cohort members in the bottom social class.

The fifth equation in the system is an ordered probit for the weekly frequency of the consumption of fried food. The estimated marginal effects show gender differences: male cohort members are around 4 percentage points more likely to consume fried food every day than females. Similar to the case of cigarette smoking, there is no statistically significant association between parental social class and the consumption of fried food. Obesity at age 16 has a negative and statistically significant effect on the consumption of fried food: on average, individuals who were obese in adolescence are 1.2 percentage points less likely to consume fried food every day than those who were not. This is in line with the rationale of individual offsetting of health risks in the face of perceived frailty. It also confirms that the harmful impact of childhood obesity on adult health is mainly a direct one, which does not operate solely through dietary choices in adulthood; this favours tacking childhood obesity as a policy objective in its own right.

Educational achievement is also found to have a negative impact on the consumption of fried food: individuals who attained O-levels or a higher qualification are approximately 1.5 percentage points less likely to eat fried food on a daily basis than the cohort members without formal qualifications. In addition, the results provide evidence of a negative association between this lifestyle and high socioeconomic status in adulthood: the cohort members in the top social class at age 42 are nearly 1 percentage point less likely than those in the bottom social class to consume fried food daily.

Finally, the estimates for the weekly consumption of alcohol at age 33 show that gender differences are decisive with respect to this lifestyle: males are associated with a much higher consumption of alcohol than females. The estimates show neither an association between parental social class at birth and the consumption of alcohol in adulthood, nor a clear gradient defined in terms of the individuals' educational qualifications and social class in adulthood. The results also do not provide evidence of an ability gradient: both cognitive ability and social maladjustment in childhood show a positive and statistically significant association with the consumption of alcohol at age 33.

3.7 Discussion and conclusions

This paper develops a behavioural model of inequality of opportunity in health in which lifestyle choices are the consequence of a utility maximising behaviour subject to constraints. This integrates John Roemer's framework of inequality of opportunity with the Grossman model of health capital and demand for health. The model generates a recursive system of equations for health and lifestyles which is jointly estimated by full information maximum likelihood with freely correlated error terms. The purpose of this approach is twofold. First, it sheds light on the triangular relationship between circumstances, effort and health. Second, it addresses the problem posed by partial observability of the relevant set of circumstances, known as the *partial-circumstance problem*.

The results indicate the presence of unobserved factors that impact simultaneously on the various health outcomes and effort factors considered in the system; this confirms the crucial importance of taking into account unobserved heterogeneity in a context of partially observed circumstances. This aspect, widely discussed in the theoretical literature, has been ignored in earlier empirical work on inequality of opportunity; it is therefore a promising avenue for further research.

Taking into account the effect of these unobserved factors, the system estimates for SAH at age 46 corroborate the key results of the existing literature on inequality of opportunity in health, which is almost exclusively focused on this health outcome. SAH in adulthood is strongly impacted by circumstances such as parental socioeconomic status and childhood health conditions, establishing the existence of inequality of opportunity. However, once alternative health outcomes are considered, such as the incidence of long standing illness, disability and mental health problems, the pattern of inequality of opportunity changes substantially, with no role for parental social class and education in the determination of these health outcomes in adulthood. While the three elements of the health vector are strongly affected by unfair circumstances, each of them responds to a different subset of circumstance factors.

Finally, the results also show that circumstances affect health outcomes both directly and indirectly, through their effect on effort. An important example relates to social development in childhood and educational qualifications, which have important implications for the lifestyle choices considered in this paper. This corroborates evidence from earlier literature, suggesting that complementary policies in the educational sector may be key to reducing health inequalities.

Appendix B

Table 1: System errors correlation matrix

System equations	Rho	Std. Dev.
SAH / Long standing illness	-0.534***	0.032
SAH / Mental illnesss	-0.267***	0.023
SAH / Smoker	-0.181***	0.034
SAH / Consumption of fried food	-0.07***	0.024
SAH / Alcohol consumption	-0.051**	0.023
Long standing illness / Mental illness	0.205***	0.026
Long standing illness / Smoker	-0.034	0.040
Long standing illness / Consumption of fried food	-0.025	0.029
Long standing illness / Alcohol consumption	-0.034	0.028
Mental illness / Smoker	0.068**	0.029
Mental illness / Consumption of fried food	0.021	0.021
Mental illness / Alcohol consumption	0.058***	0.022
Smoker / Consumption of fried food	0.177***	0.032
Smoker /Alcohol consumption	0.146***	0.031
Consumption of fried food / alcohol consumption	0.032	0.023

Table 2: System estimates (empirical version of the system of equations denoted (6) in Section 3)												
	Dep. Variable		Dep. Variable		Dep. Variable		Dep. Variable		Dep. Variable		Dep. Variable	
	SAH (Ordered probit estimates)		**Long standing illness / disability (Probit estimates)**		**Mental illness (OLS estimates)**		**Indicator: Smoker (Probit estimates)**		**Fried food (Ordered probit estimates)**		**Alcohol (OLS estimates)**	
	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.	Coefficient	Marg. Eff.
Male	0.035	0.013	0.153***	0.052	-0.678***	-0.678	-0.149	-0.03	0.646***	0.0330	16.627***	16.627
	(0.0461)		(0.055)		(0.126)		(0.062)		(0.046)		(1.544)	
Parental SES at birth: High	0.167**	0.061	-0.107	-0.036	-0.017	-0.017	-0.15	-0.038	-0.098	-0.0040	2.545	2.545
	(0.0745)		(0.089)		(0.206)		(0.101)		(0.072)		(2.045)	
Parental SES at birth: Middle	0.119*	0.043	-0.078	-0.027	0.069	0.069	-0.075	-0.019	-0.051	-0.0020	2.393	2.393
	(0.065)		(0.076)		(0.173)		(0.082)		(0.06)		(1.782)	
Years of education: Father	-0.015	-0.005	-0.012	-0.004	0.049	0.049	-0.0002	-0.005	0.006	0.0003	0.167	0.167
	(0.0171)		(0.02)		(0.05)		(0.024)		(0.018)		(0.517)	
Years of education: Mother	0.018	0.006	-0.031	-0.010	0.008	0.008	0.08**	0.021	0.052**	0.0026	-0.321	-0.321
	(0.0192)		(0.023)		(0.055)		(0.025)		(0.019)		(0.583)	
Financial hardship (age 11)	-0.121	-0.043	0.005	0.001	0.41	0.41	0.06	0.017	-0.0002	0.0000	1.466	1.466
	(0.104)		(0.131)		(0.263)		(0.138)		(0.099)		(2.707)	
Physical/mental impairments (age 1(	-0.059***	-0.021	0.060***	0.020	0.149***	0.149	-0.009	-0.002	-0.014	-0.0007	0.233	0.233
	(0.0180)		(0.021)		(0.046)		(0.024)		(0.017)		(0.5)	
Number of hospitalisations (age 11)	-0.054	-0.019	0.029	0.010	0.032	0.032	0.016	0.004	-0.001	-0.0001	-0.475	-0.475
	(0.0383)		(0.045)		(0.1)		(0.05)		(0.036)		(1.07)	
Diabetes in parents or siblings	-0.134	-0.047	-0.053	-0.018	-0.152	-0.152	-0.08	-0.022	0.018	0.0009	0.898	0.898
	(0.137)		(0.191)		(0.452)		(0.211)		(0.147)		(4.52)	
Epilepsy in parents or siblings	-0.170**	-0.060	0.196*	0.070	-0.022	-0.022	0.15	0.041	0.016	0.0008	-0.442	-0.442
	(0.086)		(0.107)		(0.243)		(0.117)		(0.085)		(2.723)	
Chronic heart disease	-0.080	-0.028	0.322*	0.119	1.009**	1.009	-0.279	-0.064	-0.01	-0.0005	-0.887	-0.887
	(0.142)		(0.174)		(0.411)		(0.262)		(0.164)		(4.5)	
Mother smoker (age 16)	-0.007**	-0.002	-0.002	-0.001	0.014	0.014	0.016***	0.004	0.00008	4.42e-06	0.023	0.023
	(0.003)		(0.003)		(0.008)		(0.004)		(0.003)		(0.092)	
Obesity (age 16)	-0.176	-0.061	0.105	0.037	-0.035	-0.035	0.228	0.065	-0.307***	-0.0120	-2.749	-2.749
	(0.111)		(0.134)		(0.299)		(0.142)		(0.106)		(3.254)	
Cognitive abiliy (age 11)	0.006	0.002	-0.009	0.000	0.03	0.03	0.018	0.004	0.01	0.0005	1.612***	1.612
	(0.020)		(0.024)		(0.054)		(0.026)		(0.019)		(0.595)	
Social development (age 11)	-0.007***	-0.002	0.008**	0.003	0.03***	0.03	0.0187***	0.004	0.001	0.0001	0.131*	0.131
	(0.002)		(0.003)		(0.007)		(0.003)		(0.002)		(0.0792)	
University degree or equivalent	-0.038	-0.014	-0.037	-0.01	-0.149	-0.149	-0.171	-0.042	-0.054	-0.0020	-2.5	-2.5
	(0.077)		(0.095)		(0.234)		(0.121)		(0.081)		(2.285)	
A-levels or higher qualification	0.108*	0.039	0.06	0.02	-0.29	-0.29	-0.251**	-0.06	-0.14**	-0.0060	-1.527	-1.52
	(0.112)		(0.085)		(0.204)		(0.1009)		(0.071)		(1.959)	
O-levels or higher qualification	0.084	0.030	0.004	0.00	-0.356**	-0.356	-0.32***	-0.093	-0.252***	-0.0154	-2.443	-2.443
	(0.079)		(0.095)		(9.193)		(0.099)		(0.071)		(2.048)	
Own socioeconomic status: High[†]	0.243***	0.088	-0.155*	-0.05	-0.133	-0.133	-0.235**	-0.061	-0.143**	-0.0070	0.087	0.087
	(0.078)		(0.091)		(0.206)		(0.102)		(0.074)		(2.178)	
Own socioeconomic status: Middle[†]	0.258***	0.094	-0.112	-0.04	-0.093	-0.093	-0.039	-0.01	0.008	0.0004	0.031	0.031
	(0.074)		(0.086)		(0.186)		(0.093)		(0.068)		(2.089)	
Constant			-0.255		2.88	2.88	-1.09***				22.729***	22.729
			(0.282)		(0.599)		(0.312)				(6.987)	
Number of observations: 2665												

*Notes: Standard errors in parentheses; *** p<0.01. ** p<0.05. * p<0.1. Coefficients and marginal effects for regional variables are suppressed here (due to statistical insignifiance) but available upon request.*
[†] at age 33.

Chapter 4

Quality of Schooling and Inequality of Opportunity in Health

4.1 Introduction

Recent empirical work, such as Trannoy et al. (2009) and Rosa Dias (2009), suggests that differences in education are a leading cause of inequality of opportunity in health. This is in line with the earlier literature on socioeconomic inequalities in health, such as Wagstaff, van Doorslaer and Watanabe (2003) and van Doorslaer and Jones (2003), and agrees with the large body of evidence emphasising the role of complementary educational policies in reducing long-run health inequalities.

The issue of complementary policies has been brought to the fore in various fields of economics, and the reciprocal association between health and education policy has attracted particular attention. First, the way childhood health constitutes a pre-requisite for the success of educational policy is well documented in empirical papers such as Mayer-Foulkes (2001), Miguel (2005), Alderman et al (2006), Contoyannis and Dooley (2010), in the official guidelines of policy makers (for example the World Food Program (2006)) and in theoretical models of child nutrition and human capital formation, such Currais et al. (2010) and De la Croix and Doepke (2003). Second, the fact that education is a vital input in the health production function has been established by papers such as Lleras-Muney (2005), Arendt (2005; 2008), Oreopoulos (2006), Silles (2009) and Van Kippersluis et al. (2009); these provide evidence of the existence of positive long term health effects of successive increases in the number of years of compulsory education in Europe and in the USA.

Cutler and Lleras-Muney (2010) recently added to this body of evidence by carrying out an empirical assessment of the most common explanations for the relationship between years of schooling and the wide disparities observed in individual health related behaviours. Nonetheless, this literature leaves important questions unanswered. One of such questions underlined in Cutler and Lleras-Muney (2008, p.22), concerns the existence of health returns to different qualities of education. This is a topical policy issue, since evidence on the existence of such returns is vital to inform the design of complementary policy interventions connecting the educational and the healthcare sectors. This paper seeks to narrow this gap. We adapt the empirical strategy put forward by Cutler and Lleras-Muney (2010) to examine the association between quality of schooling and health inequalities in adulthood. This is done by exploiting the wide variation in quality of the primary and secondary schools attended by cohort-members of the National Child Development Study (NCDS). We address three main issues:

- Whether, from a normative standpoint, there is inequality of opportunity in health by quality of education among NCDS cohort-members.
- The existence of a statistical association between quality of schooling and health and lifestyle in adulthood.
- The identification of channels that mediate this association.

The NCDS cohort-members' educational experience has some distinct features, both at primary and secondary levels. To begin, some of them attended state primary schools while others went to private primary schools; these schools were typically different in terms of available resources, peer effects, and curricula. Nonetheless, the main source of variability in the cohort members' quality of schooling relates to the very different types of secondary schools attended. This is mainly due to the fact that the cohort's secondary schooling years lie within a transition period corresponding to the major comprehensive schooling reform, implemented in England and Wales[34]. The reform was not introduced simultaneously nationwide. Some pupils were unaffected by it and attended the pre-existing, highly selective state-funded tri-partite system, which comprised grammar schools, secondary modern schools and a small and declining number of technical

[34] Data on Scotland are not used: the Scottish educational system of the 1960's and 1970's was structurally very different from the one experienced by all the other NCDS cohort-members, and comprehensive schooling was introduced earlier, preventing a legitimate comparison of types of school, educational qualifications and outcomes.

schools. The majority of the cohort was affected by the reform and attended comprehensive schools. Also, a minority of NCDS cohort went to private fee-paying schools, independent of the state schools educational systems and reforms. The distribution of the NCDS cohort members by type of secondary school is shown in Figure 1.

4.2 Quality of schooling

4.2.1 Primary education

Table 1 shows the breakdown of the type of primary education experienced by the NCDS cohort-members, by type and characteristics of the schools. The mean pupil-teacher ratios were different between state and private schools and their distributions were markedly dissimilar, as made clear in Figure 2, which contrasts state with private primary schools. The effect of these differences on educational attainment and wages was examined using NCDS data by Dearden, Ferri and Meghir (2005). However, their effect on health-related behaviours and outcomes has not been taken into account by the existing literature.

4.2.2 Secondary education: the comprehensive reform and equality of opportunity

As shown in Figure 1, nearly 40 per cent of the state schools students were not affected directly by the reform and attended the tri-partite system of state-funded education. Grammar schools were academically oriented state schools that provided teaching for the entire age range 11-18, including a sixth form for Advanced level ('A-level') studies, and prepared pupils to go on to higher education. Admission into these schools was determined by an exam taken at age 11 (the 'Eleven Plus' exam). Pupils whose examination score did not permit entry into a grammar school went to secondary modern schools, which were also state schools, but less academically oriented and covered the ages 11-16 or, in a small minority of cases, vocational schools aimed at providing training and technical apprenticeships[35].

[35] In a few cases, pupils whose grades were sufficient transferred to grammar schools or sixth form colleges to complete their A-levels.

A substantial share of the cohort members were affected by the reform, which was explicitly designed to promote equality of opportunity between children of different parental backgrounds. The reform replaced the selective educational system (both grammar and secondary modern schools) by a unified mixed ability secondary schools system ("comprehensive schools") [36]. The types of schools were substantially different in their curriculum, examinations, and academic environment and peer effects. Table 2 shows that, among the schools attended by the NCDS cohort members at age 16, 79 per cent of private schools and 68 per cent of grammar schools were single sex, while only 13 per cent of comprehensives were single sex. Streaming of classes by academic ability was common in secondary moderns and comprehensives but rare among grammar schools. Some comprehensives were former secondary moderns (18 per cent) or grammar schools (25 per cent) with rest being newly created. Furthermore, the distribution of the pupil-teacher ratio also differs considerably across these four types of schools as shown in Figure 3.

4.3 Data

The National Child Development Study (NCDS) follows a cohort of nearly 17,000 individuals, who were born in Great Britain in the week of 3rd March 1958, from birth up until age 46. Seven waves of interviews have been carried-out when cohort members were 7, 11, 16, 23, 33, 42 and 46 years old. The study compiles in-depth information on the cohort-members' childhood health and parental background. It comprehensively records cognitive ability and social development in childhood and adolescence, and, crucially for this paper, quality of schooling at primary and secondary levels together with overall educational achievement. It also includes measures of social status in adulthood, and detailed information on health-related behaviours and health outcomes in adulthood.

4.3.1 Childhood health, parental background and neighbourhood characteristics

[36] Following much controversy over the Eleven Plus, the selective system went into decline in the 1960's and 1970s, until it was abolished in England and Wales by the 1976 Education Act. The selective system has persisted in certain areas, such as Kent.

The NCDS data include extensive information on the cohort-members' early health endowments. In order to control for these we have constructed morbidity measures that aggregate twelve categories of health conditions affecting the child at ages 7 and 11 (following Power and Peckham, 1987). We have also created indicator variables for the occurrence of diabetes, epilepsy and other chronic conditions in parents and siblings in order to account for the incidence of hereditary conditions in the cohort members' family. NCDS data on the height and weight of the cohort-members also allows us to control for the long-term impact of obesity in childhood and adolescence.

In terms of parental background, the NCDS allows us to trace the social class and the years of schooling of both parents of the cohort members. Following Case et al. (2005) and Lindeboom et al. (2009), we have complemented this information with data on the incidence of household financial difficulties during the cohort member's childhood and adolescence.

The NCDS also includes rich information about the socioeconomic characteristics of the cohort-members' neighbourhood during childhood and adolescence. For the years of 1971 and 1981, NCDS survey data was linked to census data[37]; this makes it possible to use census enumeration district level data (the smallest unit for which census statistics are available with an average population of about 460) to control for geographic heterogeneity in the individual's immediate social milieu.

4.3.2 Cognitive ability, social development and educational achievement

The NCDS is rich in measures of cognitive and social development prior to secondary schooling. Scores of ability tests taken at ages 7 and 11 are available on a series of cognitive dimensions: mathematics, reading, copying designs and general ability. Since test scores are highly correlated, hence leading to multicollinearity in econometric models, we follow Galindo-Rueda et al. (2005) and use principal components analysis to construct a single measure of cognitive ability using the first

[37] This small are data are available under a special licence, which imposes restrictions on the handling and usage of the data. Details can be found at
http://www.cls.ioe.ac.uk/studies.asp?section=0001000200030015.

principal component. We use as controls both the individuals' measure of cognitive ability and their relative rank in the distribution of cognitive ability of their peers.

Social development has received growing attention as an explanatory factor for behaviour, competence and achievement in adulthood. Following Carneiro et al. (2007) the score for the Bristol Social Adjustment Guide (BSAG) is used as a measure of social development at age 11: teachers are asked whether the child has problems in twelve behavioural domains such as hostility towards children and adults, anxiety, withdrawal, 'writing off' adults, unforthcomingness, depression, restlessness, acceptance by adults, inconsequential behaviour and miscellaneous psychological and nervous symptoms. One point is attributed to each positive answer; points are then summed to obtain the BASG social maladjustment score. The distribution of both cognitive and non-cognitive ability measures is shown in Figure 4.

The NCDS also includes information on the educational attainment and qualifications awarded to cohort members: no formal qualifications; Certificates of Secondary Education (CSE), O-levels, A-levels and university degree or equivalent[38]. We further disaggregate this information on educational achievement into twelve categories, ordered according to the grades obtained and number of passes.

4.3.3 Health-related behaviours, attitudes and outcomes

The NCDS contains self-reported information on a series of health-related lifestyles: cigarettes smoked per day, average units of alcohol consumed per week[39] and dietary choices, such as the frequency of consumption of fried food, vegetables and sweets. These data are only available in the four most recent waves of the study, once respondents are aged 23 and above. We also look at other health-related

[38] CSEs and O-level (Ordinary levels) were secondary education qualifications corresponding, typically, to 11 years of education in total; CSEs were academically less demanding than O-levels. A-levels (Advanced levels) are a qualification which typically corresponds to 13 years of education. Completion of A-levels is ordinarily a prerequisite for university admission.

[39] NCDS respondents are asked about their weekly consumption of a wide range of alcoholic drinks (glasses of wine, pints of beer and so forth). These are then converted to units of alcohol using the UK National Health Service official guidelines that are available at: http://www.nhsdirect.nhs.uk/magazine/interactive/drinking/index.aspx .

behaviours among women, such as teenage pregnancy and maternal smoking during pregnancy, susceptible of being affected by qualitative aspects of education.

