

**Relative Risk Aversion in Real Life: A Dynamic Analysis of Educational Decision Making  
with Ability Updating and Heterogeneous RRA behavior**

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The Theory of Relative Risk Aversion (RRA) stipulates that students make educational decisions with the aim of minimizing the risk of downward social class mobility. In a previous paper we have formulated and tested a dynamic RRA model of educational decision making (Holm and Jæger 2008). In this paper, we extend this model in two important regards. First, we allow for actors to update information on their academic performance at several points during the educational career; i.e., we allow for people to learn “how smart they are” and to act on this new information. Second, we allow for heterogeneous RRA effects, i.e., for the possibility that not everyone adopts perfect RRA behavior and that some agents may act “irrationally” when making educational decisions. We test our new dynamic RRA model using data from the National Child Development Study. We find, first, a statistically significant RRA effect and, second, that agents to some extent update educational decisions in light of new information on academic performance.

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## 1. Introduction

In recent year a range of rational choice theories have been proposed to explain the persisting social class inequalities in educational attainment observed across many Western countries. One of the most influential of these theories is the theory of Relative Risk Aversion (RRA) (Breen and Goldthorpe 1997; see also Goldthorpe 1996; Breen 1999). According to the RRA theory individuals are utility-maximizing agents whose educational decisions are made with the explicit aim of minimizing the risk of entering a lower social class than that of their parents. The key theoretical implications of the RRA theory are, first, that individuals are forward looking agents whose educational decisions serve future as well as immediate goals (i.e., people care about the future consequences of their educational decisions) and, second, that the utility of educational decisions depend on social agents' social class background (i.e., different people need different levels of education to reach at least the same social class position as their parents). Thus, according to the RRA theory educational careers can be seen a sequence of utility-maximizing decisions whose ultimate aim is to preserve the social class position of the agent's family.

But does the RRA theory actually explain educational decisions? A range of recent empirical studies have tested the RRA theory, and the results from these studies provide mixed support for the RRA theory. However, two factors may help to explain why existing studies provide mixed results: (1) they use very different designs and (2) they only test parts of the RRA theory. Consequently, empirical studies can be categorized along two design dimensions: whether they use *subjective data* or *revealed preference* assumptions to infer RRA behavior and whether they test the RRA theory in a *reduced* or *structural* form. Both these dimensions have important bearings on the types of results obtained.

With regard to the first design dimension, existing studies which use subjective data build on the hypothesis in the RRA theory that people's subjective desires for intergenerational

status maintenance is the main motivation behind educational decisions. These studies then focus on whether expressed preferences for status maintenance affect educational decisions (e.g., Need and de Jong 2001; Becker 2003; Stocké 2007; van de Werfhorst and Hofstede 2007). By contrast, studies using a revealed preference approach infer RRA behavior from individuals' actual educational decisions. These studies test RRA indirectly by assuming that if people act according to the RRA theory then they must also follow the logic implied by this theory (e.g., Davies et al. 2002; van de Werfhorst and Andersen 2005; Breen and Yaish 2006; Holm and Jæger 2008).

With regard to the second design dimension, most existing studies test a reduced-form version of the RRA theory and not a full structural form. The structural version of the RRA theory concerns the link between origin social class, educational career, and destination social class. So far only two studies, Breen and Yaish (2006) and Holm and Jæger (2008), have tested the RRA theory in its full structural form. By contrast, most other studies test parts of the RRA theory such as the link between class background and subjective preferences concerning status maintenance (e.g., Stocké 2007), the effect of parental/child preferences on educational choices (e.g., Becker 2003; Need and de Jong 2001), and class-origin specific effects of parental education on children's educational choices (Davies et al. 2002).

In this paper we extend existing empirical tests of RRA theory in two important ways. Our first contribution is to test the RRA theory in its full structural form, i.e. "from origin class to destination class". Essentially, only a structural approach allows for a direct test of the two core assumption in the RRA theory that, first, agents are forward looking when making educational decisions and, second, the utility of educational decisions depends on *both* origin and destination social class. Our structural approach builds on the Dynamic Decision Process (DDP) model proposed by Holm and Jæger (2008) which separates the total utility of educational decisions into two components: *instantaneous utility* (for example, the "academic" utility of choosing university

education if one comes from family concerned with cultural capital) and *future utility* (the RRA utility “bonus” from eventually reaching at least one’s parents’ social class). The DDP model allows us to separate future utility from instantaneous utility and to estimate the effect of one particular type of future utility, RRA, on educational decision making. We can identify RRA because, with our data, we know each agent’s origin and destination social class and, consequently, we know if the agent eventually reached at least the same social class as that of her parents. This information allows us to analyze RRA by means of the DDP framework which is explained in more detail below.