The effect of quality of schooling is examined for a range of health outcomes in adulthood and late adolescence. The first of these is self-assessed health (SAH), measured on a five-point scale: excellent, good, fair, poor and very poor health. SAH is widely used in health economics and has been shown to predict mortality and deterioration of health even after controlling for the medical assessment of health conditions.

A more specific measure of health in adulthood is the incidence self-reported long standing illness or disability at age 46. Information on the particular medical condition associated with it is available and classified according to the International Classification of Diseases (ICD-10).

Mental health in adulthood is taken into account as a separate outcome: NCDS respondents answer to a series of questions from the Cornell Medical Index Questionnaire, each targeting a particular mental ailment; the number of positive answers given at age 42 is then used as a malaise score along the lines of Carneiro et al. (2007).

4.3.4 Sample selection and non-response

The size of our final estimation samples was significantly affected by attrition and especially by the patterns of item non-response. However, recent papers that analyse NCDS data, such as Case et al. (2005) and Lindeboom et al. (2006), recognise the problem but do not find evidence of non-random attrition. Table 3 contrasts the full NCDS sample with the estimation sample used in our econometric analysis. On average, individuals in the estimation sample come from slightly richer and better-educated backgrounds when compared with the full sample. They score higher than the full sample in ability tests taken at age 11, but do not have systematically better childhood health.

4.4 Methods

We begin by using the stochastic dominance testable conditions defined in Chapter 2 (Section 2.2.2) to detect the presence of inequality of opportunity in health by quality of schooling among NCDS cohort-members.Then we explore the existence of a statistical association between quality of schooling and both health and lifestyle in adulthood, adopting a similar approach to that of Cutler and Lleras-Muney (2009).

4.4.1 Inequality of opportunity in health

To examine the role of quality of schooling as a source of inequality of opportunity in health we adopt the framework of Roemer (2002); this has been the workhorse in most of the applied literature on inequality of opportunity in health. Roemer (2002) sorts all factors influencing individual attainment between a category of *effort factors*, for which individuals should be held partly responsible for and a category of *circumstance factors*, which, being beyond individual control, are a source of unfair differences in outcomes. In our case, we assume that the type of secondary school in which pupils are enrolled at age 11 is largely beyond their individual control and therefore constitutes a circumstance. Since the outcome of interest is a range of health outcomes in adulthood (*H*), a generalised health production function can be defined along the lines of Roemer (2002) as $H(C, E(C))$, where C denotes individual circumstances and E denotes effort, which is itself a function of circumstances.

Roemer (2002) defines social types consisting of individuals who share exposure to the same circumstances, for example the attendance at the same type of secondary school. Roemer's definition of equality of opportunity is that, on average, all those who exert the same effort should be entitled to equivalent health status, irrespective of their circumstances. Such a situation corresponds to a full nullification of the effect of circumstances, keeping untouched the differences in outcome that are caused solely by effort.

Denoting by $F(H \mid C)$ the cumulative distribution function of the health outcome of interest conditional on circumstances, a literal translation of Roemer's notion of inequality of opportunity would mean considering that there is inequality of opportunity whenever: $\forall C \neq C', F(H \mid C) \neq F(H \mid C')$. This condition is however too stringent to be useful in empirical work. Lefranc et al. (2009) consider that the data are consistent with the hypothesis of inequality of opportunity if the social advantage provided by different circumstances can be unequivocally ranked by first degree stochastic dominance[40] (FSD), i.e. if the distributions of health conditional on different circumstances can be ordered according to:

$$\forall C \neq C', F(H \mid C) \succ_{FSD} F(H \mid C').$$

We follow this literature, carrying out stochastic dominance tests to detect inequality of opportunity in a series of health outcomes. The testable condition for inequality of opportunity is therefore:

$$\forall \text{ school type A, school type B, } F(H \mid \text{school type A}) \succ_{FSD} F(H \mid \text{school type B}).$$

4.4.2 Regression analysis

We estimate, for each outcome of interest, a model of the form:

$$\text{health outcome}_{i,age46} = \alpha + \beta_{1,i} * (\text{type and characteristics of school}) + \beta_{2,i} * (\text{childhood health}) + \\ + \beta_{3,i} * (\text{ability prior to enrolment}) + \beta_{4,i} * (\text{parental background}) + \beta_{5,i} * (\text{local area / other control variables}) + \varepsilon_i$$

By exploiting the rich set of covariates that are observed prior to enrolment we control for most of the potential confounders of the relationship between quality of schooling and health in adulthood. While potentially over-controlling, this specification establishes a conveniently stringent test for the statistical significance of the association in question.

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40 A lottery stochastically dominates another if it yields a higher *expected utility*. Several orders of stochastic dominance may therefore be defined according to the restrictions one is willing to make on the individual utility function. First order stochastic dominance (FSD) holds for the whole class of increasing utility functions (*u'>0*); this corresponds to simply comparing *cdfs* of the earnings paid by alternative lotteries. Second order stochastic dominance (SSD) applies to utility functions which are increasing and concave in income, reflecting the notion of risk aversion (*u'>0* and *u''<0*); SSD evaluates integrals of the *cdfs*. While FSD implies SSD, the converse is clearly not true. SSD cannot be defined for discrete and ordinal outcomes such as the ones used in this paper, hence all definitions and tests refer to FSD.

We then estimate a sequence of models in order to illuminate three possible mediating channels for this association: academic qualifications; lifestyles; socioeconomic status in adulthood. The models that account for all of these for each health outcome are of the form:

$$\text{health outcome}_{i,age46} = \alpha + \beta_{1,i} * (\text{type and characteristics of school}) + \beta_{2,i} * (\text{childhood health}) + \\ + \beta_{3,i} * (\text{ability}) + \beta_{4,i} * (\text{parental background}) + \beta_{5,i} * (\text{local area / other control variables}) + \\ + \beta_{6,i} * (\text{highest edu. qualification}_{age42}) + \beta_{7,i} * (\text{lifestyles}_{age33/42}) + \beta_{8,i} * (\text{social class}_{age42}) + \varepsilon_i$$

4.5 Results

4.5.1 Quality of schooling and inequality of opportunity in health

Within the framework of Roemer (2002), quality of schooling, at both primary and secondary levels, constitutes a circumstance. A general picture of its association with health is patent in Figure 5, featuring the possible pairwise comparisons between the empirical distributions of SAH at age 46 by type of secondary schooling. When we contrast the SAH profiles of individuals who attended secondary modern and grammar schools, the gap between the two empirical distributions is remarkably wide. This is striking since it is attributable to one single circumstance. Conversely, the empirical distributions of SAH for grammar and private schools are very similar; the same happens when we compare the SAH profiles for comprehensive and secondary moderns. Figure 6 features the same type of pairwise comparisons applied to the empirical distributions of the mental illness index at age 46; the gaps are slightly less pronounced, but still striking.

In order to formally assess the existence of inequality of opportunity using the formulation presented in Section 4.4.1, Kolmogorov-Smirnov tests for first degree stochastic dominance are carried-out; the statistically significant results at the 1% significance level are shown in Table 6. The results for SAH at age 46 establish four statistically significant dominance relationships: the self-assessed health of cohort-members who attended at grammar and private schools dominates the one of those who went to secondary modern and comprehensive schools. For detrimental outcomes, this pattern is reversed: secondary modern schools dominate grammar schools for cigarette smoking and incidence of chronic disease and mental illness and private schools for cigarette smoking and incidence of chronic diseases. Comprehensive schools dominate grammar schools at first order for all the detrimental outcomes and private schools for cigarette smoking only. These results establish the existence of inequality of opportunity in health and health-related outcomes, favouring the cohort members who attended at grammar and private schools relatively to their counterparts who attended comprehensive and secondary modern schools.

4.5.2 Quality of schooling, health and lifestyle: primary schools

Table 4 shows estimates of the association between primary school characteristics and a series of health-related behaviours and outcomes in adulthood. Models 1 to 5 each add an additional set of control variables to the preceeding models. Model 1 includes the rich set of pre-schooling control variables described in Section 4.2 and listed in Appendix D: parental socioeconomic status and education, childhood health and local area characteristics (census enumeration district). Model 2 controls, aditionally, for cognitive and non-cognitive ability, measured at age 7. Models 3, 4 and 5 add, respectively, three potential channels of the influence of quality of schooling on health: lifestyle in adulthood, highest academic qualifications attained and socioeconomic group at age 42. Table 4 displays partial effects on the outcomes of interest, computed by averaging across all individual marginal effects in the sample. Models for self-assessed health and for the weekly consumption of fried food are ordered probit specifications; partial effects correspond, respectively, to the probability of reporting excellent health and of consuming fried food on a daily basis at age 46. For the smoking status, incidence of chronic illness, teenage pregnancy and maternal smoking during pregnancy probit specifications are used. Finally, the models for the Cornell index of mental illness and for the number of weekly units of alcohol are linear regressions.

The results do not indicate a statistically significant association between schools being privately owned and operated, teacher-pupil ratios, and self-assessed health at age 46. However, the indicator variable for whether pupils were happy at primary school is a good predictor of health in adulthood: after controlling for parental background, cognitive ability and social development, lifestyle and academic qualifications, dissatisfaction at primary school is associated with a nearly 6 percentage points reduction on the probability of reporting excellent health at age 46[41]. In terms of prevalence of long standing illness and disability, the partial effects of private school indicators and teacher-pupil ratios remain statistically insignificant and generally small. Also, the pattern of large and statistically significant partial effects of unhappiness in primary school persists; their magnitude and precision are however attenuated once the effects of overall educational achievement and social class in adulthood are controlled for (models 4 and 5).

The results for mental illness at age 46 show a different pattern. There is a clear negative and statistically significant association between the teacher-pupil ratio and the prevalence of mental illness in adulthood. The size of the partial effects is roughly constant across models, whence lifestyle choices, educational qualifications and social status in adulthood are not the chief mediators of this relationship. Also, although imprecise, the partial effects of attendance at a private primary school are consistently positive and large in all models[42]. Once more, unhappiness at school is strongly and positively associated with the incidence of mental illness at age 46 in all the models considered. Social status in adulthood appears to be an important channel for this association given that partial effects are reduced by nearly 30 percentage points once we control for the effect of social class.

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[41] As emphasised by the large literature on the harmful impact of bad parenting on human development, this association should not be interpreted as a causal effect, since *dissatisfaction at school* is likely to also reflect the lack of family-based support for schooling and early learning.

[42] Reverse causality may be a possible explanation for this association if mentally troubled children were relatively more likely to benefit from smaller class size and to attend to private schools.

In the models for these three health outcomes, self-reported health, chronic and mental disorders, the magnitude of the estimated partial effects does not change much once lifestyle choices are controlled for, suggesting that health related behaviours do not mediate the effect of quality of primary schooling on health outcomes. This fact is corroborated by the estimates obtained for the models for cigarette smoking and consumption of alcohol and fried food. In almost all cases, the partial effects for the quality of school indicators are statistically insignificant and economically negligible.

The results also provide no evidence of an impact of quality of primary education on the occurrence of teenage pregnancies and on cigarette smoking during pregnancy. Due to the smaller size of the estimation samples for the last two outcomes of Table 4 none of the female cohort-members who attended at private primary school reported to have smoked during their pregnancies; we therefore dropped the indicator for private school from the last model of the table.

4.5.3 Quality of schooling, health and lifestyle: secondary schools

Table 5 presents the results for the relationship between quality of secondary education and the same range of outcomes and health-related attitudes considered in section 4.5.2[43]. The main variables of interest are now indicators for the four types of schools described above (comprehensive schools, secondary modern schools, grammar schools, private schools), school characteristics and resources. The reference category for the comparisons between types of school is attendance at a grammar school, which, on average, is associated with the best health outcomes.

[43] Table 5 also shows partial effects on the outcomes of interest, computed by averaging across all individual marginal effects in the sample. Models for self-assessed health and for the weekly consumption of fried food are ordered probit specifications; partial effects correspond, respectively, to the probability of reporting excellent health and of consuming fried food on a daily basis at age 46. For the smoking status, incidence of chronic illness, teenage pregnancy and maternal smoking during pregnancy probit specifications are used. Finally, the models for the Cornell index of mental illness and for the number of weekly units of alcohol are linear regressions.The set of control variables included in Models 1 to 5 is the same as in Table 4.

The estimates in the table show no evidence of a statistically significant association between types of schools and SAH at age 46: the negative association with attendance at secondary modern schools, found in Model 1, disappears after controlling for differences in cognitive ability and social development. The only school characteristic that bears a negative and statistically significant association with SAH at age 46 is the schools' student expulsion rate. This variable is commonly used as a proxy for the school's academic environment and peer effects, which potentially shapes lifestyle and preferences such as risk aversion and subjective valuation of the future. Interestingly, however, the size of its estimated partial effects is relatively constant across the five models, suggesting that its association with health is not mediated by lifestyles, academic achievement, or social status in adulthood.

The models for the incidence of chronic illness and disability show a different pattern. Attendance at comprehensive and secondary modern schools is associated with a higher incidence of chronic illness and disability than grammar schools. The size of these effects is substantial: nearly 11 per cent higher incidence in the case comprehensives and roughly 8 percentage points higher incidence in the case of secondary moderns, when the full set of controls is included in the model. This constitutes evidence of a large association between quality of schooling and health, over and above the effect of educational qualifications, ability and lifestyle.

The association between the attendance at different types of schools and the occurrence of mental illness in adulthood is also sizable and statistically significant. In line with the results obtained for primary education, the partial effect of attendance at private secondary schools is positive and large, after controlling for the entire available set of covariates. The relative constancy of these partial effects across the five models suggests once more that lifestyle quality and academic qualifications are not channels for this relationship. Indicator variables for whether these schools were single-sex schools and boarding schools are not statistically significant.

Attendance at boarding schools is a perfect predictor of the two maternity-related outcomes in Table 5: none of the cohort-members educated in such schools reported either to have been a mother during teenage years or to have ever smoked during pregnancy. After controlling for ability at age 11, the female cohort-members who attended at comprehensive and secondary modern schools are more likely to be pregnant before age 18; however, this association disappears after controlling for academic qualifications. Several qualitative characteristics of secondary schooling are also statistically significantly associated with the probability of maternal smoking during pregnancy. Expulsion rates are positively associated with this health-related behaviour, although this relationship becomes statistically insignificant when educational qualifications and social class in adulthood are used as controls in the models. There is also a statistically significant positive partial effect of the pupil-teacher ratio, which remains statistically significant in all the models.

4.6 Conclusions

We provide evidence of the existence of long-term health returns to different qualities of education, over and above the effects of measured ability, social development, years of schooling and academic qualifications. This association, postulated but not explored in earlier literature, proves to be statistically significant and economically sizable for several important health outcomes and health-related behaviours, after controlling for a rich set of controls.

We use the analytical framework proposed by Roemer (2002), to examine the role of quality of schooling as a source of inequality of opportunity in health. The results show that conditioning solely on the type of secondary school attended by the cohort-members is sufficient to formally establish first order stochastic dominance relationships between the empirical distributions of most of their health outcomes.

The effect of the different qualitative dimensions of primary and secondary education is uneven across the set of outcomes of interest. Our measures of quality of primary school education are not significantly correlated either with SAH, or with the occurrence of chronic conditions in adulthood. Conversely, the pupil-teacher ratio in primary schools is strongly and negatively associated with the incidence of mental illness at age 46. Unhappiness at school, interpreted in the paper as a broad measure of adequacy of schooling, is associated with a significant increase in the incidence of mental disorders at age 46 and with a reduction in the probability of reporting excellent health at the same age of about 6 percentage points. This association remains valid after controlling for lifestyle, overall educational achievement, but social status is a possible mediating channel, linked to a roughly 30 per cent reduction of the measured effect.

The main source of variation in quality of schooling is, in the NCDS, the attendance at very dissimilar types of secondary schools. The association between types of schools and health outcomes is also much stronger than in the case of primary education. Measures of poor quality of schooling, such as the pupil expulsion rate, are positively correlated with a deterioration of SAH in all the estimated models. Attendance at particular types of schools, such as comprehensive and secondary moderns, is associated to a much larger incidence of chronic illness than others, such as grammar schools. Individuals who went to private secondary schools are also associated to a higher prevalence of mental disorders in adulthood than those who attended at grammar schools. No evidence was found to confirm the influence of the hypothesised transmission channels of these effects, since they remain sizable and statistically significant after controlling for health endowments, parental background, ability, lifestyle, educational qualifications and social status in adulthood. One explanation for this is the impracticality of controlling directly for other potentially important transmission mechanisms of the effect of education, such as subjective discount rates, risk aversion, information processing capacity, health and health care-related knowledge[44].

[44] All these possibilities are discussed in Culer and Lleras-Muney (2009, p. 11-22).

Appendix C

Table 1: NCDS cohort-members by type of primary school

	obs	unhappy at school	Pupil-teacher ratio
State primary schools	12,309	803 (6.52%)	35.07
Private primary schools	449	22 (4.9%)	21.9

Table 2: Secondary school characteristics

	Grammar	Sec Modern	Comprehensive	Private
% single sex	68.2	25.7	13.1	78.7
% with ability streams	16.6	42.8	40.6	23.7
% former grammar			24.7	
% former sec modern			18.3	
Observations	1314	2710	6134	706

Table 3: Estimation sample vs full sample

	Full sample					Estimation sample			
VARIABLES	Obs	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Self-assessed health (age 46)	5575	3.967	0.954	1.000	5.000	4.088	0.852	1.000	5.000
Northwest	12846	0.136	0.342	0.000	1.000	0.118	0.323	0.000	1.000
E. W. Riding	12846	0.083	0.276	0.000	1.000	0.089	0.284	0.000	1.000
Northmidlands	12846	0.075	0.264	0.000	1.000	0.092	0.290	0.000	1.000
Midlands	12846	0.098	0.297	0.000	1.000	0.102	0.302	0.000	1.000
East	12846	0.071	0.257	0.000	1.000	0.105	0.307	0.000	1.000
Southeast	12846	0.199	0.399	0.000	1.000	0.176	0.381	0.000	1.000
Southwest	12846	0.054	0.226	0.000	1.000	0.083	0.277	0.000	1.000
Wales	12846	0.054	0.225	0.000	1.000	0.072	0.259	0.000	1.000
% of council tenants in enumeration district	8337	33.111	38.399	0.000	100.000	26.208	34.124	0.000	100.000
Father's S.C.: high	11153	0.273	0.446	0.000	1.000	0.324	0.468	0.000	1.000
Father's S.C.: middle	11153	0.510	0.500	0.000	1.000	0.511	0.500	0.000	1.000
Father's years of schooling	6204	9.950	1.659	7.000	16.000	10.023	1.679	7.000	16.000
Mother's years of schooling	6449	9.950	1.410	7.000	16.000	10.023	1.410	7.000	16.000
Financial hardship (age 7)	8277	0.081	0.273	0.000	1.000	0.048	0.215	0.000	1.000
Morbidity index(age 7)	9389	1.772	1.412	0.000	10.000	1.731	1.383	0.000	8.000
Nb. Hospitalisations(age 7)	10124	0.355	0.624	0.000	5.000	0.370	0.624	0.000	5.000
Diabetes in close relatives(age 7)	10124	0.020	0.141	0.000	1.000	0.027	0.161	0.000	1.000
Epilepsy(age 7)	10124	0.071	0.257	0.000	1.000	0.070	0.256	0.000	1.000
Chronic hart illness: close relatives (age 7)	10124	0.023	0.148	0.000	1.000	0.030	0.170	0.000	1.000
Mother: Cigarettes per day(age 16)	6310	5.865	7.392	0.000	30.000	4.975	6.926	0.000	30.000
Obese at age 16	12846	0.027	0.163	0.000	1.000	0.048	0.215	0.000	1.000
Cognitive ability score (age 11)	9008	-0.033	1.573	-3.891	4.020	0.490	1.457	-3.299	3.926
# teachers / # pupils at school, age 16	8688	0.056	0.009	0.012	0.174	0.056	0.014	0.020	0.618
# expelled pupils / # pupils at school, age 16	8444	0.000	0.001	0.000	0.044	0.000	0.001	0.000	0.018
Social adjustment test (age11)	9034	8.609	8.951	0.000	70.000	6.259	7.564	0.000	56.000
1+ passes at CSE or O level, grades 4 or 5 only	9168	0.093	0.290	0.000	1.000	0.065	0.246	0.000	1.000
1+ passes at CSE, grades 2 or 3	9168	0.098	0.298	0.000	1.000	0.079	0.270	0.000	1.000
5+ passes at CSE, grades 2 to 5	9168	0.134	0.341	0.000	1.000	0.144	0.351	0.000	1.000
1-4 passes at GCE O level or CSE grade 1	9168	0.242	0.428	0.000	1.000	0.318	0.466	0.000	1.000
5 or 6 passesGCE O level or CSE 1	9168	0.047	0.212	0.000	1.000	0.065	0.246	0.000	1.000
7+ passes at GCE O level grades A-C, or CSE grade 1	9168	0.033	0.177	0.000	1.000	0.047	0.212	0.000	1.000
1 pass at A level, grades A-E	9168	0.027	0.163	0.000	1.000	0.036	0.188	0.000	1.000
2 passes at A levels, up to 8pts	9168	0.034	0.180	0.000	1.000	0.052	0.222	0.000	1.000
3+ passes at A levels, up to 8pts	9168	0.025	0.157	0.000	1.000	0.034	0.181	0.000	1.000
2 passes at A levels and 9+ pts	9168	0.002	0.045	0.000	1.000	0.002	0.046	0.000	1.000
3+ passes at A levels and 9+pts	9168	0.039	0.194	0.000	1.000	0.045	0.207	0.000	1.000
University degree or eq.	5579	0.190	0.392	0.000	1.000	0.199	0.399	0.000	1.000
# cigarettes per day (age 33)	6943	5.574	9.506	0.000	80.000	3.993	8.164	0.000	60.000
Units of alcohol per week(age 33)	7005	16.809	24.076	0.000	294.930	16.933	21.339	0.000	234.220
Own social class: high (age 46)	5603	0.428	0.495	0.000	1.000	0.454	0.498	0.000	1.000
Own social class: middle (age 46)	5603	0.418	0.493	0.000	1.000	0.396	0.489	0.000	1.000
Comprehensive School	8946	0.566	0.496	0.000	1.000	0.557	0.497	0.000	1.000
Secondary Modern	8946	0.254	0.435	0.000	1.000	0.229	0.420	0.000	1.000
Private School	8946	0.068	0.251	0.000	1.000	0.052	0.222	0.000	1.000