Our second contribution consists in bringing more “behavioral realism” into the analysis of RRA. We bring more realism, first, by allowing for agents in our DDP model to update information on their academic ability during their educational careers and, second, by allowing for heterogeneous RRA effects.

*Information updating* implies that we allow for agents to obtain new information on their academic ability at several points during their educational career and to incorporate this new information into their educational decisions. In the RRA theory an agent’s decision to proceed to a higher educational level (also) depends on her subjectively expected probability of successfully completing this level. Information on own academic ability is thus crucial when an agent decides on whether or not to continue in the educational system. An agent may, however, possess inaccurate information about her own initial academic ability (for example, by being too optimistic or pessimistic) or may learn new information about her ability as she moves along in the educational system. Our model, which uses the British educational system as the institutional setting, takes this possibility into account by allowing for agents to incorporate information about their academic performance at the end of elementary school (GCE examinations) into the decision to continue in secondary education, and the performance at the end of secondary education (A-level examinations)

to influence the decision to continue in higher (university) education. In doing so, our model allows for agents to respond in a dynamic way to new information.

*Heterogeneous RRA effects* imply that we take into account the possibility that not all agents act according to the RRA theory. The RRA theory entails that all agents care equally much about avoiding downward social mobility. However, in a real-life scenario it is unrealistic to assume that the RRA effect is constant in a population of individuals; i.e., RRA preferences are heterogeneous. Inspired by Houser et al. (2004), we extend the DDP framework to account for heterogeneous RRA effects by empirically identifying latent subpopulations of individuals in our data that exhibit different levels of “compliance” with the RRA theory (i.e., subpopulation of more or less “rational” individuals).

The paper proceeds as follows. In the next section we present the RRA theory, as well as discuss related rational choice theories of educational decision making. Section 3 presents the DDP model in a formalized framework, the estimation procedure, and the British educational system at the time our respondents passed through this system. In section 4 we describe the data, the National Child Development Study, and the variables used. Section 5 presents the results from the empirical analysis and section 6 concludes.

## **2. Theoretical Background**

The theoretical section is divided into two sections. In the first part (section 2) we present the general objectives and assumption in the RRA theory. In the second part (section 3) we formalize the RRA theory and situate the theory specifically within the UK context. The second part thus develops the DDP model of RRA behavior in educational decision making we analyze in the empirical analysis.

## 2.1 The RRA theory

Most recent rational choice theories of educational decision making in social stratification research can be tracked back to Boudon (1974) and Gambetta (1987). Significant theoretical contributions in this literature include Goldthorpe (1996, 1998), Erikson and Jonsson (1996), Breen and Goldthorpe (1997), and Morgan (1998, 2002, 2005). We present results from empirical studies below.

The most influential recent rational choice theory of educational decision making is the theory of Relative Risk Aversion (RRA). The RRA theory is conceptually rooted in Boudon (1974) and Kahneman and Tversky (1979) but was extended and formalized by Breen and Goldthorpe (1997). Boudon (1974) distinguished between two types of effects of social class background on educational success: *primary effects* which summarize the effect of class background on children's academic ability and *secondary effects* which summarize the effect of class background on educational choices over and above academic ability. Primary effects pertain to the class-related factors (economic, cultural, social, etc.) that shape differences in academic ability among children with different class backgrounds. Secondary effects pertain to class-related factors that affect educational decisions for children with the same level of academic ability.

The RRA theory presents an explanation of secondary effects: i.e., why children with the same level of academic ability but with different social class backgrounds chose systematically different levels of education (Breen and Goldthorpe 1997; see also Goldthorpe 1996, 1998; Breen 1999). The core proposition in the RRA theory is that agents use education as a means of minimizing the risk of downward social class mobility. Consequently, the primary objective of education is to reach at least the same social class position as that of the agent's parents. It follows that because more education generally leads to a higher probability of reaching a higher social class position, agents with different social class backgrounds need different levels of education to be reasonably sure that they will reach at least the same social class position as their parents. It also

follows that children with working class background need less education to reach the working class compared to children with service class background. According to the RRA theory, this goal of intergenerational status maintenance is the principal explanation of why children with service class background tend to obtain systematically more education than children with working class background.

The RRA theory is a rational choice theory because agents are assumed to make educational decisions in light of the expected utility and costs of these decisions. The most important utility component in educational decision making process is the future RRA utility “bonus” of eventually reaching at least one’s parents’ social class. Thus, unlike standard human capital theory, returns to education in the RRA theory are social rather than economic (see also Akerlof 1997; Jæger 2007). The costs of educational decisions include both economic costs (tuition fees, earnings foregone, etc.) and “psychological” costs (more education requires higher levels of academic ability, more work effort, a higher risk of failure, etc.). Children with service class backgrounds obtain more education than children with working class backgrounds because, first, they need more education to reach their parents’ social class position (and thus obtain RRA utility “bonus”) and, second, they also face lower costs of pursuing higher education because of having higher academic ability (primary effects) and better economic and social support.