Table 4: Quality of primary schooling, health and health related behaviours

	Model1	Model2	Model3	Model4	Model5
Dep. Variable: SAH, age 46					
Private school, 1969	-0.045	-0.047	-0.055	-0.045	-0.041
Ratio: #pupils / # teachers, 1969	0.001	0.000	0.001	0.001	0.001
Unhappy at school, 1965	-0.068**	-0.050*	-0.064**	-0.057*	-0.051
Dep. Variable: Long standing illness / disability, age 46					
Private school, 1969	0.026	0.027	0.033	0.017	0.012
Ratio: #pupils / # teachers, 1969	-0.002	-0.002	-0.003*	-0.002	-0.001
Unhappy at school, 1965	0.073**	0.083**	0.061	0.029	0.044
Dep. Variable: Mental illness, age 46					
Private school, 1969	0.427	0.427	0.562	0.618	0.634
Ratio: #pupils / # teachers, 1969	-0.022**	-0.022**	-0.019**	-0.018*	-0.019*
Unhappy at school, 1965	0.788***	0.788***	0.871***	0.761**	0.374
Dep. Variable: Smoker, age 42					
Private school, 1969	-0.039	-0.038	--	-0.032	-0.020
Ratio: #pupils / # teachers, 1969	-0.001	-0.000	--	0.000	0.000
Unhappy at school, 1965	0.016	-0.002	--	-0.003	-0.012
Dep. Variable: Units of alcohol / week, age 42					
Private school, 1969	-0.325	0.233	--	1.413	1.666
Ratio: #pupils / # teachers, 1969	0.010	0.001	--	-0.016	-0.019
Unhappy at school, 1965	-2.545*	-2.080	--	-2.734*	-1.162
Dep. Variable: Fried food / week, age 42					
Private school, 1969	0.008	0.004	--	-0.001	-0.002
Ratio: #pupils / # teachers, 1969	-0.000	-0.000	--	0.000	-0.000
Unhappy at school, 1965	-0.003	-0.004	--	-0.004	-0.002
Dep. Variable: Teenage pregnancy					
Private school, 1969	-0.033	-0.018	--	-0.018	-0.011
Ratio: #pupils / # teachers, 1969	-0.002*	-0.001	--	-0.001	-0.000
Unhappy at school, 1965	0.012	0.003	--	-0.001	0.000
Dep. Variable: Smoking during pregnancy					
Private school predicts failure in 100% of cases				--	--
Ratio: #pupils / # teachers, 1969	-0.002	-0.001	--	-0.002	-0.003
Unhappy at school, 1965	-0.025	-0.052	--	-0.053	-0.071

*** p<0.01, ** p<0.05, * p<0.1

Notes:

1.**Model 1** includes the rich set of pre-schooling control variables listed in Appendix D: parental socioeconomic status and education, childhood health and local area characteristics (census enumeration district).

Model 2 controls, aditionally, for cognitive and non-cognitive ability, measured at age 7.

Model 3 controls, in addition to the covariates in Model 2, for lifestyle in adulthood (cigarette smoking, alcohol consumption and weekly consumption of fried food).

Model 4 controls, in addition to the covariates in Model 3, for the highest academic qualifications attained.

Model 5 controls, in addition to the covariates in Model 4, for socioeconomic group at age 42

2. The partial effects on the outcomes of interest are computed by averaging across all individual marginal effects in the sample. Models for self-assessed health and for the weekly consumption of fried food are ordered probit specifications; partial effects correspond, respectively, to the probability of reporting excellent health and of consuming fried food on a daily basis at age 46. For the smoking status, incidence of chronic illness, teenage pregnancy and maternal smoking during pregnancy probit specifications are used. Finally, the models for the Cornell index of mental illness and for the number of weekly units of alcohol are linear regressions.

Table 5: Quality of secondary schooling, health and health related behaviours

	Model 1	Model 2	Model 3	Model 4	Model 5
Dep. Variable: SAH, age 46					
Comprehensive School	-0.039	-0.014	-0.016	-0.021	-0.029
Secondary Modern	-0.060**	-0.013	-0.013	-0.004	-0.025
Private School	-0.018	-0.006	-0.011	-0.025	-0.034
singlesex	0.000	-0.006	-0.002	0.005	0.005
Boarder	-0.057	0.001	0.046	0.021	-0.052
school class allocation	-0.015	-0.015	-0.022	-0.027	-0.022
# pupils at school / # teachers, age 16	-0.001	-0.002	-0.002	-0.002	-0.000
# expelled pupils / # pupils at school, age 16	-15.279***	-14.192***	-16.616**	-20.020***	-14.747**
Dep. Variable: Long standing illnesss / disability, age 46					
Comprehensive School	0.085***	0.079**	0.108***	0.108***	0.111***
Secondary Modern	0.083**	0.057	0.072*	0.071*	0.078*
Private School	0.031	0.032	0.042	0.059	0.087
singlesex	0.022	0.025	0.037	0.029	0.036
Boarder	-0.046	-0.033	-0.069	-0.010	-0.025
school class allocation	0.006	0.001	0.003	0.015	0.004
# pupils at school / # teachers, age 16	-0.001	0.001	0.000	-0.001	-0.003
# expelled pupils / # pupils at school, age 16	11.364	12.334	16.478	17.956	11.922
Dep. Variable: Mental illness, age 46					
Comprehensive School	0.346*	0.052	0.058	0.137	0.211
Secondary Modern	0.293	-0.241	-0.293	-0.163	-0.225
Private School	0.729**	0.858**	0.918***	1.161***	0.993***
singlesex	0.034	-0.019	-0.041	0.040	0.047
Boarder	0.123	-0.229	-0.198	0.300	1.435
school class allocation	-0.062	-0.074	-0.035	0.098	0.198
# pupils at school / # teachers, age 16	0.025	0.024	0.011	0.028	0.029
# expelled pupils / # pupils at school, age 16	54.209	80.642	83.476	62.277	34.156
Dep. Variable: Smoker, age 42					
Comprehensive School	0.040	0.014	---	-0.012	-0.037
Secondary Modern	0.068**	0.013	---	-0.030	-0.050
Public School	-0.011	-0.010	---	-0.052	-0.055
singlesex	-0.010	-0.009	---	-0.023	-0.026
Boarder	0.091	0.032	---	0.107	0.190
school class allocation	0.010	0.011	---	0.014	0.004
# pupils at school / # teachers, age 16	0.003	0.002	---	0.001	0.002
# expelled pupils / # pupils at school, age 16	13.381**	4.700	---	3.997	4.522

	Model 1	Model 2		Model 4	Model 5
Dep. Variable: Units of alcohol / week, age 42					
Comprehensive School	-0.811	0.169	---	0.095	-0.351
Secondary Modern	-2.339*	-0.770	---	-0.878	-1.316
Private School	0.023	1.480	---	1.570	1.372
singlesex	-1.325	-1.194	---	-1.281	-1.548
Boarder	4.834	4.539	---	0.456	1.151
school class allocation	-0.004	0.145	---	-0.449	-0.212
# pupils at school / # teachers, age 16	-0.020	-0.018	---	0.036	0.109
# expelled pupils / # pupils at school, age 16	447.360	515.972	---	225.261	536.518
Dep. Variable: Fried food / week, age 42					
Comprehensive School	0.007*	0.002	---	0.005	0.003
Secondary Modern	0.001	-0.004	---	0.002	0.001
Private School	0.009	0.005	---	0.001	0.002
singlesex	0.002	0.001	---	0.001	0.000
Boarder	0.009	0.011	---	0.023	0.042
school class allocation	-0.000	-0.001	---	-0.001	-0.001
# pupils at school / # teachers, age 16	0.000	0.000	---	0.000	0.000
# expelled pupils / # pupils at school, age 16	1.043	1.513	---	1.224	1.784
Dep. Variable: Teenage pregnancy					
Comprehensive School	0.079***	0.040*	---	0.024	-0.001
Secondary Modern	0.119***	0.054*	---	0.020	-0.018
Private School	0.121**	0.084	---	0.146	0.084
singlesex	0.011	0.018	---	0.028	0.013
Boarder: dropped due to perfect collinearity			---	---	---
school class allocation	-0.004	-0.005	---	-0.007	-0.012
# pupils at school / # teachers, age 16	-0.003	-0.003	---	-0.001	0.000
# expelled pupils / # pupils at school, age 16	-6.387	-3.915	---	-11.149	-4.585
Dep. Variable: Smoking during pregnancy					
Comprehensive School	0.051	0.007	---	0.005	0.007
Secondary Modern	0.095	0.006	---	0.004	-0.042
Private School	-0.071	-0.087	---	-0.044	-0.034
singlesex	0.021	0.011	---	0.021	0.077
Boarder: dropped due to perfect collinearity			---	---	---
school class allocation	-0.007	0.006	---	0.059	0.027
# pupils at school / # teachers, age 16	0.012	0.013	---	0.019*	0.033***
# expelled pupils / # pupils at school, age 16	33.131**	29.502*	---	17.366	18.244

*** p<0.01, ** p<0.05, * p<0.1

Notes:

1.Model 1 includes the rich set of pre-schooling control variables listed in Appendix D: parental socioeconomic status and education, childhood health and local area characteristics (census enumeration district). **Model 2** controls, aditionally, for cognitive and non-cognitive ability, measured at age 7. **Model 3** controls, in addition to the covariates in Model 2, for lifestyle in adulthood (cigarette smoking, alcohol consumption and weekly consumption of fried food). **Model 4** controls, in addition to the covariates in Model 3, for the highest academic qualifications attained. **Model 5** controls, in addition to the covariates in Model 4, for socioeconomic group at age 42.

2. The partial effects on the outcomes of interest are computed by averaging across all individual marginal effects in the sample. Models for self-assessed health and for the weekly consumption of fried food are ordered probit specifications; partial effects correspond, respectively, to the probability of reporting excellent health and of consuming fried food on a daily basis at age 46. For the smoking status, incidence of chronic illness, teenage pregnancy and maternal smoking during pregnancy probit specifications are used. Finally, the models for the Cornell index of mental illness and for the number of weekly units of alcohol are linear regressions.

Table 6: Stochastic dominance tests for inequality of opportunity in health

SAH (age 46)	Comprehensive school	Secondary modern school	Grammar school	Private school
Comprehensive school				
Secondary modern school				
Grammar school	Gr. *FSD* Comp.	Gr. *FSD* Sc. Mod.		
Private school	Priv. *FSD* Comp.	Priv. *FSD* Sc. Mod.		

Chronic illness / disability (age 46)	Comprehensive school	Secondary modern school	Grammar school	Private school
Comprehensive school			Comp. *FSD* Gr.	
Secondary modern school			Sc. Mod. *FSD* *Gr.*	Sc. Mod. *FSD* Priv.
Grammar school				
Private school				

Mental illness (age 42)	Comprehensive school	Secondary modern school	Grammar school	Private school
Comprehensive school			Comp. *FSD* Gr.	
Secondary modern school			Sc. Mod. *FSD* *Gr.*	
Grammar school				
Private school				

Smoking (age 42)	Comprehensive school	Secondary modern school	Grammar school	Private school
Comprehensive school			Comp. *FSD* Gr.	Comp. *FSD* Priv.
Secondary modern school			Sc. Mod. *FSD* *Gr.*	Sc. Mod. *FSD* Priv.
Grammar school				
Private school				

Notes: Kolmogorov-Smirnov test results at 1 per cent significance level

Figure 1: NCDS cohort-members by type of school (age 16)

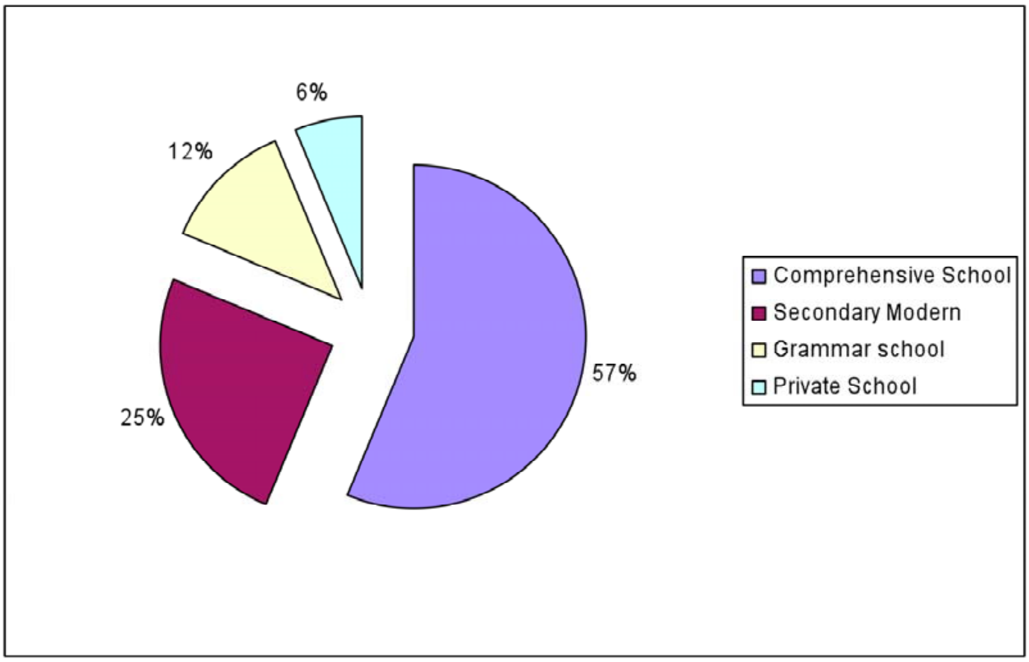


Figure 2: Distribution of pupil-teacher ratios by type of primary school

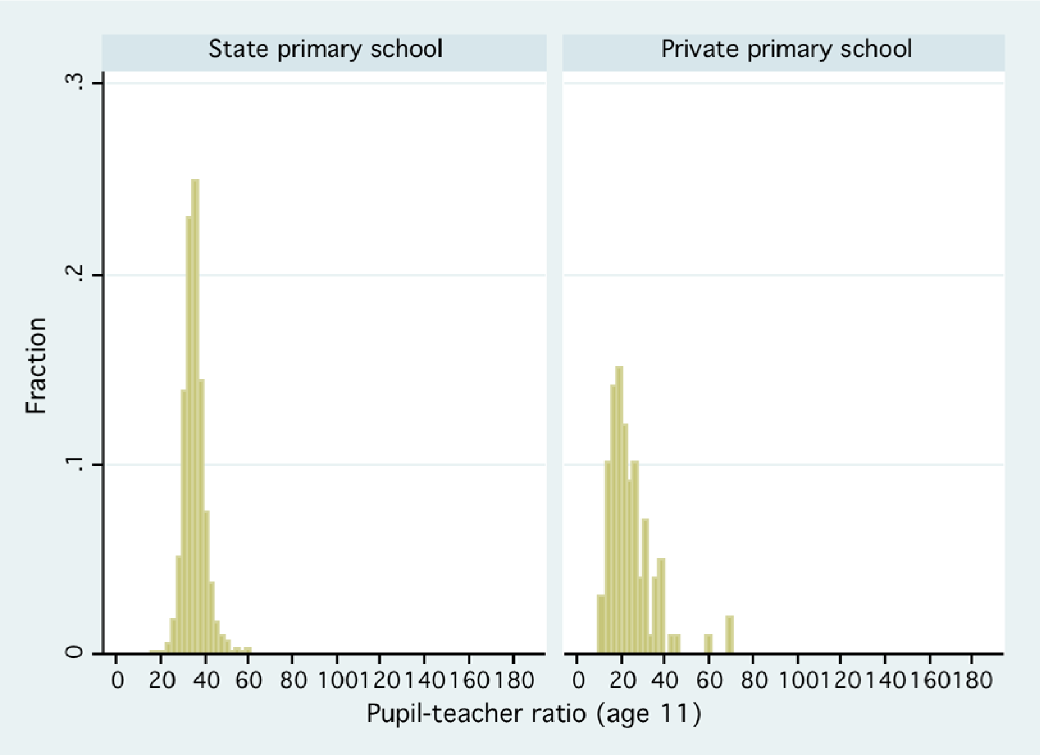


Figure 3: Distribution of pupil-teacher ratios by type of secondary school

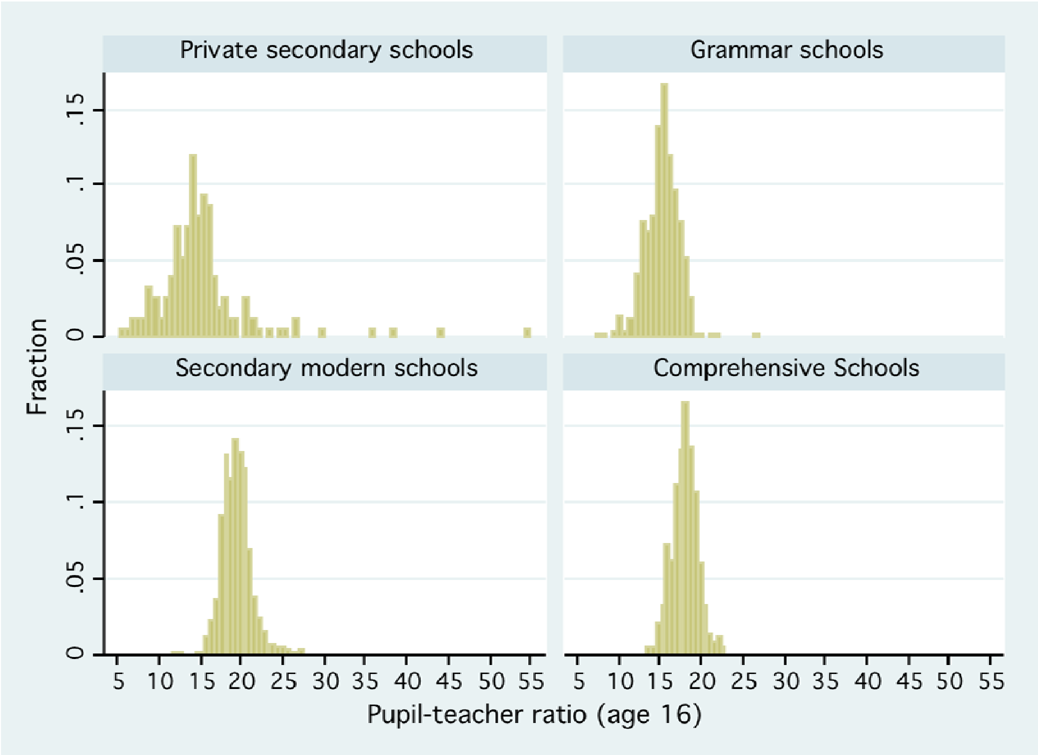


Figure 4: Distribution of cognitive and non-cognitive ability in the NCDS cohort

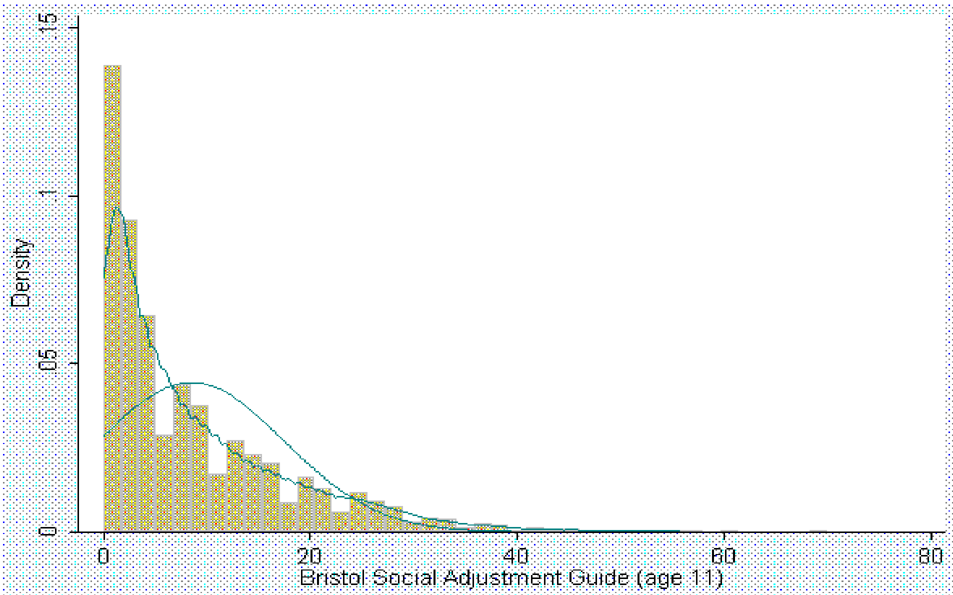


Figure 5: Stochastic dominance: empirical distributions of SAH (age 46) by type of secondary school

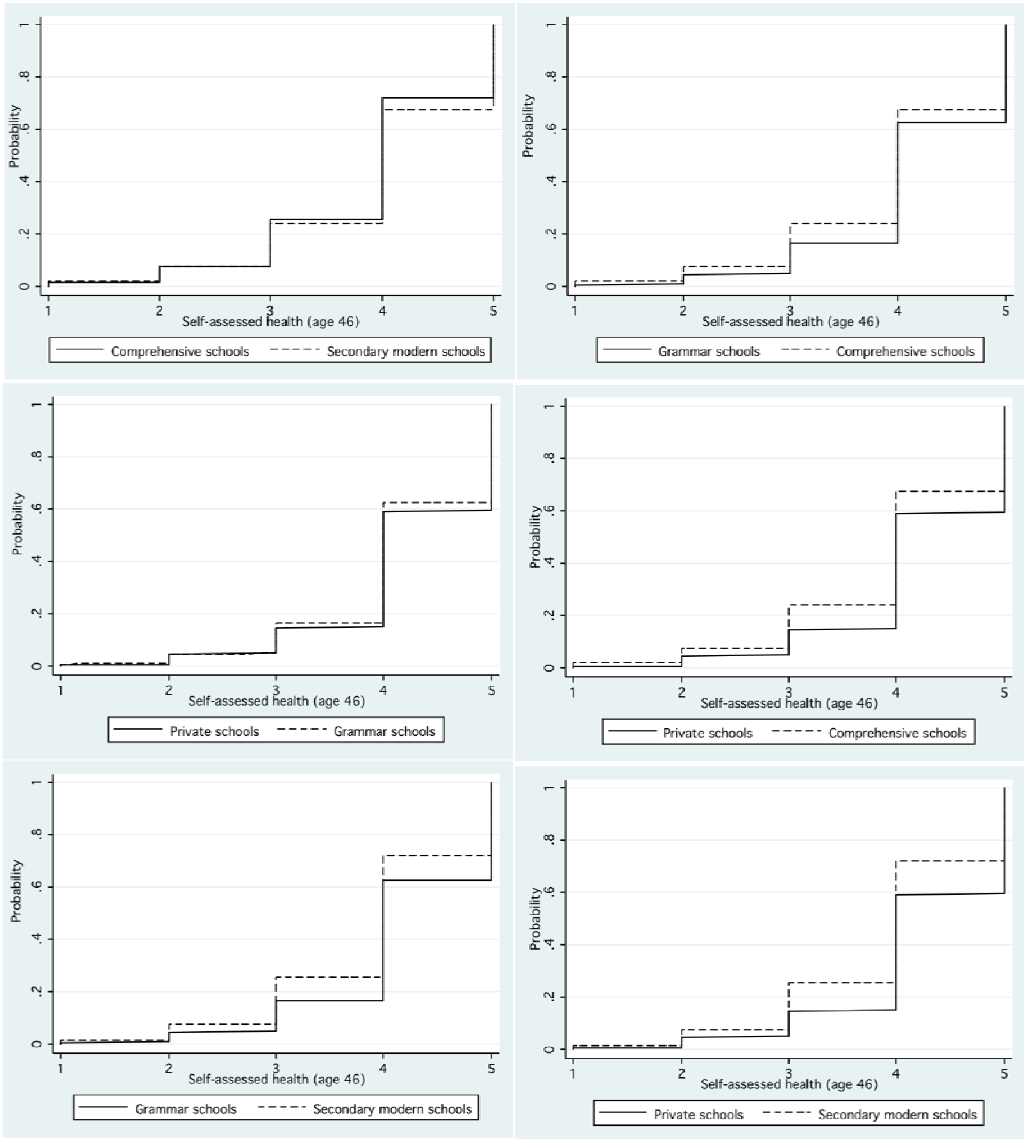
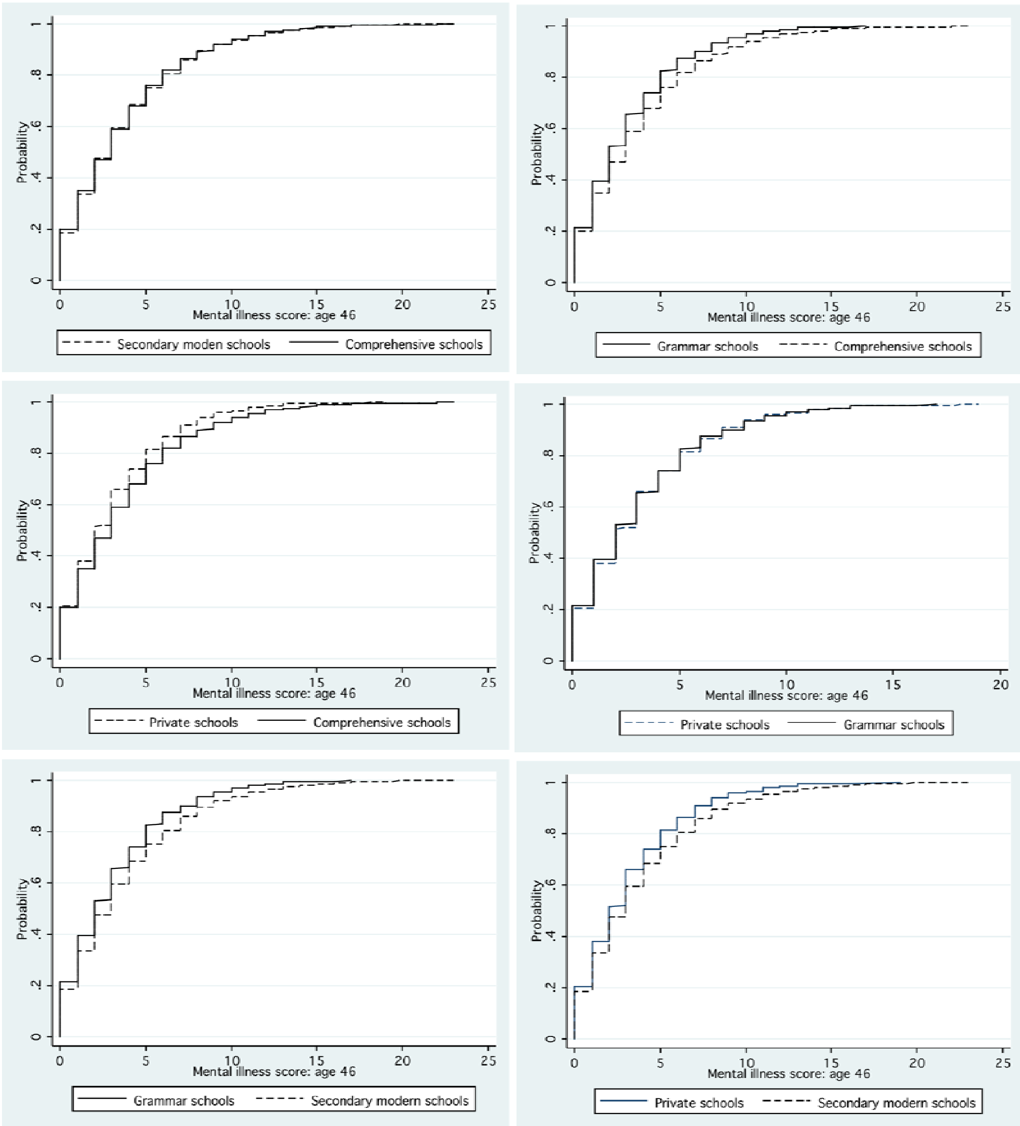


Figure 6: Stochastic dominance: empirical distributions of mental illness (age 46) by type of secondary school



Chapter 5

The Impact of Childhood Cognitive Skills, Social Adjustment and Schooling on Adult Health and Lifestyle

5.1 Introduction

The association between educational attainment and a range of health outcomes is well documented in the economic literature, as reviewed by Grossman (2006) and Cutler and Lleras-Muney (2008). Studies such as Currie and Moretti (2003), Lleras-Muney (2005), Arendt (2005), Lindeboom *et al.* (2009), Kenkel *et al.* (2006), Oreopoulous (2006), Grimard and Parent (2007), and Webbink *et al.* (2010) additionally find evidence to suggest that part of this relationship may be causal. Mazumder (2008) and Cutler and Lleras-Muney (2008, 2010) outline some of the channels through which education may have an impact on health and health-related behaviours: these include the effect of education on employment, both the type of jobs available to people and their lifetime earnings; the effect on relative social status; and the effect on use of health care and other health-related behaviours, through the acquisition of specific health knowledge, through improved information processing and decision-making skills, and through the influence on behavioural responses to future costs and benefits and to perceived health risks. Another recent strand of papers, such as Trannoy *et al.* (2009) and Rosa Dias (2009), suggests that, in addition to family background, differences in education may be a leading cause of inequality of opportunity in health. Less is known, however, about whether quality of schooling also has an impact on health and how this interacts with the effect of educational attainment[45].

The National Child Development Study (NCDS) follows a cohort of around 17,000 individuals, who were born in the week of 3rd March 1958, from birth up until age 46. Members of the cohort were aged 11 in March 1969. They went through secondary schooling during the 1970s and attended very different types of school. The cohort's secondary schooling lie within the transition period of

[45] This gap in the literature is acknowledged in Cutler and Lleras-Muney (2008: p. 22).

the comprehensive education reform that was implemented in England and Wales from the mid-1960s[46]. This was a major reform, aimed at reducing inequality of opportunity, which transformed secondary education. Comprehensive schooling was not implemented simultaneously nationwide, hence some of the cohort members attended the highly selective tri-partite system of state-funded education, which comprised grammar schools, secondary modern schools and a dwindling number of technical schools. Among members of the NCDS cohort, 12 per cent attended grammar schools at age 16, 25 per cent attended secondary moderns and 57 per cent attended comprehensives. A further 6 per cent of NCDS cohort members attended private fee-paying schools, independent of the state educational system and reforms[47].

This paper is concerned with evaluating the impact of educational attainment and of attending qualitatively different types of school on health outcomes and health-related behaviour later in life. It contrasts the health outcomes of the NCDS cohort members who experienced the selective system with those who experienced the comprehensive system of education. This is in line with the strategy of using major educational policy reforms to identify causal effects of education on health. Similar identification strategies have been used in the recent literature, often focusing on changes in the minimum school leaving age and related reforms (see e.g., Lleras-Muney, 2005; Arendt, 2005, 2008; Oreopoulos, 2006; Albouy and Lequien, 2008; Mazumder, 2008; Silles, 2009; Van Kippersluis *et al.*, 2009; Chou *et al.,* 2010).

The comprehensive education reform was aimed at reducing inequality of opportunity by improving the quality of schooling available to children from disadvantaged backgrounds. These reforms have been evaluated in terms of their direct impact on educational attainment and subsequent impact on labour market outcomes (see e.g., Kerkchoff *et al.,* 1996; Jesson, 2000; Dearden *et al.,* 2002; Galindo-Rueda and Vignoles, 2004, 2005; Pischke and Manning, 2006). Here we

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[46] Data on those who attended school in Scotland at age 16 are not used: the Scottish educational system of the 1960s and 1970s was structurally very different from the one experienced by the other NCDS cohort-members, and comprehensive schooling was introduced earlier, preventing a legitimate comparison of types of school, educational qualifications and outcomes.

[47] Historically the leading private schools within the independent sector have been known as "public schools" in Britain. To avoid confusion we use the label "private schools" throughout. Most of our analysis focuses on those who went to state schools (grammar, secondary modern and comprehensive).

focus on a possible indirect consequence of the reform, by estimating the effect of educational attainment and quality of schooling on adult health outcomes. We do not evaluate the impact of comprehensive schooling *per se* but use the consequent variation in quality of schooling and educational attainment as a natural experiment to explore the impact on health and health-related behaviour.

We use a matching framework to pre-process the data: using a combination of coarsened exact matching along with propensity score and Mahalanobis matching (Ho *et al.*, 2007). This is important because our own descriptive analysis, as well as previous work with the NCDS, shows an imbalance between the observed pre-schooling characteristics of those who attended comprehensive and selective schools (Pischke and Manning, 2006). This is reinforced by regressions for cognitive ability at age 7 and 'value-added' regressions of ability at age 11, given ability at age 7, of the type used by Pischke and Manning (2006). First we use matching to improve the balance of a broad set of observed pre-schooling characteristics, including cognitive ability measured at age 7, between those who attended comprehensive schools and a control group who attended selective state schools. Then, to explore heterogeneity in the impact of attainment, those who attended grammar schools are matched with a comparable group who attended comprehensive schools and, likewise, those who went to secondary modern schools are matched with a comparable group from comprehensive schools. A key matching variable is ability at age 11, which is closely linked to likely performance in the 'Eleven Plus' entry examination. But, rather than using absolute cognitive ability at age 11, which is likely to be contaminated by a form of post-treatment bias due to the 'coaching effect' for those who actually faced the Eleven Plus examination, we use the relative ability ranking of those within the selective and non-selective systems. The success of our matching strategy is assessed using value-added regressions and other diagnostics.

The use of matched samples is coupled with parametric modelling of health outcomes and health-related behaviour, using regression and instrumental variables (IV) estimators. Our study design is structured to answer the following research questions:

- On average, what is the overall impact of educational attainment, captured by a detailed measure of the highest qualification attained, and of the quality of schooling on adult health and health-related behaviour? This comparison uses matching to balance the sample and controls for an extensive set of observed pre-schooling characteristics using linear and nonlinear regression methods.

- How do the estimated impacts of attainment and quality of schooling differ when we take account of unobserved factors? This is addressed by adopting an IV strategy, based on geographic variation in implementation of the new policy and in the availability of comprehensive school places, that has been used in earlier work.
- The key feature of the pre-comprehensive system was the distinction between attending grammar and secondary modern schools: is there heterogeneity in the impact of educational attainment, particularly according to the type of school attended? This is explored by creating matched samples, linking those who actually went to grammar or secondary modern schools with comparable counterparts who went to comprehensive schools and then applying parametric models to these matched sub-samples.

Our results show that cognitive ability at age 7 is not significantly associated with health outcomes but there is a strong association with non-cognitive skills, as reflected by social adjustment as a child. Those who had problems with social adjustment are more likely to suffer both physical and mental illness as adults. There is also evidence of a socioeconomic gradient in illness by father's social class. Those with poorer social adjustment as children are more likely to become smokers and those whose father came from the higher or middle social classes are less likely to become smokers. When those who went to grammar and to secondary modern schools are matched separately to comparable groups who attended comprehensives there is evidence of heterogeneity in the impact of educational attainment, as measured by qualifications. Attainment has an impact on adult health-related behaviours for both groups, in particular on smoking, drinking and diet. But attainment only has an impact on adult health, both long-standing illness and mental health problems, for those who either did or would have attended grammar schools.

5.2 Comprehensive schooling reforms and the 1958 cohort

The comprehensive education reform, put into place during the 1960s and 1970s in England and Wales, replaced the selective educational system with a non-selective, comprehensive system of secondary schooling. This policy reform was implemented at different speeds at the local level: some local education authorities (LEAs) implemented it quickly, but others resisted the change, some for decades. Because of this slow and uneven transition, the two systems co-existed for a long period of time and approximately 40 per cent of the NCDS cohort, who entered state secondary schools in 1969, experienced the pre-reform selective system; the remaining 60 per cent attended comprehensive schools.

Grammar schools were academically oriented state schools that provided teaching for the entire age range 11-18, including a sixth form for Advanced level ('A-level') studies, and prepared pupils to go on to higher education. Admission into these schools was determined by an exam taken at age 11 (the 'Eleven Plus')[48]. Pupils whose examination score did not permit entry into a grammar school attended either secondary modern schools, which were less academically oriented and covered the ages 11-16 or, in a small minority of cases, vocational schools aimed at providing training and technical apprenticeships[49].

The different types of schools varied in their curricula, examinations and academic environment, along with other qualitative differences. Table 1 shows that, among the schools attended by the NCDS cohort members used in our analysis at age 16, 79 per cent of private schools and 69 per cent of grammar schools were single sex, while only 13 per cent of comprehensive schools were single sex. Streaming of classes by academic ability was common in secondary modern schools (42 per cent) and comprehensive schools (39 per cent) but rare among grammar schools (17 per cent). Some comprehensive schools were former secondary moderns (26 per cent) or grammar schools (19 per cent), with the rest being newly created.

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[48] Following much controversy, the selective system went into decline in the 1960s and 1970s, until the Eleven Plus was abolished as a national examination in England and Wales by the 1976 Education Act. Despite this, the selective system and the existence of grammar schools has persisted in certain areas, such as Kent.

[49] In a few cases, pupils whose CSE grades were sufficient transferred to grammar schools or sixth form colleges to complete their A-levels.

Table 1
Characteristics of different types of schools (as attended by NCDS cohort at age 16)

	Grammar	Sec Modern	Comprehensive	Private
% single sex	68.7	26.1	13.8	78.9
% with ability streams	16.6	42.3	38.8	22.8
% former grammar	-	-	19.0	-
% former sec modern	-	-	26.3	-

Note: The percentages are computed using all available observations for the relevant variables.

The comprehensive reform has received considerable attention in the literature and its impact on educational outcomes has been assessed. The evidence for the impact on educational outcomes is mixed. Kerckhoff *et al.* (1996) review a series of LEA case studies and use NCDS data to examine the association between types of secondary schools and exam performance at age 18. After controlling for a wide range of observables, including measures of cognitive ability prior to secondary education, the authors find no association between the average academic achievements of pupils in selective and in comprehensive schools. However, when the impact of the reform is examined for different quantiles of ability, the study finds that high-ability pupils performed relatively worse and low-ability pupils performed relatively better in comprehensive schools. Jesson (2000) implements a value-added approach that corroborates most of these results. Accounting for a rich set of controls, the paper finds no significant differences between the exam performance of pupils in the selective and comprehensive systems of education. Nevertheless, pupils in secondary modern schools performed worse in exams than their comprehensive school counterparts.