## *2.2 Previous Tests of the RRA Theory*

As described in the introduction, existing empirical studies provide mixed support for the RRA theory (see Need and de Jong 2000; Davies et al. 2002; Becker 2003; Breen and Yaish 2006; van de Werfhorst and Hofstede 2007; Stocké 2007; Holm and Jæger 2008). The mixed results may, on the one hand, be attributable to RRA playing a stronger role in some institutional contexts than in others (for example, RRA may depend on how strongly education is directly linked to

socioeconomic attainment). On the other hand, the mixed results may also be attributable to the very different designs and identifying assumption in previous studies.

Most studies test parts of the RRA theory. Using subjective data, several studies have analyzed if parents or students' expressed concerns about status maintenance (and the perceived costs of "failure") are linked to social class and whether these concerns affect students' educational decisions (Becker 2003; Stocké 2007; van de Werfhorst and Hofstede 2007). These studies generally show that concerns about status maintenance, measured in different ways, affect educational decisions in Germany and the Netherlands. These studies then provide some support for key mechanisms in the RRA theory.

Another group of studies use a revealed preference approach to analyzing RRA. Mostly due to data limitations, these studies identify RRA by assuming that an RRA effect exists if children reach the same level of education as their parents. Taking this approach, Need and de Jong (2001) show that Dutch children tend to reach the same level of education as their parents. Davies et al. (2002) analyze the RRA theory by investigating if the effect of parental education on the probability of children making several educational transitions in Denmark exhibits a "kink" when children reach their parents' educational level. The idea behind their approach is that when children approach their parents' educational level, the costs of further education outweigh the utility of more education and they stop their educational career. Davies et al. (2002) test the assumption of a "kinked" effect of parental education on children's educational transitions and they find evidence of RRA in 10 out of a total of 17 regression analyses.

A final group of studies test the RRA in its original structural form; that is, as a theory seeking to explain educational choices on *both* origin and destination social class. Breen and Yaish (2006) frame the RRA theory as a test of the existence of a minimum acceptable threshold level of education that children recognize as required to get into the same social class position as their

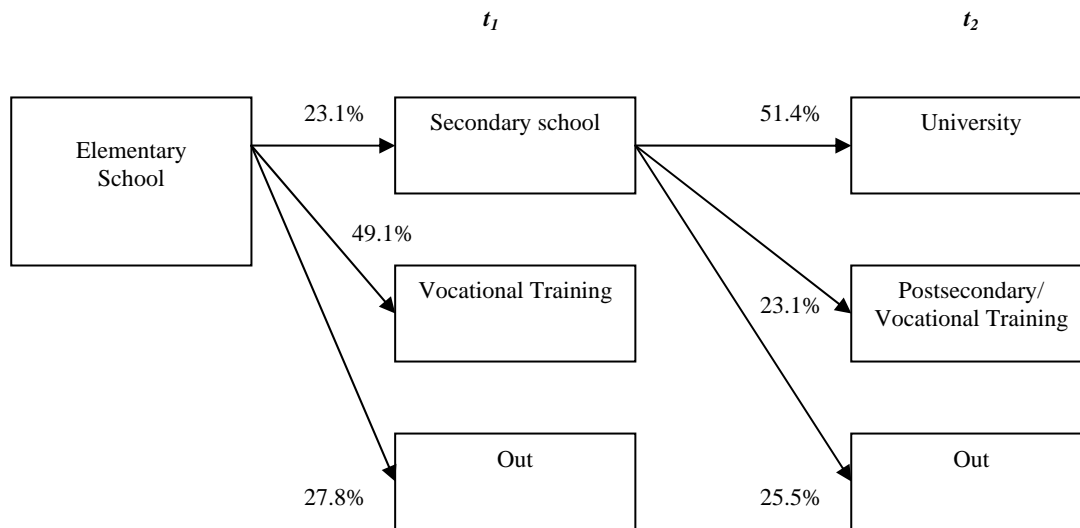
parents. Furthermore, they identify this threshold level by calculating the actual probabilities of reaching certain social class destinations given educational choices, as derived from a secondary data source. Their empirical analysis of British data supports the RRA theory in that the threshold levels of education children should recognize as required to gain access to their parents' social class affect their educational decisions. Holm and Jæger (2008) develop a dynamic model of educational decision making which distinguishes utility-maximizing RRA behavior from instantaneous determinants of educational decisions (for example, cultural capital). Analyzing Danish data they find that RRA behavior to some extent explains educational decisions.

### **3. RRA in the British Educational System**

This section presents the Dynamic Decision Process (DDP) model of RRA behavior within the context of the British educational system. In this system, students face two educational transitions (see Figure 1). The first transition ( $t_1$ ) occurs around age 16 after students take their first examinations at the end of elementary school. For our respondents these examinations were either the Ordinary Level General Certificate of Education or the Certificate of Secondary Education. We refer jointly to these exams as GCE. After their GCE examinations respondents have three options: (1) leave the educational system, (2) leave the educational system and take up vocational training as an apprentice, or (3) enter secondary school.

Students who complete secondary school face a second transition around age 18 ( $t_2$ ). After taking their Advanced Level (A-level) examinations at the end of secondary school (similar to a high school degree), these students face three options: (1) leave the educational system, (2) take up postsecondary, non-university education, or (3) enter university. Transition probabilities in our empirical sample (which are very similar to those reported by Breen and Yaish (2006)) are shown in Table 1 and illustrated in Figure 1.

Figure 1. Summary of Educational Transitions



### 3.1 From Education to Class Destination

Our DDP RRA model is recursive and begins with a model for the utility of ending up in  $c$  different social class destinations, given class origin. We label this transition from final educational level into class destinations third-stage choices because our model also includes second-stage choices (after A-levels) and first-stage choices (after elementary school). We explain the DDP model backwardly, beginning with third-stage choices and ending with first-stage choices. In this version of the paper we do not consider the pre/post secondary vocational training options. Consequently, our DDP framework only takes into consideration whether agents choose A-levels (yes/no) and, for those who complete A-levels, whether they choose university education. We will incorporate the vocational training in a future version of the paper.

Following Breen and Yaish (2006) and Holm and Jæger (2008), our model operates with three (origin and destination) social classes: (I) the service class, (II) the middle class, and (III) the working class ( $c = I, II, III$ ). The utility  $U$  of “choosing” destination class  $c$  can be written as

$$\begin{aligned}
& \beta_I x_I + \delta \cdot \mathbf{1}(\text{origin} \geq I) + e_I \\
U = & \beta_{II} x_{II} + \delta \cdot \mathbf{1}(\text{origin} \geq II) + e_{II} \\
& \beta_{III} x_{III} + \delta \cdot \mathbf{1}(\text{origin} \geq III) + e_{III}
\end{aligned}$$

Here, the indicator variable  $I(\cdot)$  measures whether the origin class is equal to or higher than the destination class, and the parameter  $\delta$  captures the effect of  $I(\cdot)$  on the utility of reaching a destination class. The parameter  $\delta$  thus captures the utility “bonus” associated with reaching at least one’s parents’ (here father’s) social class; i.e., the RRA effect. The utility of reaching a destination social class also depends on many other factors. Observable variables that affect this utility are labeled  $x$  (with regression coefficients  $\beta_j$ ;  $j = I, II, III$ ) and unobservable variables are jointly captured in the term  $e$ .

Our analysis extends the DDP model in Holm and Jæger (2008) by allowing for agents to base educational decisions on new information on their academic performance they receive during their educational career. In other words, we allow for people to take into account how they performed in previous exams when they decide on whether or not to continue in the educational system. In our model, observable academic performance is measured by grades obtained from respectively GCE examinations (at around age 16 and before  $t_1$ ) and A-level examinations (at around age 18 and before  $t_2$ ). Furthermore, in our model agents’ grades are determined by a set of observed and unobserved variables in the following way (where  $g_1 =$  GCE grades and  $g_2 =$  A-level grades)

$$\begin{aligned}
g_1 &= \beta_{g_1} x_{g_1} + e_{g_1} \\
g_2 &= \beta_{g_2} x_{g_2} + e_{g_2},
\end{aligned}$$

where  $x$  refer to observed variables (for example family background characteristics) with effects  $\beta_g$ , and where  $e$  refer to unobserved variables. The equations for grade outcomes then essentially capture the *primary effects* of family background on academic performance (Boudon 1974). We allow the two error terms  $e$  to be correlated to capture how innate IQ or other types of abilities might influence both sets of academic outcomes.