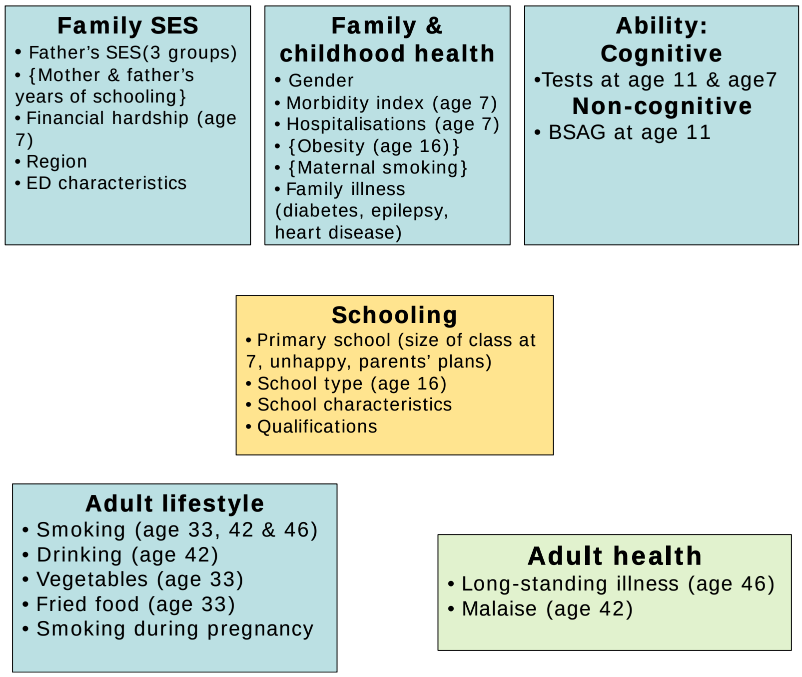
Galindo-Rueda and Vignoles (2004) investigate the causal effects of the comprehensive reform on educational outcomes; the data used are from the NCDS and their research strategy is based on matching and instrumental variables estimators. Two instruments are used for type of schooling: Conservative Party control of the cohort members' LEA (which the authors claim to be negatively correlated with the probability of attending a comprehensive school, but orthogonal to the educational outcomes) and the share of comprehensive schools in a cohort-member's LEA. Although point estimates of the policy impact are shown to be sensitive to the choice of instrument, the results suggest that the most able 20 per cent of pupils did relatively better in the selective school system than they would have done in a comprehensive one; no statistically significant effect of the reform was found for pupils in the lower ability quantiles. Maurin and MacNelly (2007) add to this body of evidence by evaluating a different school reform, implemented in Northern Ireland in the late 1980s. The educational system in Northern Ireland remained selective, with the policy reform designed to increase the number of pupils allowed to attend a grammar school by 15%. The paper compares the educational outcomes between Northern Ireland and England before and after the reform (using the English comprehensive education system as a control group); the wider access to grammar schools within the Northern Irish selective system is found to have a large positive impact on educational attainment.

Pischke and Manning (2006) have raised a fundamental challenge to this literature. They also use NCDS data but they question the main results of earlier work. First, contrary to Kerckhoff *et al.* (1996), they find that comprehensive areas were systematically poorer and populated by children with lower ability than selective areas. The policy impacts reported in the literature may thus be the result of selection bias. Second, using a series of placebo tests based on value-added regression for ability, they find that the comparison between areas exposed to different degrees of educational selectivity tend to produce the same results regardless of whether the educational outcomes are measured after the reform or before it. We draw on Pischke and Manning's (2006) placebo tests to assess whether our empirical strategy achieves the goal of making valid inferences about the impact of educational attainment and of quality of schooling.

5.3 NCDS data and study design

Members of the National Child Development Study (NCDS) cohort were all born in the week of 3rd March 1958. Seven waves of interviews have been carried-out when cohort members were 7, 11, 16, 23, 33, 42 and 46 years old. The study compiles detailed information on the cohort-members' childhood health, parental background, and educational achievement. It also includes self-reported information on social status in adulthood, health-related behaviour and a wide range of health outcomes. The NCDS gathers data from a variety of sources. In the early waves this includes information from parents, medical examinations, tests of ability and from the child's school. In the later waves these are augmented by interviews with the cohort members and data linked from the Census.

Fig. 1. *Schematic view of study design and NCDS variables*



Note: Items in braces are not used in our main analysis but are used in the checks for robustness.

The structure of the NCDS is well-suited to our study design, which is summarised in Figure 1. Our goal is to identify the impact of educational attainment and of the characteristics of secondary schooling experienced by members of the 1958 cohort on outcomes later in life, with a focus on health-related behaviour and adult health. The NCDS allows us to condition on a broad set of pre-treatment factors that reflect early life circumstances, occur prior to secondary schooling, and are not influenced by subsequent educational choices (Dearden *et al.,* 2002). These factors fall into three broad groups: measures of family socioeconomic status and the local environment during early childhood; measures of childhood health and use of health care and health within the family; and measures of cognitive and non-cognitive skills and social adjustment of the child. In addition we condition on characteristics of the individual's primary education. The aim is to estimate the impact of the type and characteristics of the secondary schooling experienced by each individual on their adult outcomes, both the intermediate outcomes, such as smoking at age 42, and final health outcome, such as long-standing illness at age 46. The specific variables that are available within each of the broad categories are described below and are listed in full in Table A.1 (Appendix D).

5.3.1 Childhood health and parental background

Rich information is available to characterise the cohort members' childhood health and parental circumstances, which have both been linked to adult health outcomes (see e.g., Case *et al.,* 2005; Currie and Stabile, 2004). Following Power and Peckham (1987), indicators of morbidity are constructed by aggregating twelve categories of health conditions, that affect the child at ages 7 and 11. Dummy variables for the occurrence of diabetes, epilepsy and other chronic conditions among parents and siblings are included in order to account for the incidence of hereditary conditions in the cohort member's family. Information on obesity at age 16 is also available, as well as an indicator variable for maternal smoking after the fourth month of pregnancy.

In terms of parental background, the NCDS allows us to trace the social class and the years of schooling of the parents of cohort members. We use the father's occupational socioeconomic status (SES), measured in three groups (see Carneiro *et al.,* 2007). Following Case *et al.* (2005) and Lindeboom *et al.* (2009), this information is complemented by data on the incidence of household financial difficulties during the cohort member's childhood and adolescence.

5.3.2 Cognitive ability, non-cognitive skills and social adjustment

Auld and Sidhu (2005) argue that failure to control for cognitive ability will confound the relationship between health and education. Non-cognitive skills have also received considerable attention in recent studies (see for example, Heckman *et al.,* 2006; Heckman, 2008) and have been linked to health and health-related behaviours (see e.g., Carneiro *et al.*, 2007; Coneus and Laucht, 2008; Cutler and Lleras-Muney, 2010; Keaster, 2009). Among these non-cognitive skills, social adjustment is of particular relevance for schooling and health (Carneiro *et al.*, 2007).

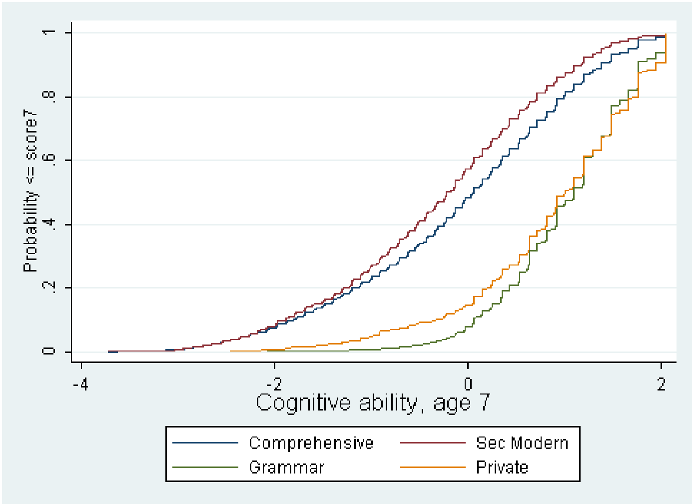
The NCDS provides measures of cognitive and non-cognitive ability collected before respondents began their secondary schooling. Scores of ability tests taken at age 7 and 11 are available on a series of cognitive dimensions: mathematics, reading, copying designs and general ability. These test scores are highly correlated at the individual level leading to problems with precision in econometric models, due to multicollinearity. To avoid this, we follow Galindo-Rueda and Vignoles (2005) and use principal components analysis to construct a single measure of cognitive ability using the first principal component[50]. The empirical distributions of these combined scores, for the tests at ages 7 and 11, split by type of secondary school attended at age 16 are presented in Figure 2.

The similarity of the distribution of scores between the two ages and the pattern across schools provides confidence in their face validity: ability scores are lowest among those who attended secondary moderns, followed by those who attended comprehensives. The distributions for grammar and private schools are similar, but with more children in both the lower and upper tails among private school pupils.

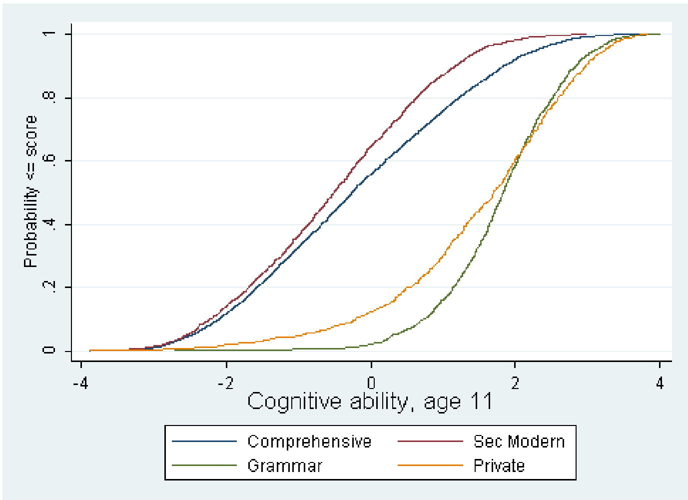
It should be emphasised that the three dimensions of cognitive ability used to construct our index – mathematics, reading and general ability – along with the fact that the index derived from the first principal component gives equal weight to each dimension, mirrors the three elements of the Eleven Plus examination. So the cognitive ability score at age 11 can be viewed as a proxy for performance in the Eleven Plus for those who took the examination.

[50] For example, with the scores at age 11, the first principal component accounts for 85 per cent of the joint variation and, strikingly, the weights attached to the three dimensions – 0.583, 0.567 and 0.582 – are virtually identical.

Fig. 2. *Empirical distributions of cognitive ability scores by type of school*



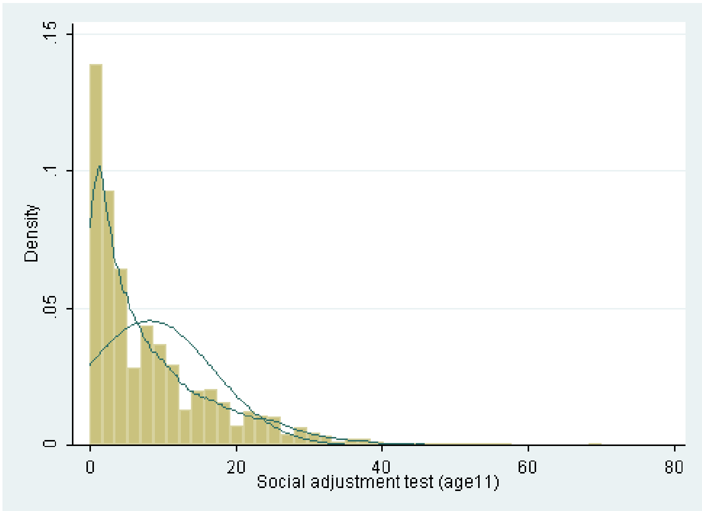
(a) Age 7 scores



(b) Age 11 scores

Following Carneiro *et al.* (2007) the score for the Bristol Social Adjustment Guide (BSAG) is used as a measure of social skills. This is a measure of problems with social adjustment at age 11: teachers were asked to report whether the child had problems in twelve behavioural domains such as hostility towards children and adults, anxiety, withdrawal, 'writing off' adults, unforthcomingness, depression, restlessness, acceptance by adults, inconsequential behaviour, as well as miscellaneous psychological and nervous symptoms (Stott, 1987). One point is attributed to each positive answer; points are then summed to obtain the BSAG social maladjustment score[51]. The distribution of the BSAG measure is presented in Figure 3, which shows that the distribution is highly skewed with relatively few respondents having high scores for social maladjustment.

Fig. 3. *Empirical density of Bristol Social Adjustment Guide (BSAG)*



Note: The Figure shows the histogram of the BSAG score, a kernel density estimate and a normal curve.

5.3.3 Local area characteristics

The NCDS includes information about the area in which the cohort-members lived, aggregated at different geographic levels. Data on the cohort members' UK standard region is available for all the waves of the study. For the years 1971 and 1981, NCDS survey data was linked to the Census, allowing a detailed demographic and socioeconomic characterisation of each individual's local area, at the electoral constituency level, local education authority level and census enumeration district level (the smallest unit for which census statistics were then available, with an average population of about 460) [52]. Measures include the percentage of the local

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[51] The NCDS data dictionary notes that that this the scores "are added together to give a figure which indicates, fairly crudely, the total amount of behavioural deviance (maladjustment) as measured by the Guide".

[52] This small area data are available under a special licence, which imposes restrictions on the handling and usage of the data. Details can be found at: http://www.cls.ioe.ac.uk/studies.asp?section=0001000200030015.

population who are unemployed or long-term sick, working women, employed in particular sectors (manufacturing and agricultural), who are in different occupational groups (professional/managerial, other non-manual, skilled manual, semi-skilled, unskilled), owner occupiers, council tenants, non-whites, and immigrants (see Dearden *et al.,* 2002; Galindo-Rueda and Vignoles, 2004; Pischke and Manning, 2006).

5.3.4 Educational attainment and quality of schooling

The NCDS includes information on the educational attainment and qualifications awarded to cohort members. This was collected in the 1978 Survey of Public Exams, based on a questionnaire sent to the school attended by NCDS respondents at wave 3. The usual practice, in the literature that uses the NCDS, has been to differentiate individuals according to broad categories of educational attainment: Certificates of Secondary Education (CSE), O-levels, A-levels and university degree or equivalent[53]. We adopt a richer classification and the information on educational achievement in secondary education is further disaggregated into thirteen categories, ordered according to the grades obtained and number of passes[54]. In our empirical analysis we use the simple 0-12 scaling of this variable as a parsimonious measure of educational attainment[55]. The distribution of this measure is shown in Table 2.

Table 2
Educational attainment: highest secondary qualification
(NCDS variable E386)

	%
No grade at CSE, GCE O or A levels	20.6
1+ passes at O level, grades 4 or 5 only	0.6
1+ passes at CSE, grades 4 or 5 only	8.2
1+ passes at CSE, grades 2 or 3	9.5
5+ passes at CSE, grades 2 to 5	13.6
1-4 passes at GCE O level or CSE grade 1	25.5
5 or 6 passesGCE O level or CSE 1	5.0

53 CSEs and O-level (Ordinary levels) were secondary education qualifications corresponding, typically, to 11 years of education; CSEs were academically less demanding than O-levels. A-levels (Advanced levels) are a qualification which corresponds to 13 years of education. Completion of A-levels is ordinarily a prerequisite for university admission.
54 This is variable 'E386' in the NCDS data dictionary.
55 We have also used models with dummy variables for each category to check the robustness of the results.

7+ passes at GCE O level grades A-C, or CSE grade 1	3.5
1 pass at A level, grades A-E	2.9
2 passes at A levels, up to 8pts	3.7
3+ passes at A levels, up to 8pts	2.7
2 passes at A levels and 9+ pts	0.2
3+ passes at A levels and 9+pts	4.0
	N=11,086

Note: A level points are allocated as 5, 4, 3, 2 and 1 for grades A-E respectively.

Our analysis of the impact of secondary schooling controls for information about the individual's experience in primary school as well as their parents' educational aspirations for their child (see Dearden *et al.,* 2002). This includes the number of children in the child's primary school class at age 7 in 1965, whether parents reported that their child was unhappy at school in 1965, and an indicator of the parents' aspirations for the child, indicating whether they wished the child to continue beyond the minimum school leaving age.

Type of secondary schooling is captured by indicators of the school attended at age 16 (in 1974): secondary modern, grammar, comprehensive or private. This classification is augmented by information on the characteristics of the school, including the teacher/pupil ratio, the ratio of expelled pupils to the total number, and indicators of whether the school was single sex and whether classes were streamed by ability (see Dearden *et al.,* 2002). It is these measures that are used to capture quality of schooling in the regression models[56].

Geographic variation in the availability of comprehensive schooling provides the instruments used in the IV strategy. These variables are described in more detail below, but they include the percentage of the LEA that was comprehensive in 1974 and a measure of local political affiliation based on Conservative party control of electoral constituencies (as used by Galindo-Rueda and Vignoles, 2004).

5.3.5 Intermediate outcomes: health-related behaviours

[56] The literature on the impact of school resources, as reflected in the pupil-teacher ratio, on educational attainment in the NCDS provides mixed results (Feinstein and Symons, 1999; Dearden *et al.,* 2002; Dustmann *et al.,* 2003).

The NCDS contains self-reported information on a series of health-related behaviours which may be influenced by schooling and go on to affect adult health. The survey includes data on the number of cigarettes smoked per day, average units of alcohol consumed per week[57] and dietary choices, such as the frequency of consumption of fried food and vegetables. These data are only available in the latter four waves of the study, once respondents are aged 23 and above. The other measure of health-related behaviour relates only to the women in the cohort: an indicator for whether mothers, of any age up to 42, smoked during their pregnancies.

A particular focus is on smoking which is the largest cause of avoidable premature death in the UK. We have information on smoking at each of the waves 4-7, spanning ages 23 to 46. As there is item non-response at each wave using a combined measure leads to loss of sample size, so we have decided to focus on smoking at age 42 (wave 6). The prevalence of smoking at age 42 is 25 per cent. Of those with available data on smoking for waves 5-7 (ages 33, 42 and 46) 69 per cent never smoked. Among those who smoked at some point, 74 per cent reported smoking at age 42. The remainder are mostly those who had smoked at age 33 but not at 42 or 46[58]. So our measure captures those whose damaging health-related behaviour persists into their mid-forties.

5.3.6 Main outcomes: adult health

Our principal measure of health in adulthood is self-reported long-standing illness or disability at age 46. Information on the particular medical condition associated with the long-standing illness is available and classified according to the International Classification of Diseases (ICD-10). Table 3 shows that the conditions most often listed as the source of the long-standing illness are problems with the musculoskeletal system (25.7 per cent), circulatory system (11.8 per cent),

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[57] NCDS respondents are asked about their weekly consumption of a wide range of alcoholic drinks (glasses of wine, pints of beer and so forth). These are then converted to units of alcohol using the UK National Health Service official guidelines that are available at: http://www.nhsdirect.nhs.uk/magazine/interactive/drinking/index.aspx .

[58] To check robustness all of our analyses were repeated with an indicator of smoking in any of the waves 5-7. The prevalence of smoking in any of these waves is 30 per cent. Results for these analyses are not presented here. The sample sizes are smaller but otherwise results are comparable to the ones for smoking at wave 6. The same applies to using the prevalence of smoking at wave 7 rather than wave 6.

respiratory system (11.4 per cent) and metabolic problems (9.5 per cent), of which 70 per cent suffer from diabetes.

Mental health in adulthood is also taken into account as an outcome through respondents' answers to a series of questions from the Cornell Medical Index Questionnaire, each targeting a particular mental ailment. The number of positive answers given, at age 42, is then used as a malaise score along the lines of Carneiro *et al.* (2007). The malaise score is a measure of psychiatric morbidity (with a special focus on depression), developed at the Institute of Psychiatry from the Cornell Medical Index (Rutter *et al.*, 1970). The NCDS team suggest the use of a severity scale: individuals are considered normal if they score between 0 and 7 points and depressed if they score between 8 and 24 points (Rodgers *et al.*, 1999)[59]. In our data the malaise index, at age 42, ranges from 0 to 23, with a mean of 3.4.

Table 3

Breakdown of long-standing illness (LSI) by percentage with specific main conditions (ICD-9)

	Wave 7 (age 46)
Infectious & parasitic diseases	0.7
Neoplasms	1.6
Diseases of blood & immune mechanism	1.5
Endocrine, nutritional and metabolic	9.5
Mental and behavioural disorders	5.9
Nervous system	5.9
Eye, ear and mastoid process	4.6
Circulatory system	11.8
Respiratory system	11.4
Digestive system	5.5
Skin	2.1
Muscoloskeletal system	25.7
Genitourinary system	2.0
Congenital malformations	0.3
Undiagnosed illness	1.8
Injury, poisoning etc	5.3
Other LSI/uncoded	4.3
	N=2990

[59] Carneiro *et al.* (2007) define an indicator variable for depression based on this rule of thumb.

5.4 Sample selection and balanced samples

5.4.1 Sample selection and non-response

Due to sample attrition and especially due to patterns of item non-response, the number of missing values in the variables of interest is large. This reduces the size of the estimation sample considerably; a feature of the data that has been acknowledged in previous studies that use the NCDS and that use similar sample sizes (Case *et al.*, 2005; Cutler and Lleras-Muney, 2010; Dearden *et al.,* 2002; Lindeboom *et al.*, 2009; Pischke and Manning, 2006). Nevertheless, the periodic reports produced by the NCDS Advisory Panel, as well as recent research papers that have analysed the implications of non-random attrition, have concluded that this is not serious source of bias for models based on the data (for example, Case *et al.*, 2005; Lindeboom *et al.*, 2009; Plewlis *et al.,* 2004). In their study of educational attainment and wages Dearden *et al.* (2002, p.5), who condition on a similar set of variables to us, conclude: "Given the large array of characteristics relating to ability and background, we have reasonable grounds to believe that, in our analysis, attrition is exogenous, given the observables."