### 3.2 Choices after GCE

In our model the student makes a number of sequential educational decisions. After completing GCE the student chooses between leaving school and continuing with A-levels (first-stage choices). The utility of leaving school is the utility of life outside the educational system plus the expected utility of reaching different class destinations. This utility depends on class origin and the transition probabilities into destination classes, conditional on having GCE as the highest educational qualification. Formally, the utility of reaching class different destinations with GCE can be written as

$$\begin{aligned}
 u_{gce} &= \beta_{gce}x + e_{gce} + \sum_{j=1}^{j=III} P_j^{gce} U_j \\
 &= \beta_{gce}x + e_{gce} + \sum_{j=1}^{j=III} P_j^{gce} \beta_j x_j + \delta \sum_{j=1}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \sum_{j=1}^{j=III} P_j^{gce} e_j \\
 &= \tilde{\beta}_{gce}x + \delta \sum_{j=1}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{gce}
 \end{aligned} \tag{1}$$

where  $\tilde{\beta}_{gce} = \beta_{gce} + \sum_{j=1}^{j=III} P_j^{gce} \beta_j$  and where  $\tilde{e}_{gce} = e_{gce} + \sum_{j=1}^{j=III} P_j^{gce} e_j$ . The term  $\sum_{j=1}^{j=III} P_j^{gce} U_j$  represents

the expected utility of the destination classes conditional on leaving the educational system after GCE, which is the utility of each destination class weighted by the probability of entering each class

with GCE as the highest level of education,  $P_j^{gce}$ ,  $j = I, II, III$ . The term  $\beta_{gce}x$  captures the effect of observed individual and family-background characteristics on the instantaneous utility of life outside the educational system immediately after leaving the educational system but before entering a final destination class. The term  $e_{gce}$  captures *unobserved* characteristics which affect this utility.

The first part of equation (1) shows that total utility of leaving after GCE is comprised from the instantaneous utility of leaving the educational system after GCE,  $\beta_{gce}x + e_{gce}$ , plus the expected

utility of reaching a class destination,  $\sum_{j=I}^{j=III} P_j^{gce} U_j$ . The second part of equation (1) shows that the

utility of leaving after GCE is a linear function of observed independent variables,  $\tilde{\beta}_{gce}x$ , which captures both instantaneous and future utility, a function of an error term  $\tilde{e}_{gce}$  that captures

unobserved variables from both instantaneous and future utility, and finally a function of the

expected value of destination class,  $\delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j)$  (which in the RRA theory depends on

class origin). Note from equation (1) that we are not able to identify the independent contributions

from  $x$  on the instantaneous and future utility components but that we are able to identify the

contribution from the expected value of reaching various destination classes.

Rather than leaving the educational system agents may also choose to take up A-levels after their GCE examinations. The utility of choosing A-levels after GCE can be written as

$$\begin{aligned}
 u_{A-level} &= \beta_{A-level}x + \gamma_1 g_1 + e_{A-level} + \sum_{j=I}^{j=III} P_j^{A-level} U_j \\
 &= \tilde{\beta}_{A-level}x + \gamma_1 g_1 + \delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{A-level} \quad (2)
 \end{aligned}$$

where  $\tilde{\beta}_{A-level} = \beta_{A-level} + \sum_{j=I}^{j=III} P_j^{A-level} \beta_j$  and where  $\tilde{e}_{A-level} = e_{A-level} + \sum_{j=I}^{j=III} P_j^{A-level} e_j$ . This model is very similar to equation (1) except for the inclusion of the term  $\gamma_1 g_1$  which captures the effect of GCE grades on the utility of choosing A-levels. We include this term in the DDP model to account for the (very realistic) possibility that agents' knowledge about their previous academic performance affects their utility of continuing in A-levels. Thus, poor academic performance in GCE examinations (i.e., low values of  $\gamma_1 g_1$ ) is likely to lower agents' expected utility of A-levels, while high performance is likely to increase this utility.

### 3.3 Choices after A-Levels

The utility of continuing in higher education (HE) after A-levels (i.e., second-stage choices) is defined similarly to the utility of leaving school after GCE and after A-levels. Again, we include a term to capture the impact of A-level performance,  $\gamma_2 g_2$ , on the expected utility of continuing in HE; i.e., we allow for agents to take new information on their academic performance into account when they decide on whether or not to continue in the educational system. Formally, we write the utility of completing HE

$$\begin{aligned} u_{HE} &= \beta_{HE} x + \gamma_2 g_2 + e_{HE} + \sum_{j=I}^{j=III} P_j^{HE} U_j \\ &= \tilde{\beta}_{HE} x + \gamma_2 g_2 + \delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{HE} \end{aligned} \quad (3)$$

where  $\tilde{\beta}_{HE} = \beta_{HE} + \sum_{j=I}^{j=III} P_j^{HE} \beta_j$  and where  $\tilde{e}_{HE} = e_{HE} + \sum_{j=I}^{j=III} P_j^{HE} e_j$ .

### 3.3. The Total Choice Set

Equations 1-3 describe the utility associated with leaving the educational system after GCE, A-levels, or HE. Each utility component contains an *instantaneous* (or “short-term”) *component* reflecting life immediately after making the educational choice (and the cost of completing a certain level of education) and a *future component* reflecting the expected RRA utility of ultimately reaching different class destinations. We now proceed by modeling how agents choose between whether to continue in the educational system or to leave given the available information at the particular stage. After GCE the agent knows her GCE performance and to some extent also her relative position in the distribution of GCE performance. Based on this information, she can infer about the likelihood of passing A-levels. She does not, however, know what her actual A-level performance will be. Consequently, after GCE the agent can make qualified guesses about her expected utility of leaving after GCE and after A-levels. However, part of the utility of completing A-levels is the optional possibility of continuing in HE, and this utility depends critically on A-level performance. Based on GCE performance the agent has some idea about how well she will perform at A-level and, thus, she can also to some extent infer about the expected utility of passing A-levels, including the expected optional value of HE. The utility of choosing to continue after GCE, including the optional value of choosing to leave or to continue after A-levels, is the expected maximum of leaving or continuing after A-levels and can be expressed as

$$E \max(u_{A-level}, u_{HE} | g_1), \quad (4)$$

where

$$\begin{aligned}
u_{HE} | g_1 &= \tilde{\beta}_{HE} x + \gamma_2 E(g_2 | g_1) + \delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{HE} \\
&= \tilde{\beta}_{HE} x + \gamma_2 \beta_{g_2} x + \gamma_2 \frac{\rho_{12}}{\sigma_{g_1}} e_{g_1} + \delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{HE} \\
&= \tilde{\beta}_{HE} x + \gamma_2 \frac{\rho_{12}}{\sigma_{g_1}} e_{g_1} + \delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{HE}
\end{aligned}$$

where  $\tilde{\beta}_{HE} = \tilde{\beta}_{HE} + \gamma_2 \beta_{g_2}$ . This equation describes the utility of completing HE when the agent has completed GCE but has not completed A-levels. Here, the agent substitutes the expected value of A-level performance conditional on GCE performance to form the expected utility of completing HE before actually completing A-levels. Given knowledge about her GCE performance the agent can now compare the expected maximum of either completing A-levels and leaving or completing A-levels and continuing in HE. Following Ker (2007) and Taber (2000),  $E \max(u_{A-level}, u_{HE} | g_1)$  is equal to

$$\begin{aligned}
&\mu_{HE|g_1} \Phi\left(\frac{\mu_{HE|g_1} - \mu_{A-level}}{\theta}\right) + \mu_{A-level} \Phi\left(\frac{\mu_{A-level} - \mu_{HE|g_1}}{\theta}\right) + \theta \varphi\left(\frac{\mu_{HE|g_1} - \mu_{A-level}}{\theta}\right) \\
&= \mu_{HE|g_1} + (\mu_{A-level} - \mu_{HE|g_1}) \Phi\left(\frac{\mu_{A-level} - \mu_{HE|g_1}}{\theta}\right) + \theta \varphi\left(\frac{\mu_{HE|g_1} - \mu_{A-level}}{\theta}\right)
\end{aligned}$$

where

$$\begin{aligned}
\mu_{A-level} &= \tilde{\beta}_{A-level} x + \gamma_1 g_1 + \delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) \\
\mu_{HE|g_1} &= \tilde{\beta}_{HE} x + \gamma_2 \frac{\rho_{12}}{\sigma_{g_1}} e_{g_1} + \delta \sum_{j=I}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j)
\end{aligned}$$

and where

$$\begin{aligned}
\theta &= \sqrt{\text{var } \tilde{e}_{HE} + \text{var } \tilde{e}_{A-level} - 2 \text{cov}(\tilde{e}_{HE}, \tilde{e}_{A-level})} \\
&= \sqrt{\text{var } e_{HE} + \sum_{j=I}^{j=III} (P_j^{gce})^2 \text{var}(e_j) + \text{var } e_{A-level} + \sum_{j=I}^{j=III} (P_j^{gce})^2 \text{var}(e_j) - 2 \sum_{j=I}^{j=III} (P_j^{gce})^2 \text{var}(e_j)} \\
&= \sqrt{\text{var } e_{HE} + \text{var } e_{A-level}}
\end{aligned}$$

Perhaps a summary phrase which describes in plain English what's going on ...