Tables 4 and 5 compare the sample means for selected outcomes and some of the key control variables used in the paper for the estimation sample used in the econometric analysis and for all other available observations for each variable. This gives a sense of the impact of item non-response. Table 4 shows that the prevalence of long-standing illness is very similar across the two samples, it also shows how the prevalence grows from 15 per cent at wave 5 to 34 per cent at wave 7. The malaise index and the prevalence of smoking at wave 6 and over waves 5-7 are also comparable over the samples. Table 5 shows that individuals in the estimation sample are comparable to those in the rest of the sample in terms of the kind of schools they attended but there is a notable difference in the cognitive ability score, with the estimation sample having a higher average score.

Table 4
Sample means for outcomes

	Estimation sample	All other observations
LSI wave 7	0.34	0.35

	(n=2832)	(n=4663)
LSI wave 6	0.27	0.29
	(n=2700)	(n=6159)
LSI wave 5	0.15	0.15
	(n=2593)	(n=6286)
Malaise wave 6	3.35	3.63
	(n=2689)	(n=6103)
Smoker wave 6	0.21	0.27
	(n=2698)	(n=6152)
Smoker waves 5-7	0.28	0.32
	(n=2377)	(n=3695)

Table 5

Sample means for type of schooling and cognitive ability

	Estimation sample	All other observations
Comprehensive	0.55	0.57
Secondary modern	0.24	0.25
Private school	0.06	0.07
Attainment	4.76	3.95
Single sex school	0.28	0.27
Ability streams	0.35	0.38
Pupil-teacher ratio	0.06	0.06
Expelled ratio	0.0003	0.0004
Cognitive ability age 7	0.25	-0.02

5.4.2 Balance of covariates between selective and non-selective schools

Pischke and Manning (2006) have drawn attention to the fact that there may be an imbalance in the pre-schooling characteristics of the NCDS respondents who went to selective versus non-selective schools. They find that comprehensive areas were systematically poorer and populated by children with lower educational achievement than selective areas. In this section we explore this imbalance and adopt a matching approach to preprocess the data and improve balance.

One measure that is commonly used to assess the balance of the distribution of covariates in a treated (x^1) and a control group (x^0), before and after matching, is the percentage bias, or normalised difference in means (Rosenbaum and Rubin, 1983; Lalonde, 1986)[60]:

$$\frac{\overline{x}^1 - \overline{x}^0}{\sqrt{(Var(x^1) + Var(x^0)}}.100 \qquad (1)$$

The first column of results in Table 6 shows the percentage bias measure for the unmatched data in our estimation sample for some of the key pre-schooling variables: cognitive ability at 7, the BSAG score, father's social class and ill health at age 7. These reveal fairly substantial imbalance between those who went to comprehensive schools and those who went to selective state schools, with the percentage bias being as high as -16.8 per cent for cognitive ability. It is notable that the percentage bias is even greater, at -31 per cent, for cognitive ability at age 11. The fact that the imbalance is greater for the score at age 11 than it is for age 7 is explored below: in addition to the selection bias discussed by Pischke and Manning (2006) there appears to be a 'coaching effect' - those in selective areas were more likely to practice the kind of ability tests used in the NCDS as part of their preparation for the Eleven Plus.

Table 6

Percentage bias (normalised difference in means between comprehensive and selective schools) before and after pruning and matching for key covariates

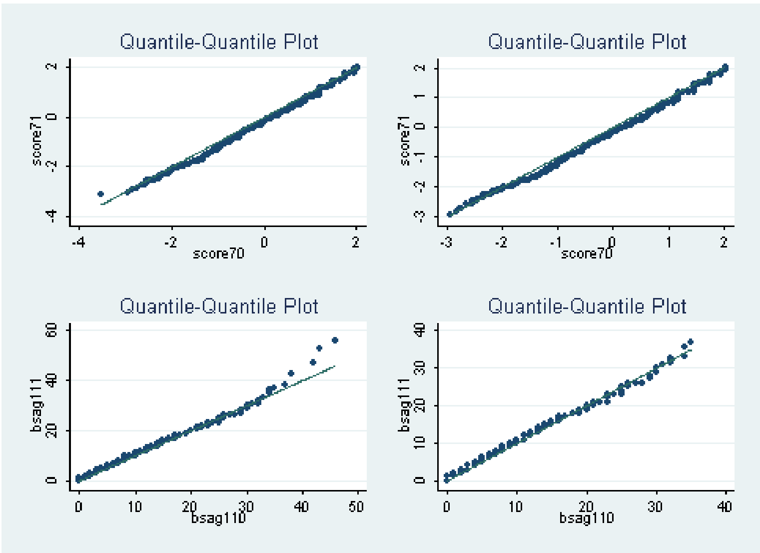
	Unmatched	Matched	t-test (p value)
Cognitive ability age 7	-16.8	-0.1	-0.02 (0.984)
BSAG score	3.8	-0.9	-0.25 (0.799)
Father's social class high	-12.3	0.7	0.19 (0.852)
Father's social class middle	11.6	2.5	0.70 (0.487)
Ill-health age 7	0.8	0.2	0.05 (0.964)
Cognitive ability age 11	-31.0	-30.1	-8.30 (0.000)

Note: Cognitive ability at age 11 is not used as a matching variable.

60 t-tests for the difference in means are often proposed as a way of checking for balancing. This approach is criticised by Ho *et al.* (2007) and Imbens and Wooldridge (2008): for example, "the critical misunderstood point is that balance is a characteristic of the observed sample, not some hypothetical population. The idea that hypothesis tests are useful for checking balance is therefore incorrect." (Ho *et al.,* 2007). They argue that this is compounded by the fact that pruning the sample affects the statistical power of the hypothesis tests and that it is therefore misleading to use tests, such as t-ratios for the difference in means, as a guide to the quality of matching. However this diagnostic is widely used and, for completeness, we do present t-ratios for the differences in means within the matched sample in the final column of Table 6 and subsequent tables.

As the balancing condition relates to the full empirical distribution, not just the sample means, it is wise to check higher moments and cross-moments. Ho *et al.* (2007) suggest that nonparametric density plots and quantile-quantile (QQ) plots for each covariate and their interactions should be compared for the treated and controls. Figure 4 shows the empirical QQ plots for cognitive ability at age 7 and the BSAG score for the unmatched and matched samples. For the unmatched sample the divergence between the distributions is most clear in the tails of the distributions, especially for the upper tail of the distribution of the BSAG score.

Fig.4. *Empirical QQ-plots for cognitive score at 7 and BSAG score: Before (left panels) and after (right panels) matching*



Perfect balancing is unlikely to be achieved in practice and, rather than simply comparing means after matching, running parametric regression models on the matched sample is likely to improve causal inferences (see e.g., Rubin, 1973, 1979, 2006; Heckman, Ichimura and Todd, 1998; Imbens, 2004; Abadie and Imbens, 2006; Ho *et al.,* 2007). In this sense, matching can be used as a nonparametric preprocessing of the data to select observations prior to parametric modelling. We adopt this approach here.

We implement the matching in two steps. In the first step coarsened exact matching is applied to the key measures of cognitive and non-cognitive skills, the ability score at age 7 and the BSAG score at age 11[61]. Then any observations that lie outside the common support of their joint distribution are excluded: this is only 34 cases in our data. The second step uses a combination of propensity score and Mahalanobis exact matching. The propensity score for attending a comprehensive school, as a function of all of the pre-schooling variables, is estimated using a logit model. The propensity score controls for the main pre-policy potential confounders of the relationship between attendance at a particular type of school and the health outcomes of interest. Figure 5 shows the distribution of the propensity score among those who went to selective and to comprehensive schools. Those who went to comprehensive schools are then matched with those who went to selective schools using the propensity score, within the common support and with a caliper of 0.1, combined with exact Mahalanobis matching for two key covariates, cognitive ability at age 7 and the BSAG score. The matching weights are then used in the subsequent regression analyses.

The normalised differences and t-ratios shown in Table 6 and the QQ plots in Figure 4 show how the imbalance in the key covariates is largely removed by this matching process. Table 6 also includes the cognitive ability scores at age 11, which are not used in the matching process. The percentage bias remains substantial for this variable (30.1 per cent) in the matched data. This is explored in the next section.

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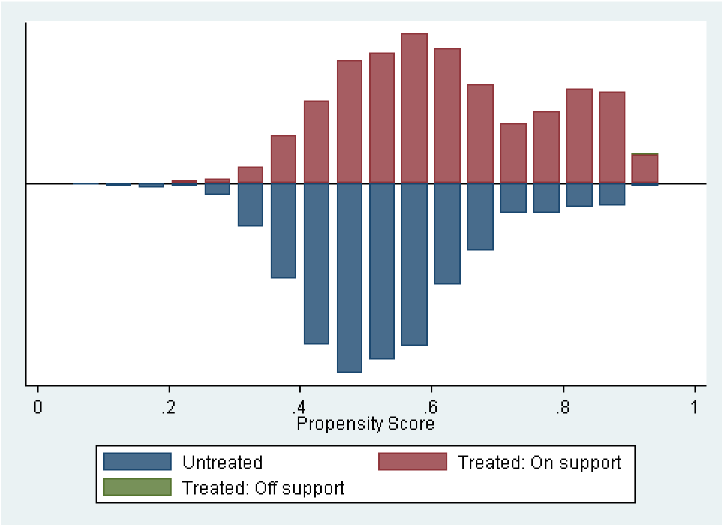
[61] Coarsened exact matching works by splitting the support of continuous covariates into discrete intervals and computing cell frequencies for the multivariate histogram (Blackwell *et al.,* 2009).

Fig.5. *Distribution of propensity score over selective ("untreated") and non-selective ("treated") schools*



5.4.3 'Coaching effects': absolute and relative cognitive ability

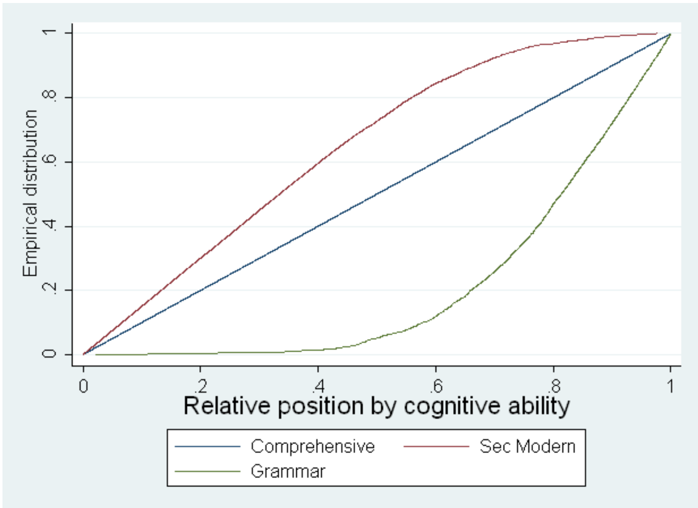
Cognitive ability at age 11 is not used in the matching process because there are good reasons to suspect that matching on the score at age 11 may be a source of post-treatment bias[62]. Those children who lived in areas which had not gone comprehensive may have been exposed to 'coaching' to prepare them for the Eleven Plus, both within their primary schools, where time was often set aside in lessons to prepare for the test, and at home. The cognitive ability test, also administered at age 11, have a lot in common with the components of the Eleven Plus and the resulting scores may therefore be indirectly affected by the kind of secondary school the child was likely to attend. In the matching approach described above we avoid this post-treatment bias by matching on ability at age 7.

Another way of looking at the issue is to focus on relative ability. Figure 6 shows the empirical distributions for relative ability, where rank in the distribution of ability is computed separately for those who went to comprehensive schools and who went to selective schools. By construction the distribution is uniform among the group who went to comprehensive schools, but among those who went to

[62] In fact, in our checks for robustness, we have repeated the matching and regression analyses using absolute ability. This shows that the qualitative estimates of the impact of educational attainment and type of schooling are robust to using either absolute or relative measures and that changes in the magnitudes of the estimates are small.

selective schools there is a clear threshold, around the lower 60 per cent of ability scores between those who went to secondary moderns and those who went to grammar schools. Relative ability therefore plays a central role in creating matched samples by type of school.

Fig.6. *Empirical distributions of relative ability by type of school*



This coaching effect is one way of explaining the results presented by Pischke and Manning (2006) and this is now explored in more detail. First we estimate simple regressions for cognitive ability at age 7 (*Score7*), conditioning on an indicator of attending a comprehensive school (*Comp*) and the other pre-schooling characteristics. The coefficient on *Comp* indicates any selection bias due to systematic differences between those who attended selective versus comprehensive schools, over and above the pre-schooling variables included in the equation, that influence cognitive ability. Table 7 shows that there is a statistically significant difference in the raw data but this disappears when the matched sample is used. The second regression is a value-added specification that regresses cognitive ability at age 11 on ability at age 7, the indicator for comprehensive schooling and an interaction between the two, as well as the other pre-schooling characteristics. Lagged ability captures any selection that has occurred up to age 7 as well as the inherent persistence in cognitive ability, the coefficient on *Comp* is now interpreted as capturing the 'coaching effect' and the coefficient on the interaction term captures any difference in the value-added between those who went on to become comprehensive pupils and others. The coaching effect is large and statistically significant but we do not find evidence of a statistically significant interaction effect for either the unmatched or matched data.

Table 7

Regressions for cognitive ability scores at ages 7 and 11: full sample

	Score age 7		Score age 11	
	Unmatched	Matched	Unmatched	Matched
Comp	**-0.143**	-0.020	**-0.252**	**-0.438**
	(-3.43)	(-0.36)	**(-5.79)**	**(-7.58)**
Score7	-	-	**0.785**	**0.732**
			(27.04)	**(13.98)**
Score7*comp	-	-	-0.028	0.014
			(-0.78)	(0.25)
R^2	0.135	0.147	0.514	0.493
Sample size	2657	2211	2657	2211

Notes:

i. All regressions also condition on the full set of pre-schooling covariates. See Table A.1 for a full list.

ii. Robust t-ratios are given in parentheses. Coefficients that are statistically significant at least a 10 per cent level are shown in bold.

5.4.4 Matched sub-samples

The impact of educational attainment and quality of schooling is likely to depend on the particular type of school that is attended. The existence of heterogeneous effects is explored using a further round of matching that exploits the natural dividing in the population line drawn by the reform: the one separating those who experienced, or would have experienced in the absence of the reform, a grammar school education and those who attended, or would have attended, secondary modern schools. The matching is based on the propensity score for the probability of attending a grammar versus a secondary modern school. This is estimated by a logit model using only the sample who attended selective schools. Predictions of the propensity score are then computed for the whole sample, including those who attended comprehensive schools. The key predictor, that dominates the predictions from the logit model, is relative ability at age 11 (as shown in Figure 6). Those who were exposed to the non-selective system but whose propensity score indicates that they would have attended a grammar school (secondary modern) were they not exposed to the reform, are then matched with those who actually attended at a grammar school (secondary modern). The matching is over the common support with a caliper of 0.1 and uses Mahalanobis matching on the propensity score and exact matching on relative ability at age 11, absolute ability at age 7, the BSAG score and father's social class. Tables 8 and 9 compare the balancing of selected covariates before and after matching for the two sub-samples and demonstrate that a good balance is achieved for both. The final rows of the table show that balance in terms of relative ability at age 11 does not imply balancing of absolute ability[63].

Table 8

Percentage bias (normalised difference in means between grammar and comprehensive schools) before and after matching for key covariates: sub-sample of grammar and comprehensive pupils

	Unmatched sample	Matched sample	t-ratio (p value)
Relative ability age 11	107.3	2.1	0.43 (0.670)
Cognitive ability age 7	93.2	1.8	0.35 (0.724)
BSAG score	-44.7	3.1	0.57 (0.569)
Father's social class high	47.4	0.0	0.00 (1.000)
Father's social class middle	-31.9	0.0	-0.00 (1.000)
Ill-health age 7	-15.0	9.2	1.43 (0.152)
Cognitive ability age 11	144.6	41.5	8.37 (0.000)

Note: Cognitive ability at age 11 is not used as a matching variable.

Table 9

Percentage bias (normalised difference in means between secondary modern and comprehensive schools) before and after matching for key covariates: sub-sample of secondary modern and comprehensive pupils

	Unmatched sample	Matched sample	t-ratio (p value)
Relative ability age 11	-66.3	-2.4	-0.51 (0.613)
Cognitive ability age 7	-25.4	-0.8	-0.16 (0.873)
BSAG score	21.1	3.2	0.55 (0.582)
Father's social class	-13.6	0.0	0.00 (1.000)

[63] This is to avoid the potential for post-treatment bias. We have done robustness checks that include an analysis of what happens when relative ability is replaced by absolute ability.

high			
Father's social class middle	1.7	0.0	0.00 (1.000)
Ill-health age 7	9.2	1.7	0.31 (0.760)
Cognitive ability age 11	-28.8	31.4	6.54 (0.000)

Note: Cognitive ability at age 11 is not used as a matching variable.

5.5 Econometric models and results

5.5.1 Pre-schooling characteristics

Before exploring the direct impact of schooling we begin with simple regressions of the health outcomes on pre-schooling characteristics. These are estimated as unweighted linear regressions with robust standard errors.

Health-related behaviours

Table 10 shows selected results for the measures of health-related behaviour and focuses on key pre-schooling characteristics: cognitive ability at age 7, the BSAG measure of social adjustment at age 11 and father's occupational SES. Childhood cognitive ability has a statistically significant association with two of the adult behaviours: those with higher cognitive ability at age 7 drink more units of alcohol at age 42 but also consume vegetables on more occasions at age 33. As higher cognitive ability is likely to be associated with higher earnings later in life this suggests standard income effects on consumption, irrespective of whether the behaviours are 'healthy' or 'unhealthy'. Most of the other characteristics reported in the table do not have statistically significant associations with the health-related behaviours. An exception is smoking, where those with poorer social adjustment as children are more likely to become smokers and those whose father came from the higher or middle SES are less likely to become smokers.

Table 10
Selected regression results for pre-schooling characteristics and health-related behaviours

	Smoking (age 42)	Drinking (age 42)	Vegetables (age 33)	Fried food (age 33)	Smoking during pregnancy
Sample size	2496	2102	2407	2406	392
Cognitive ability	-0.008	**1.241**	**0.077**	-0.031	-0.016
at 7	(-0.97)	**(2.11)**	**(3.20)**	(-1.55)	(-0.82)
BSAG	**0.007**	0.089	-0.001	-0.001	0.006
	(5.19)	(0.89)	(-0.14)	(-0.16)	(1.53)
Father's SES:	**-0.128**	-0.231	0.009	-0.025	-0.065
professional	**(-4.87)**	(-0.11)	(0.12)	(-0.41)	(-0.97)
Father's SES:	**-0.075**	0.710	-0.060	-0.011	-0.080

other non-manual	**(-3.00)**	(0.37)	(-0.89)	(-0.20)	(-1.27)

Notes:

i. The regression estimates are based on the un-weighted sample.

ii. Robust t-ratios are given in parentheses. Coefficients that are statistically significant at least a 10 per cent level are shown in bold.

iii. All regressions also condition on the full set of pre-schooling covariates. See Table A.1 (Appendix D) for a full list.

Health outcomes

Table 11 shows selected results for the health outcomes: long-standing illness at age 46 and malaise at age 42[64]. Cognitive ability is not significantly associated with health outcomes but there is a strong association with social adjustment. Those with more problems with social adjustment as children are more likely to suffer both physical and mental illness as adults. There is also evidence of a socioeconomic gradient in illness by father's social class.

Table 11

Selected regression results for pre-schooling characteristics and health outcomes

	LSI		Malaise
	LPM	Probit	
Sample size	2623		2487
Cognitive ability at age 7	-0.008	-0.008	-0.062
	(-0.87)	(-0.85)	(-0.89)
BSAG score	**0.005**	**0.005**	**0.050**
	(3.65)	**(3.74)**	**(4.11)**
Father's SES: professional	-0.036	-0.035	**-0.376**
	(-1.23)	(-1.22)	**(-1.78)**
Father's SES: other non-manual	**-0.044**	**-0.043**	-0.076
	(-1.70)	**(-1.71)**	(-0.40)

See notes for Table 10.