### 3.4 The Likelihood Function for the Choice Set

The DDP model describes the utility of choosing between leaving the educational system after GCE (equation 1) that can be compared to continuing given knowledge about GCE performance, as well as an expression of the utility of leaving after A-levels (equation 2) that can be compared to continuing in HE (equation 3) given knowledge about A-level performance. Using these models we can construct the probabilities of making different educational choices. Let  $Y$  denote a discrete random variable which takes the value 1 if the agent leaves after GCE, the value 2 if the agent leaves after A-levels, and the value 3 if the agent completes HE. We then find that the probability that an individual chooses to leave school after GCE is

$$\begin{aligned}
P(Y=1) &= P\left(E \max(u_{A\text{-level}}, u_{HE} \mid g_1) < u_{gce}\right) \\
&= P\left(E \max(u_{A\text{-level}}, u_{HE} \mid g_1) < \tilde{\beta}_{gce}x + \delta \sum_{j=1}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{gce}\right) \\
&= 1 - \Phi \left( \frac{E \max(u_{A\text{-level}}, u_{HE} \mid g_1) - \left( \tilde{\beta}_{gce}x + \delta \sum_{j=1}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) \right)}{\sqrt{\text{var}(\tilde{e}_{gce})}} \right) \\
&= 1 - \Phi \left( \frac{E \max(u_{A\text{-level}}, u_{HE} \mid g_1) - \left( \tilde{\beta}_{gce}x + \delta \sum_{j=1}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) \right)}{\sqrt{\text{var}(e_{gce}) + \text{var}\left(\sum_{j=1}^{j=III} P_j^{gce} e_j\right)}} \right)
\end{aligned}$$

This is the probability that (1) is larger than (4). Next, we form the probability of choosing A-levels over HE (i.e., to leave after A-levels) conditional on having completed A-levels

$$\begin{aligned}
P(Y=2) &= P(u_{HE} \mid g_2 < u_{A\text{-level}}) \\
&= P\left(\left(\sum_{j=1}^{j=III} P_j^{A\text{-level}} \beta_j\right)x + \delta \sum_{j=1}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{A\text{-level}} > \right. \\
&\quad \left. \tilde{\beta}_{HE}x + \gamma_2 g_2 + \delta \sum_{j=1}^{j=III} P_j^{gce} \mathbf{1}(\text{origin} \geq j) + \tilde{e}_{HE}\right) \\
&= P\left(\left(b_{A\text{-level}} - \tilde{\beta}_{HE}\right)x - \gamma_2 g_2 \right. \\
&\quad \left. + \delta \sum_{j=1}^{j=III} (P_j^{A\text{-level}} - P_j^{HE}) \mathbf{1}(\text{origin} \geq j) > \tilde{e}_{HE} - \tilde{e}_{A\text{-level}}\right) \\
&= \Phi \left( \frac{\left(b_{A\text{-level}} - \tilde{\beta}_{HE}\right)x - \gamma_2 g_2 + \delta \sum_{j=1}^{j=III} (P_j^{A\text{-level}} - P_j^{HE}) \mathbf{1}(\text{origin} \geq j)}{\theta} \right)
\end{aligned}$$

where  $b_{A-level} = \sum_{j=1}^{j=III} P_j^{A-level} \beta_j$ . Finally we find that the probability of choosing HE is given residually since  $P(Y = 3) = 1 - P(Y = 2)$ . From these three probabilities, and from our NCDS data which includes information on educational choices, academic performance, origin and destination social class (and other parental and student characteristics), we can construct the log-likelihood function for the DDP model and maximize this function to obtain the model parameters. In particular, we are interested in the empirical estimate of the RRA effect,  $\delta$ .

### *3.5 Identification*

To come ...

### *3.6 Heterogeneous RRA effects*

To come ...

## **4. Data and Variables**

### *4.1 Data*

We analyze data from the National Child Development Study (NCDS). The NCDS is a representative longitudinal study of all children (approximately 17,500) born during the first week of March 1958 in the United Kingdom (see Plewis et al. 2004). Follow-ups have been carried out in 1965 (age 7), 1969 (age 11), 1974 (age 16), 1981 (age 23), 1991 (age 33) and 1999/2000 (age 42). We restrict our sample to respondents with valid observations on all key variables (origin social class, destination social class, educational careers). This restriction leaves an effective sample size of 3,499.

## 4.2 Variables

To the extent it was possible we have replicated the coding of all the main variables from Breen and Yaish (2006) (who also used the NCDS) and Holm and Jæger (2008) to maximize comparability of the results.

### 4.2.1 Educational Choices

The choice set and the transition probabilities into different educational levels have been described in section 3.

### 4.2.2 Academic Performance and Ability

We include two measures of academic performance (which are observable to the agent) and one measure of general academic ability (which is only partially known to the agent). Our measures are coded similarly to Breen and Yaish (2006).

Our first performance measure is the respondent's performance at the GCE examinations in 1974. The NCDS data includes equivalent scales of 21 O-level/CSE exams (with the codes: 1 = O-level, grade A or B; 2 = O-level, grade C and CSE grade 1; 3 = O-level, grade D or E and CSE grade 2 or 3; 4 = CSE grade 4 or 5; 5 = other result; 6 = no entry). Similarly to Breen and Yaish (2006), we inverted these codes (so that higher values signify a better grade) and summarized respondents' total score across the 21 exams.