64 The results show estimates for both a linear regression (linear probability) model and partial effects from a probit model, estimated at the mean of the regressors, for long-standing illness. The two specifications give virtually identical results and are presented to illustrate this finding. This applies to all of the nonlinear regression models we estimated and the rest of the paper focuses on linear regression results.

5.5.2 The impact of attainment and quality of schooling with controls for observables

We begin our analysis of the impact of educational attainment and the quality of schooling by presenting parametric models of adult health-related behaviours and health outcomes. These are estimated for the full matched sample and condition on all of the pre-schooling variables that are also used in the matching process which span parental socioeconomic status, childhood and family health, cognitive ability (relative score at age 11 and absolute score at 7), social adjustment, experience of primary schooling, and characteristics of the child's neighbourhood (ED). The models are estimated as linear regressions with robust standard errors[65].

Health-related behaviours

Table 12 shows that educational attainment, measured by the 12-point scale for highest secondary qualification, has a statistically significant association with smoking, diet and maternal behaviour. Those with higher attainment are less likely to be smokers and they consume vegetables more frequently. There is little evidence of quality of schooling, as measured by single sex schools, academic streaming, the pupil-teacher ratio and the ratio of expelled pupils, having a direct effect on health-related behaviours.

Table 12

Effect of educational attainment and quality of schooling on health-related behaviours

	Smoking (age 42)	Drinking (age 42)	Vegetables (age 33)	Fried food (age 33)	Smoking during pregnancy
Sample size	2100	1772	2024	2023	319
Attainment	**-0.021**	-0.243	**0.026**	-0.012	**-0.025**
	(-4.45)	(-0.61)	**(1.99)**	(-1.09)	**(-2.31)**
Single sex	-0.011	-0.237	-0.112	-0.090	0.030
	(-0.47)	(-0.12)	(-1.29)	(-1.44)	(0.54)
Streaming	0.030	-2.482	-0.091	0.092	0.045
	(1.34)	(-1.45)	(-1.37)	(1.60)	(0.84)
Pupil-teacher	1.476	85.66	-5.493	2.373	**-7.105**
	(0.73)	(0.57)	(-0.93)	(0.51)	**(-1.96)**
Expelled	10.20	-691.4	-22.326	30.39	26.45

65 Nonlinear versions of the models have been estimated as well and the partial effects from these models show little difference from the linear specifications.

	(0.76)	(-0.91)	(-0.77)	(0.80)	(0.57)

Notes:

i. The regression estimates are based on the matched sample.
ii. Robust t-ratios are given in parentheses. Coefficients that are statistically significant at least a 10 per cent level are shown in bold.
iii. All regressions also condition on the full set of pre-schooling covariates. See Table A.1 (Appendix D)for a full list.

Health outcomes

Table 13 shows that, on average, lower educational attainment is associated with poorer mental health later in life. There is no evidence of a statistically significant effect on long-standing illness or of an association between either of the health outcomes and quality of schooling.

Table 13
Effect of educational attainment and quality of schooling on health outcomes

	LSI		Malaise
	LPM	Probit	
Sample size	2211		2092
Attainment	-0.007	-0.007	**-0.096**
	(-1.10)	(-1.10)	**(-2.40)**
Single sex school	-0.025	-0.028	-0.105
	(-0.81)	(-0.86)	(-0.46)
Streaming	0.035	0.037	0.224
	(1.36)	(1.39)	(1.18)
Pupil-teacher ratio	1.121	1.242	18.73
	(0.48)	(0.52)	(1.13)
Ratio of pupils expelled	8.739	9.087	69.40
	(0.67)	(0.72)	(0.91)

See notes for Table 12.

5.5.3 Instrumental variables estimates

The strategy of controlling for observables, implemented in Section 4.2 accounts for many factors identified in the literature as potential joint determinants of schooling and adult health. This section adopts an instrumental variables (IV) strategy to complement the previous results. Due to the transition period following the comprehensive education reform, some NCDS cohort members experienced the pre-existing tri-partite selective system of education, but others experienced the comprehensive system introduced by the reform. The literature devoted to the impact evaluation of this policy reform raises concerns about the allocation of pupils to one of these two educational systems; in particular, this could be guided by self-selection on perceived gains. Following Vignoles and Galindo-Rueda (2004), an instrumental variable strategy can be adopted that exploits geographic variation in the availability of places at selective and non-selective schools. The most direct measure is the percentage of the LEA that was comprehensive in 1974. The other instrument used by Vignoles and Galindo-Rueda (2004) is based on the 1974 General Election results. The Conservative Party opposed the comprehensive reform and the prevalence of selective system schools was higher in the constituencies controlled by them than in other constituencies.

In practice we find that the share of comprehensive places in a LEA has far greater predictive power in the first stage regressions than the indicator of conservative controlled constituencies so we focus on results that use the former as an instrument[66]. The IV estimates are substantially larger in absolute magnitude than the non-IV estimates, but the standard errors are also proportionately larger so that the estimated effects are not statistically significant. Other studies have reported similarly large effects when an instrumental variable approach is applied, both in the context of health (see e.g., Arendt, 2005, 2008; Lleras-Muney, 2005) and educational attainment (e.g., Vignoles and Galindo-Rueda, 2004). But, even though these estimates can be interpreted as local average treatment effects, the large magnitude of the estimates casts some doubt on the validity of the IV identification conditions.

Table 14

Effect of educational attainment on health-related behaviours: IV estimates

	Smoking	Drinking	Vegetables	Fried	Smoking

[66] Following Galindo-Rueda and Vignoles (2004) and Pischke and Manning (2006) we have investigated heterogenity in the impact of the instrument by interacting it with cognitive ability. Reduced form regressions for educational attainment show that the share of comprehensives in a LEA is a significant predictor of attainment. When the models are extended to include interactions of the instrument with cognitive ability at age 11, either split into the bottom 60% and top 40% or split into deciles, these show that the impact of the instrument is relatively homogeneous across the distribution of ability.

	(age 42)	(age 42)	(age 33)	food (age 33)	during pregnancy
Non-IV	**-0.021**	-0.243	**0.026**	-0.012	**-0.025**
	(-4.45)	(-0.61)	**(1.99)**	(-1.09)	**(-2.31)**
IV	-0.039	-2.387	-0.094	-0.015	0.118
	(-1.31)	(-1.17)	(-0.94)	(-0.18)	(0.48)
Robust F	38.58	37.58	34.99	34.82	0.69
	(0.000)	(0.000)	(0.000)	(0.000)	(0.406)

Notes:

i. The regression estimates are based on the matched sample. Non-IV reports the coefficient for educational attainment from the standard regression moldels IV reports the instrumental variable estimate.

ii. Robust t-ratios are given in parentheses. Coefficients that are statistically significant at least a 10 per cent level are shown in bold.

iii. All regressions also condition on the full set of pre-schooling covariates. See Table A.1 for a full list.

iv. Robust F is the robust F statistic for the predictive power of the instrument in the first stage regression.

Table 15

Effect of educational attainment on health outcomes: IV estimates

	LSI	Malaise
Non-IV	-0.007	**-0.096**
	(-1.10)	**(-2.40)**
IV	**-0.075**	**-0.855**
	(-1.93)	**(-2.84)**
Robust F	36.53	38.62
	(0.000)	(0.000)

See notes for Table 14.

5.5.4 Heterogeneous effects by type of school

To explore heterogeneity in the impact of educational attainment by the type of school attended we repeat the regressions using the matched sub-samples. The first sub-sample consists of those who went or would have gone to grammar schools and the second sub-sample consists of those who went or would have gone to secondary moderns.

Tables 16 and 17 show selected results for the impact of educational attainment on health-related behaviours. For both sub-samples educational attainment has some statistically significant impacts on health-related behaviours: reducing the likelihood of being a smoker and increasing the frequency of eating vegetables. Among the secondary modern sub-sample educational attainment also reduces the frequency of eating fried food but increases the weekly consumption of alcohol, perhaps reflecting a standard income effect on consumption rather than a health effect.

Table 16

Effect of educational attainment on health-related behaviours: matched sample of grammar and comprehensive pupils

	Smoking (age 42)	Drinking (age 42)	Vegetables (age 33)	Fried food (age 33)	Smoking during pregnancy
Sample size	713	629	690	690	162
Attainment	**-0.010**	-0.355	**0.036**	-0.011	-0.016
	(-1.99)	(-0.86)	**(2.12)**	(-0.81)	(-1.40)

Notes:

i. The regression estimates are based on the matched sub-sample.

ii. Robust t-ratios are given in parentheses. Coefficients that are statistically significant at least a 10 per cent level are shown in bold.

iii. All regressions also condition on the full set of pre-schooling covariates. See Table A.1 for a full list.

Table 17

Effect of educational attainment on health-related behaviours: matched sample of secondary modern and comprehensive pupils

	Smoking (age 42)	Drinking (age 42)	Vegetables (age 33)	Fried food (age 33)	Smoking during pregnancy
Sample size	1063	873	1027	1027	125
Attainment	**-0.038**	**0.959**	**0.064**	**-0.054**	-0.010
	(-5.00)	**(2.06)**	**(2.68)**	**(-2.95)**	(-0.33)

See notes for Table 16.

Tables 18 and 19 show selected results for the impact of schooling on health outcomes for the matched sub-samples. These reveal that the impact of educational attainment on adult health is concentrated among those who either did or would have attended grammar schools.

Table 18
Effect of educational attainment on health outcomes: matched sample of grammar and comprehensive pupils

	LSI		Malaise
	LPM	Probit	
Sample size	743		710
Attainment	**-0.012**	**-0.012**	**-0.110**
	(-1.82)	**(-1.78)**	**(-2.39)**

See notes for Table 16.

Table 19
Effect of educational attainment on health outcomes: matched sample of secondary modern and comprehensive pupils

	LSI		Malaise
	LPM	Probit	
Sample size	1127		1059
Attainment	0.006	0.006	-0.012
	(0.67)	(0.66)	(-0.19)

See notes for Table 16.

5. 6 Discussion

The economic literature on human development was initially centred on documenting the relationship between cognitive ability and a wide range of social outcomes of interest. More recent work has additionally underlined the importance of non-cognitive skills most notably in determining education (Heckman and Rubinstein, 2001), and labour market outcomes (Carneiro *et al.*, 2007; Heckman *et al.*, 2006; Kuhn and Weinberger, 2005; Feinstein, 2000). This literature has suggested that cognitive and non-cognitive skills may act as substitutes in determining some outcomes (e.g. employment) but complements for others (e.g. wages) and that their impact operates both directly and through educational attainment (Carneiro *et al.*, 2007). Cognitive and non-cognitive skills have also been linked to a series of health and health-related behaviours. Heckman *et al.* (2006) find that both influence smoking in adolescence and teenage pregnancy with non-cognitive skills being more important determinants than cognitive skills. Similarly

Carneiro *et al.* (2007) find a negative relationship between social skills and teenage smoking and pregnancy but report cognitive and non-cognitive skills to be equally important. In addition they find evidence of a link between cognitive and non-cognitive skills and adult health status.

Our findings corroborate some of this earlier work. We find that non-cognitive ability measured through social adjustment as a child is strongly associated with health, with those who had problems with social adjustment being more likely to suffer both physical and mental illness as adults. In addition there is also a strong relationship with smoking age at 42 with those with poorer social adjustment as a child more likely to be an adult smoker. In contrast, conditional on social adjustment we find cognitive ability at age 7 is not significantly associated with health outcomes in adulthood.

We find evidence of a socioeconomic gradient in health and health related behaviours by father's occupational SES, with those whose father had a non-manual occupation less likely to report physical and mental illness and less likely to become smokers. Taken together these results corroborate evidence for the existence of inequality of opportunity in health among NCDS cohort members reported by Rosa Dias (2009). Childhood health also has a statistically significant effect on adult health, corroborating similar results from Case *et al.* (2005).

Members of the National Child Development Study (NCDS) cohort attended very different types of secondary schools, as their schooling lie within the transition period of the comprehensive reform in England and Wales. This provides a natural experiment to explore the impact of educational attainment and of school quality on health and health-related behaviour later in life. We use a combination of matching methods, parametric regressions, and instrumental variable approaches to evaluate differences in adult health outcomes for cohort members exposed to the old selective and to the new comprehensive educational systems.

We find educational attainment to have the expected association with health-related behaviours (smoking, smoking in pregnancy and the consumption of healthy foods) and to be negatively related to mental ill-health in adulthood but not physical health. However, this overall net impact encases important heterogeneity that we explore by splitting the sample across the key dividing line in the population drawn by the reform, the one separating those who experienced, or would have experienced, a grammar school education and those who attended, or would have attended, secondary modern schools. When those who went to grammar are matched to comparable individuals who attended comprehensives, higher attainment is associated with lower rates of adult smoking, higher rates of the consumption of vegetables and lower incidence of both physical and mental health. Interestingly, however, the impact of attainment on health-related behaviours is larger and covers a wider range of behaviours for those who attended (or would have attended) secondary modern schools. Given that detrimental lifestyles are more prevalent in the latter sub-sample, this may indicate the existence of diminishing returns by level of educational attainment. Carneiro *et al.* (2007) report findings that are akin to these, suggesting that the health returns to investments in social adjustment may be diminishing in the relative social position of one's parental background.

The asymmetry in the impact of attainment on health outcomes is even more striking. For the sub-sample in which cohort members who attended grammar schools are matched with comparable individuals who attended comprehensives we find positive and statistically significant effects both on physical and on mental health. In contrast, no effects were found for those who attended (or would have attended) secondary modern schools. Variation in attainment within the former sub-sample, which is partly generated by the fact that some of the group went to academically intensive grammar schools while the others went to comprehensives, has more impact on health than variation in attainment in the latter sub-sample. This may imply that quality of schooling works as a catalyst in the relationship between attainment and health. Cutler and Lleras Muney (2010) point-out a similar hypothesis, suggesting that peer effects do not explain why better educated groups have better health to begin with, but are likely to magnify the positive impact of education on health. Additionally, the different effect between sub-samples may also reflect a non-linearity in the returns to different levels of attainment, given that average attainment is lower, and its distribution more compressed, in the latter group than in the former.

Appendix D

Table A.1

Full set of pre-schooling and secondary school characteristics

	Variables
Pre-schooling characteristics	
	Cognitive ability score (age 7)
	Relative rank of cognitive ability (age 11)
	BSAG score (age 11)
	Number of chldren in primary school class (age 7)
	Indicator for unhappy at primary school (age 7)
	Indicator for parents' wanting child to stay in school
	Indicator for male
	Morbidity index (age 7)
	Number of hospitalisations (age 7)
	Indicator for diabetes in family
	Indicator for epilepsy in family
	Indicator for heart disease in family
	Indicator for father's occupational SES professional
	Indicator for father's occupational SES other non-manual
	Indicator for financial hardship in family (age 7)
	Enumeration district: percentage unemployed/long-term sick
	Enumeration district: percentage women working
	Enumeration district: percentage employed in manufacturing
	Enumeration district: percentage emplyed in agriculture
	Enumeration district: percentage in professional/managerial occupations
	Enumeration district: percentage in other non-manual occupations
	Enumeration district: percentage in skilled manual occupations
	Enumeration district: percentage in semi-skilled manual occupations
	Enumeration district: percentage in unskilled manual occupations
	Enumeration district: percentage owner occupiers
	Enumeration district: percentage council tenants
	Enumeration district: percentage non-white
	Enumeration district: percentage immigrants
	Indicators for Standard Regions
Secondary school characteristics	
	Indicator for single sex school
	Indicator for streaming by ability within school
	Pupil-teacher ratio
	Ratio of expelled to total pupils

Chapter 6

Conclusions

Inequality of opportunity in health and human development is the common thread that connects the chapters in this thesis.

Chapter 2 shows that after accounting for differences in health outcomes arising from individual choice, and despite largely free healthcare provision, there remains a sizeable degree of inequality of opportunity among NCDS cohort members that accounts for at least 21% of overall observed health inequalities. This corroborates earlier contributions by confirming that parental socioeconomic status, health endowments in early life and financial hardship in childhood have long-lasting consequences on health. But it also adds to the literature, by focusing on the complex network of channels through which these consequences arise. While part of the effect of circumstances on health is shown to be a direct effect, the analysis also finds an important part that is exerted by means of conditioning individual choices and health-related behaviours later in life. This has clear policy implications. For example, the case of childhood obesity is presented as an example of a circumstance whose effect is mainly a direct one, hence amenable to policy only during the early years of life; this lends support to a series of policies currently in place to target childhood obesity as an objective in itself. Evidence on indirect effects is also provided in Chapter 2, such as the effect of education, which affects health through lifestyle choices. This suggests that educational policies may be an important complement of health care interventions towards the reduction of health inequalities.

An important aspect that is left unexplored in Chapter 2 concerns the role played by health care use; this is dictated by the paucity of the NCDS data on key aspects of health care received. Nonetheless, identifying, measuring and explaining inequality of opportunity in health care use is a promising avenue for further research, and the methods proposed in Chapter 2 can be readily extended for that purpose[67].

Chapter 3 proposes a behavioural model that integrates the normative framework of inequality of opportunity with positive economic theory of health capital and demand for health. This model is also built with the purpose of explicitly addressing the widely discussed *partial-circumstance problem*. Chapter 3 confirms that this problem is empirically relevant, but also shows that it can be dealt with through standard econometric methods by implementing a FIML system estimation with freely correlated errors.

The analysis in Chapter 3 also sheds further light on the triangular relationship between circumstances, effort and health. First, it extends the analysis to a broader set of health outcomes, comprising the incidence of long-standing illness, disability and mental disorders, in addition to self-assessed health. Taking into account this vector of outcomes makes clear that, while all of its elements are strongly affected by unfair circumstances, each element responds to a different subset of circumstance factors. Second, it corroborates the importance of indirect effects of circumstances on health, such as those of social adjustment in childhood and educational attainment on crucial lifestyle choices.

Two promising of avenues for future research can be devised as extensions to this chapter. The first is theoretical and consists of the analytical derivation of conjectural bounds for the error incurred, in the Roemer model, while ignoring the partial observability of circumstances. This is an interesting, but especially complex, mathematical problem, which is beyond the scope of this thesis. The second consists of generalising the econometric approach implemented in this chapter so that other instruments developed for tackling unobserved heterogeneity can be made useful to surmount the partial circumstance problem. For example, in the context of the Roemer model, latent class specifications might be particularly useful

[67] Another interesting issue concerns the trajectory of inequality of opportunity in health after age 46: the prevalence of illness in a cohort tends to increase sharply after the mid-40's and it would be interesting to analyse the way in which this affects the inequality of opportunity trends reported in Chapter 2.

for achieving a definition of social types reflecting both observed and unobserved circumstances.

Chapters 4 and 5 explore the relationship between different aspects of human development, education and health in adulthood. The motivation for this focus is twofold. First, it allows the determination of the differences in education that are leading sources of inequality in health; as suggested by the results of Chapters 2 and 3, understanding this relationship is vital if educational policy is to be used to equalise opportunities in health. Second, despite a large literature on the relationship between education and health, little is known about crucial aspects of this relationship, such as the role played by quality of schooling. The analysis of such aspects constitutes a separate contribution to this literature, independent from normative considerations.

Chapter 4 examines the association between several dimensions of quality of education and a range of health outcomes in adulthood. According to the stochastic dominance conditions proposed in Chapter 2, conditioning on attendance at different types of secondary schools is sufficient to establish inequality of opportunity among NCDS cohort-members with regard to most health outcomes.

Overall, the results support the existence of long-term health returns to different qualities of education, over and above the effects of measured ability, social development, years of schooling and academic qualifications. However, the association between different qualitative dimensions of primary and secondary schooling is uneven across the set of outcomes of interest. For example, the majority of proxies for quality of primary schooling do not have a statistically significant association with self-assessed health and with the incidence of physical long-term impairments in adulthood, but are closely associated with the incidence of mental illness.

The main source of variation in school quality in the NCDS is attendance at different types of secondary schools. The results show that after controlling for a rich set of control variables, attendance at some types of schools, such as secondary modern and comprehensive schools, is associated with a much higher incidence of chronic illness and disability in adulthood, than others, such as grammar schools. There is also a statistically significant and economically relevant association between standard measures of poor quality of secondary schooling, such as the pupil expulsion rate, and a deterioration of self-assessed health in adulthood.

The results in Chapter 4 do not, however, substantiate the statistical importance of several hypothesised mediating channels between quality of schooling and health: hard evidence is only found for the importance of socioeconomic status in adulthood as a mechanism linking quality of primary schooling to health later in life. This is likely to be due to the impracticality of using NCDS data to investigate plausible mediating factors such as subjective discount rates, risk aversion patterns, information processing capacity and health-related literacy. Information for carrying-out this type of investigation is available in other datasets, such as the *National Survey of Midlife Development in the United States* used recently in Cutler and Lleras-Muney (2010), and can form the basis for future research in this area.