Our second performance measure is the respondent's performance at A-level examination taken at around age 18. This measure is only available for respondents who chose secondary school at  $t_1$ . The NCDS data includes a variable which measures A-level grades in the form of a 15-point scale formed by summing the three best A-level grades ( $A = 5$ ).

Our measure of general academic ability is the respondent's score on the General Ability Test (GAT) at age 11. This test is considered to be the best proxy for IQ in the NCDS (Breen and Yaish 2006: 241). The NCDS respondents were also subjected to math and reading ability tests at age 7, 11, and 16. We used respondents' test scores on these tests to impute missing values on the GAT at age 11. After imputation we have valid GAT scores for all except 2 respondents in our sample. GAT scores are not (yet) included in the DDP model?

#### 4.2.3 Social Class

As our measure of social class we use a reduced version of the Erikson-Goldthorpe-Portocarero classification (see Erikson and Goldthorpe, 1992). We distinguish between the service class (I), the middle class (II), and the working class (III). We use the social class position of the NCDS respondent at age 42 as the destination social class and the social class position of the respondent's father (which is normally used as the primary indicator of social class background) at age XX as the origin class.

#### 4.2.4 Other Control Variables

In addition to the education, performance/ability, and social class variables, we also include several control variables. Since the DDP model is already very complex we restrict to number of control variables to gender, mother's education, and number of siblings. Maybe we should include other variables since none of those currently employed have any particular effect ...?

Table 1. Descriptive Statistics

	Percent/mean	SD
<b>Educational choices:</b>		
<i>First transition</i> $t_1$		
Out	27.8	

Vocational training	49.1	
Secondary school	23.1	
<i>Second transition <math>t_2</math></i>		
<i>(only respondents who completed secondary school)</i>		
Out	25.5	
Postsecondary/vocational training	23.1	
University	51.4	
<b>Academic ability/performance:</b>		
O-level performance	15.91	12.44
A-level performance	1.04	2.89
General Ability Test score at age 11	46.81	14.59
Gender (= female)	0.48	0.49

## 5. Results

In this section we present empirical results. The estimation results are shown in Table 1. Note that according to section 3.5 (not done yet) we have to normalize a set of regression coefficient from one of the educational choices. In our case we choose to normalize regression coefficients from HE, i.e.

we set  $\tilde{\beta}_{HE} = 0$ .

Table 1. Estimation results

	Estimate	Standard error	t-value	
$\tilde{\beta}_{gce}$	Constant	0.31762	0.165084	1.923983
	Mother's education	-0.03709	0.016479	-2.251
	Mother's education, missing	-0.27207	0.216017	-1.25947
	Gender	-0.02418	0.037715	-0.64111
	No. siblings	0.007648	0.01111	0.688397
$\tilde{\beta}_{a-level}$	Constant	-1.5772	0.36663	-4.30188
	Mother's education	0.047734	0.024377	1.958142
	Mother's education, missing	0.649487	0.448655	1.447631
	Gender	-0.13462	0.089571	-1.50293

	No. siblings	-0.03604	0.036311	-0.99259
<b>RRA</b>	$\delta$	<b>0.073693</b>	<b>0.030088</b>	<b>2.449249</b>
	$\gamma_1$	0.051836	0.009221	5.621404
	$\gamma_2$	-0.03594	0.022674	-1.58509
	$\theta$	0.261638	0.164577	1.589759
	$c$	0.097332	0.048188	2.019835
	-2lnL		9220.93	
	N		3346	

Note:  $c$  is the ratio between 
$$\frac{b_{a-levels}}{\tilde{\beta}_{a-level}} = \frac{\sum_{j=I}^{j=III} P_j^{a-levels} \beta_j}{\sum_{j=I}^{j=III} P_j^{a-levels} \beta_j + \beta_{a-level}}$$

- The regression coefficients for choosing to leave after GCE are shown in the first panel and the coefficients for choosing A-levels over HE is shown in the second panel.
- The RRA parameter,  $\delta$ , is positive and significant (at  $p < 0.01$ ?) indicating that on average the students obtains positive enumeration from reaching at least the class level of their parents (father). Can we say something about the size of the RRA effect vis-à-vis other effects?
- The value of  $\gamma_1$  is positive and significant, indicating that GCE grade increases the utility of completing A-levels, probably because it makes this transition more likely. The value of  $\gamma_2$  is insignificant, indicating that grades from A-levels are unimportant in making the HE transition (must be a selection effect, transition probabilities into A-levels are already fairly low?).
- Also show effects of  $x$ 's on academic performance ( $g1, g2$ ) to get an idea of primary effects?

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