Chapter 5 advances the analysis of Chapter 4 in two ways. First, by exploiting the natural experiment provided by the comprehensive education reform implemented in England and Wales to investigate the existence of causal effects of educational attainment and quality of schooling on health and health-related behaviour later in life. Second, by extending the analysis to aspects such as non-cognitive ability, which has recently been given centre stage in the economics of human development.

Results show that non-cognitive ability as a child is strongly associated with health and health-related behaviour in adulthood: those who had social maladjustment problems in childhood are significantly more likely to suffer from physical illness, mental disorders and to be smokers later in life. In contrast, conditional on non-cognitive ability, cognitive skills at age 7 are not significantly associated with the majority of the health outcomes at age 46.

Educational attainment is also found to have the expected association with health-related behaviours (smoking, smoking in pregnancy and the consumption of healthy foods) and to be negatively related to mental ill-health in adulthood. However, this overall net impact encases important heterogeneity that is explored by splitting the sample across the key dividing line drawn by the reform: that separating those who experienced, or would have experienced, a grammar school education and those who attended, or would have attended, secondary modern schools. When those who went to grammar schools are matched to comparable individuals who attended comprehensives, higher attainment is associated with lower rates of adult smoking, higher rates of the consumption of vegetables and lower incidence of both physical and mental health. Interestingly, the impact of attainment on health-related behaviours is larger and covers a wider range of behaviours for those who attended (or would have attended) secondary modern schools. The standard rationale of diminishing returns by level of educational attainment is a plausible explanation for this result.

The impact of attainment on health outcomes is even more markedly asymmetric: large positive effects are found on physical and mental health for the sub-sample in which individuals who attended grammar schools are matched with cohort-members who attended comprehensives. In contrast, no effect is found for individuals who attended, or would have attended, secondary modern schools. In other words, variation in attainment within the former sub-sample, generated partly by the fact that some in the group attended academically intensive grammar schools while the others attended comprehensives, has a greater impact on health than variation in attainment in the latter sub-sample. A range of possible interpretations is suggested for this result. It may reflect a non-linearity in the returns to different levels of attainment, since the distribution of attainment is considerably more compressed for those who attended the least academically demanding types of schools. Alternatively, this asymmetry may reflect that quality of schooling is a catalyst in the relationship between attainment and health: it does not explain why better educated sub-samples have better health to begin with, but is likely to magnify the positive impact of education on health.

Bibliography

Abadie, A. and Imbens, G. 2006. Large sample properties of matching estimators for average treatment effects, Econometrica, 74, 235-67.

Albouy, V. and Lequien, L. 2008. Does compulsory education lower mortality? Journal of Health Economics, 28, 155-168.

Alderman, H., Hoddinott, J., Kinsey, B. 2006. Long term consequences of early childhood malnutrition. Oxford Economic Papers 58, 450–474.

Arendt, J. N. 2005. Does education cause better health? A panel data analysis using school reforms for identification. Economics of Education. 24(2), 149-160.

Arendt, J. N. 2008. In sickness and in health - Till education do us part: education effects on hospitalization. Economics of Education Review (27) 161–172.

Arneson, R. 1989. Equality and equal opportunity for welfare. Philosophical Studies 56, 77-93.

Auld, M.C. and Sidhu, N. 2005. Schooling, cognitive ability and health, Health Economics, 14, 1019-1034

Balia, S. and Jones, A. M. 2008. Mortality, lifestyle and socio-economic status. Journal of Health Economics 27(1), 1-26.

Barker, D.J.P. 1995. Foetal origins of coronary disease. British Medical Journal 311, 171-174.

Barry, B. 1991. Chance, Choice and Justice in: Liberty and Justice: Essays in Political Theory. 142-158. Oxford University Press, Oxford.

Bensaid, J. and Fleurbaey, M. 2003. La fiscalité des ensembles de budgets: Quelques

Betts, J. and Roemer, J. 1998. Equalizing opportunities through educational finance reform. U. C. Davis Working Paper No. 99-08.

Blackwell, M., Iacus, S., King, G. and Porro, G. 2009. Cem: coarsened exact matching in Stata, The Stata Journal, 9, 524-546.

Bommier, A. and Stecklov, G. 2002. Defining health inequality: why Rawls succeeds where social welfare theory fails. Journal of Health Economics 21, 497-513.

Bossert, W. 1995. Redistribution mechanisms based on individual characteristics. Mathematical Social Sciences 29, 1-17.

Bourguignon, F. Ferreira, F and Menéndez, M. 2005. Inequality of Opportunity in Brazil. World Bank Policy Research Working Paper Series No. 3174.

Carbone, J. C., Kverndokk, S. and Rogeberg, O. J. 2005. Smoking, health, risk and perception. Journal of Health Economics 24(4), 631-653.

Carneiro, P. Crawford, C. and Goodman, A. 2007. The impact of cognitive and non-cognitive skills on later outcomes. CEE Discussion Papers.

Case, A. Ferting, A. and Paxon, C. 2005. The lasting impact of childhood health and circumstance. Journal of Health Economics 24, 365-389.

Chou, S-Y. Liu, J-T. Grossman, M. and Joyce, T. 2010. Parental education and child health: evidence from a natural experiment in Taiwan, American Economic Journal: Applied Economics, 2, 33-61.

Cohen G. A. 1989. On the currency of egalitarian justice. Ethics 99, 906-944.

Coneus, K. and Laucht, M. 2008. The effect of early noncognitive skills on social outcomes in adolescence, ZEW Centre for European Economic ResearchDiscussion Paper No. 08-115.

Contoyannis, P. and Forster, M. 1999. The distribution of health and income: a theoretical framework. Journal of Health Economics 18, 605-622.

Contoyannis, P. and Jones, A.M. 2004. Socio-economic status, health and lifestyle. Journal of Health Economics 23(5), 965-995.

Contoyannis, P. Jones, A.M. and Rice, N. 2004. The dynamics of health in the British Household Panel Survey. Journal of Applied Econometrics 19, 473-503.

Contoyannis, P. and Dooley, M. 2009. The Role of Child Health and Economic Status in Educational, Health and Labour Market Outcomes in Young Adulthood. Canadian Journal of Economics 43(1) 323-346.

Currie, J. and Moretti, E. 2003. Mother's education and the intergenerational transmission of human capital: evidence from college openings. Quarterly Journal of Economics, 118(4), 1495–1532.

Currie, J. Stabile, M. 2004. Socioeconomic status and health: why is the relationship stronger for older children? American Economic Review 93(5), 1813-1823.

Cutler, D. and Lleras-Muney, A. 2008. Education and Health: evaluating theories and evidence, in (R.F. Schoeni, J.S. House, G. Kaplan and H. Pollack, eds), Making Americans Healthier: Social and Economics Policy as Health Policy, New York: Russell Sage Foundation.

Cutler, D. and Lleras-Muney, A. 2010. Understanding differences in health behaviors by education. Journal of Health Economics, 29(1), 1-28.

Dardanoni, V. and Wagstaff, A, 1987. Uncertainty, inequalities in health and the demand for health. Journal of Health Economics 6(4), 283- 290.

Dardanoni, V. and Wagstaff, A, 1990. Uncertainty and the demand for medical care. Journal of Health Economics 9(1), 23-38.

De la Croix, D., Doepke, M. 2003. Inequality and growth: why differential fertility matters. American Economic Review 93, 1090–1113.

Dearden, L. Ferri, J. And Meghir, C. 2002. The effect of school quality on educational attainment and wages, Review of Economics and Statistics. vol. LXXXIV, 1-20.

Deb, P and Trivedi, P. 2006. Specification and Simulated Likelihood Estimation of a Non-normal Outcome Model with Selection: Application to Health Care Utilization. Econometrics Journal, 9(2) 307-331.

Devaux M., Jusot F., Trannoy A. and Tubeuf S. 2008. La santé des séniors selon leur origine sociale et la longévité de leurs parents. Economie et Statistique, in press.

Dustmann, C., Rajah, N. and van Soest, A. 2003. Class size, education and wages. Economic Journal, vol. 113, F99-F120.

Dworkin, R. 1981. What is equality? Part 2: Equality of resources. Philosophy & Public Affairs 10, 283-345.

Dworkin, R. 2000. Sovereign Virtue. The Theory and Practice of Equality, Harvard University Press, Cambridge, Mass.

Dworkin, R. 2002. Sovereign Virtue revisited. Ethics. 113, 106-143.

Erreygers, G. 2009. Correcting the Concentration Index. Journal of Health Economics 28(2), 504-15.

Feinstein, L. and Symons, J. 1999. Attainment in secondary school, Oxford Economic Papers, 51, 300-321.

Feinstein, L. 2000. The relative economic importance of academic, psychological, and behavioural attributes developed in childhood, CEP Discussion Paper.

Fleurbaey, M. 1994. On fair compensation. Theory and Decision 36, 277-307.

Fleurbaey, M. 2008. Fairness, responsibility and welfare. Oxford University Press

Fleurbaey, M. and Schokkaert, E. 2009. Unfair inequalities in health and health care. Journal of Health Economics 28(1), 73-90.

Forster, M. 2001. The meaning of death: some simulations of a model of healthy and unhealthy consumption. Journal of Health Economics 20, 613-638.

Galindo-Rueda, F. and Vignoles, A. 2004. The heterogeneous effect of selection in secondary schools: understanding the changing role of ability. IZA Discussion Paper No. 1245.

Galindo-Rueda, F. and Vignoles, A. 2005. The declining relative importance of ability in predicting educational attainment. *Journal of Human Resources* 40(2), 335-353

Gravelle, H. 2003. Measuring income related inequality in health: standardisation and the partial concentration index. Health Economics 12, 803-819.

Grimard, F. and Parent, D. 2007. Education and smoking: Were Vietnam War draft avoiders also more likely to avoid smoking? Journal of Health Economics, 26(5), 896-926.

Grossman, M. 1972. On the concept of health capital and the demand for health. Journal of Political Economy 80(2), 223-255.

Grossman, M. 2006. Education and nonmarket outcomes, in (E. Hanushek and F. Welch, eds.), Handbook of the Economics of Education. Amsterdam: Elsevier.

Heckman, J.J., Ichimura, H. and Todd, P.E. 1998. Matching as an econometric evaluation estimator, Review of Economic Studies, 65, 261-94.

Heckman, J.J. and Rubinstein, Y. 2001. The importance of noncognitive skills: lessons from the GED testing program, American Economic Review, 91, 45-49.

Heckman, J., Stixurd, J. and Urzua, S. 2006. The effects of cognitive and noncognitive abilities on labour market outcomes and social behavior. Journal of Labor Economics 24(3), 411-482.

Heckman, J.J. 2008. Role of income and family influence on child outcomes, Annals of New York Academy of Sciences, 1136, 307-323.

Ho, D.E., Imai, K., King, G. and Stuart, E.A. 2007. Matching as nonparametric preprocessing for reducing model dependence in parametric causal inference, Political Analysis, 15, 199-236.

Idler, E L. and Kasl, S. V. 1995. Self-ratings of health: do they also predict change in functional ability? Journal of Gerontology 50(6), 344-53.

Imbens, G.W. 2004. Nonparametric estimation of average treatment effects under exogeneity: a review, Review of Economics and Statistics, 86, 4-29.

Imbens, G.W. and Wooldridge, J.M. 2008. Recent developments in the econometrics of program evaluation, NBER Working Paper 14251.

Jesson, D. 2000. The comparative evaluation of GCSE value-added performance by type of school and LEA, University of York discussion paper No. 2000/52.

Jones, A. M. 1989. A double hurdle model of cigarette consumption. Journal of Applied Econometrics 4, 23-39.

Keaster, R. 2009. Adolescent cognitive and non-cognitive correlates of adult health, National Bureau of Economic Research, Working Paper 14924.

Kenkel, D. S. 1995. Should you eat breakfast? Estimates from health production functions. Health Economics 5, 15-25.

Kerckhoff, A.C. Fogelman, K., Crook, D. and Reeder, D. 1996. Going comprehensive in England and Wales: A Study of Uneven Change. London, The Woburn Press.

Kuh, D. J. and Wadsworth, M. E. 1993. Physical health status at 36 years in a British national cohort. Social Science and Medicine 37(7), 905-916.

Kuhn, P. and Weinberger, C. 2005. Leadership skills and wages', The Journal of Labor Economics, 23, 395-436.

Lalonde, R.J. 1986. Evaluating the econometric evaluations of training programs with experimental data, American Economic Review, vol. 76, 604-20.

Lambert, P. J. 2001. The Distribution and Redistribution of Income. Manchester University Press.

Le Grand, J. and Burchardt, T. 2002. Constraint and Opportunity: Identifying Voluntary Unemployment. CASE discussion paper series No. 55, LSE.

Lechene, V. and Adda, J. 2004. On the identification of the effect of smoking on mortality. CeMMAP working paper series No. CWP13/04.

Lefranc, A. Pistolesi, N and Trannoy, A. 2004. Le revenue selon l'origine sociale. Économie et Statistique 31, p.49-88.

Lefranc, A., Trannoy, A. and Pistolesi, N. 2008a. Equality of opportunity: Definitions and testable conditions with an application to income in France. THEMA working papers series No. 2006-13, University of Cergy-Pontoise.

Lefranc, A., Trannoy, A., and Pistolesi, N. 2008b. Inequality of opportunities vs inequality of outcomes: Are western societies all alike? Review of Income and Wealth 54, 513-546

Lefranc, A., Pistolesi, N. and Trannoy, A. 2009. Equality of opportunity and luck: Definitions and testable conditions, with an application to income in France. Journal of Public Economics 93(11-12), 1189-1207.

Lindeboom, M., Llena-Nozal, A. and van der Klaauw, B. 2006. Disabiliy and work: the role of childhood circumstances. Timbergen Institute discussion paper 06-039/3, Tinbergen Institute.

Lindeboom, M., Llena-Nozal, A. and Van der Klaauw, B. 2009. Parental education and child health: evidence from a schooling reform, Journal of Health Economics, vol. 28, 109-131.

Lleras-Muney, A. 2005. The relationship between education and adult mortality in the United States. Review of Economic Studies. 72(1) 189-221.

Marmot, M.G., Brunner, S., Hemingway, S. 2001. Relative contributions of early life and adult socioeconomic factors to adult morbidity in the Whitehall II study. Journal of Epidemiology and Community Health 55, 301-307.

Maurin, E. and McNally, S. 2007. Educational effects of widening access to the academic track: a natural experiment, IZA DP No.2596.

Mayer-Foulkes, D. 2001. The long-term impact of health on economic growth in Mexico, 1950-1995. Journal of International Development. 13(1), 123-126

Mazumder, B. 2008. Does education improve health? A re-examination of the evidence from compulsory schooling laws. Economic Perspectives, Federal Reserve Bank of Chicago Economic Perspectives, vol. Q2, 2-16.

Mullahy, J. and Portney, P. 1990. Air pollution, cigarette smoking and the production of respiratory health. Journal of Health Economics 9, 193-205.

Oreopoulos, P. 2006. Estimating average and local average treatment effects of education when compulsory schooling laws really matter. American Economic Review, vol. 96(1), 152-175.

Pischke, S. and Manning, A. 2006. Comprehensive versus selective schooling in England and Wales: what do we know? IZA DP No. 2072

Plewis, I . 2004. NCDS and 1970 BCS Technical Report: Changes in the NCDS and BCS70 populations and samples over time. 1st Edition. Centre for Longitudinal Studies.

Power, C. and Peckham, C. 1987. Childhood morbidity and adult ill-health, National Child Development Study User Support Working Paper No. 37.

Propper, C., Burgess, S. and Rigg, J.A. 2004. The Impact of Low Income on Child Health: Evidence from a Birth Cohort Study. CASE discussion paper series No. 085.

Pudney, S. and Shields, M. A. 2000. Gender and racial discrimination in pay and promotion for NHS nurses. Oxford Bulletin of Economics and Statistics 62, 801-35.

Ravelli, A.C.J., van der Meulen, J.H.P., Michels, R.P.J., Osmond, C., Barker, D.J.P., Hales, C.N., Bleker, O.P. 1998. Glucose tolerance in adults after prenatal exposure to famine. The Lancet 351, 173-177.

Rawls, J. 1971. A Theory of Justice. Harvard University Press, Cambridge, Mass.

Rodgers, B., Pickles, A., Power, C., Collishaw, S. and Maughan, B. 1999. Validity of the Malaise Inventory in general population samples, Social Psychiatry and Psychiatric Epidemiology, vol. 34, pp.333-341.

Roemer, J.E. 1996. Theories of Distributive Justice, Harvard University Press, Cambridge, Mass.

Roemer J. E. 1998. Equality of Opportunity. Harvard University Press.

Roemer J. E. 2002. Equality of opportunity: A progress report. Social Choice and Welfare 19, 455-471.

Roemer, J. E. 2004. Equal opportunity and intergenerational mobility: Going beyond intergenerational income transition matrices. In Miles Corak (ed.), Generational income mobility in North America and Europe, Cambridge: Cambridge University Press.

Roodman, D. 2009. Estimating fully observed recursive mixed-processes models with cmp. Center for Global Development Working Paper No. 168.

Rosa Dias, P. and Jones, A. M. 2007. Giving equality of opportunity a fair innings Health Economics 16, 109-112.

Rosa Dias, P. 2009. Inequality of opportunity in health: evidence from a UK cohort study. Health Economics 18(9), 1057-1074.

Rosenbaum, P.R. and Rubin, D.B. 1983. The central role of the propensity score in observational studies for causal effects, Biometrika, vol. 70, pp. 41-55.

Rubin, D.B. 1973. The use of matched sampling and regression adjustments to remove bias in observational studies, Biometrics 29, 185-203.

Rubin, D.B. 1979. Using multivariate matched sampling and regression adjustment to control bias in observational studies, Journal of the American Statistical Association, 74, 318-328.

Rubin, D.B. 2006. Matched Sampling for Causal Effects. Cambridge: Cambridge University Press.

Rutter, M., Tizard, J. and Whitemore K. 1970. Education, Health and Behaviour, London.

Schokkaert, E. Dhaene, G. van de Voorde, C. 1998. Risk adjustment and the trade-off between efficiency and risk selection: an application of the theory of fair compensation. Health Economics 7, 465-480.

Sen, A.K. 2002. Why health equity? Health Economics 11, 659-666.

Silles, M. 2009. The causal effect of education on health: evidence from the United Kingdom. Economics of Education Review 28 (1): 122-128.

Stott, D.H. 1987. The social adjustment of children: Manual to the Bristol Social Adjustment Guides. London: Hodder and Stoughton.

Trannoy, A., Tubeuf, S., Jusot, F. and Devaux, M. 2009. Inequality of opportunities in health in France: a first pass. Health Economics, DOI: 10.1002/hec.1528.

Vallentyne, P. 2008. Brute luck and responsibility. Politics, Philosophy and Economics 7, 57-80.

Van de Gaer, D. 1993. Equality of opportunity and investment in human capital. Ph.D. thesis, K. U. Leuven.

Van Doorslaer, E., Jones, A. 2003. Inequalities in self-reported health: validation of a new approach to measurement. Journal of Health Economics, 22(1), 61-87.

Van Doorslaer, E. and Koolman, X. 2004. Explaining the differences in income-related health inequalities across European countries. Health Economics 13, 609-628.

Van Kippersluis, H., O'Donnell, O. and Van Doorslaer, E. 2009. Long run returns to education: does schooling lead to an extended old age? Timbergen Institute Discussion Paper 037/3.

Vera-Hernandez, M. 2003. Structural estimation of a principal agent model: moral hazard in medical insurance. The RAND Journal of Economics 34, 670-93.

Wagstaff, A. Paci, P. and Van Doorslaer, E. 1991. On the measurement of inequalities in health. Social Science and Medicine 33(5), 545-557.

Wagstaff, A. van Doorslaer, E. and Watanabe, N. 2003. On decomposing the causes of health sector inequalities with an application to malnutrition inequalities in Vietnam. Journal of Econometrics, 112(1), 207-223

Webbink, D., Martin ,N. G. and Visscher, P.M. 2010. Does education reduce the probability of being overweight? Journal of Health Economics, 29, 29-38.

Williams, A. 1997. Intergenerational equity: an exploration of the "fair innings" argument. Health Economics 6, 117-132.

World Bank. 2005. World Development Report 2006: Equity and Development. Washington.

World Food Programme. 2006. World Hunger Series 2006: Hunger and Learning. FAO - United Nations, Rome.

Zheng, B. 2006. Measuring Health Opportunity. Working Paper 06-06, Department of Economics, University of Colorado at Denver and Health Sciences Centre.