Department of Economics

Altruism, Education and Inequality in the United States

Christoph Winter

Thesis submitted for assessment with a view to obtaining the degree of Doctor of Economics of the European University Institute

Florence, January 2009

EUROPEAN UNIVERSITY INSTITUTE
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Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Contents

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

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Part I

Introduction

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

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Introduction

This thesis contains several lines of research conducted during my four years at the European University Institute. It consists of three chapters that analyze the link between parental inter-vivos transfers, education and inequality.

In the first chapter, "*Accounting for the Changing Role of Family Income in Determining College Entry*", I present a computable dynamic general equilibrium model with overlapping generations and incomplete markets and I use this model to measure the fraction of households constrained in their college entry decision. College education is financed by family transfers and public subsidies, where transfers are generated through altruism on part of the parents. Parents face a trade-off between making transfers to their children and own savings. Ceteris paribus, parents who expect lower future earnings transfer less and save more. Data from the 1986 Survey of Consumer Finances give support to this mechanism. I show that this trade-off leads to substantially higher estimates of the fraction of constrained households compared to the results in the empirical literature (18 instead of 8 percent). The model also predicts that an increment in parents' earnings uncertainty decreases their willingness to provide transfers. In combination with rising returns to education, which makes college going more attractive, this boosts the number of constrained youths and explains why family income has become more important for college access over the last decades in the U.S. economy.

In chapter two, titled *"Why Do the Rich Save More: The Role of Housing"*, I analyze the determinants of the wealth-income gradient with educational attainment that is observable in the data. This gradient is very steep: using the 1989 wave of the Survey of Consumer Finances (SCF), I find the median college graduate near retirement age holds twice as much wealth as the median high school dropout. In this paper, I argue that housing plays an important role for explaining the wealth-income gradient that is observable in the data.

In order to shed more light on the role of housing, I set up a computable life cycle model. Markets are incomplete, and household face idiosyncratic earnings shocks. Households receive utility from the consumption of housing services and non-housing consumption. In total, housing serves as a consumption good, asset and collateral for financial loans.

I show that a version of this model that is calibrated to match key features of the U.S. economy can generate a wealth-income gap between the median of two education groups, namely college graduates and high school dropouts, that is observable in the 1989 SCF.

Housing accounts for a substantial fraction of the observable wealth-income gap between the two education groups: I find that a share of 25 percent of the total gap is due to the presence of housing in the model. Strikingly, introducing housing raises the retirement savings of the median college graduates.

The last chapter, *"Parental Transfers and Parental Income: Does the Future Matter More Than the Present?"* adds to the results that were derived in the first chapter. More precisely, I present a model of parental transfers that is based on the assumption of one sided altruism. I use this model to analytically study the link between parental expectations about their future resources and their present transfer behavior. In the context of my model, I show that parents with brighter earnings prospects are willing to transfer more to their offspring already today, all other things equal.

I use data from the 1983 and the 1986 Survey of Consumer Finances (SCF) to analyze whether these theoretical predictions receive empirical support. In line with the theoretical predictions, I find that better educated households transfer more to their children, for a given level of their income and wealth. If better educated households have higher mean earnings profile and lower uncertainty about their earnings as suggested by the empirical literature, this suggests that households with better earnings prospects do indeed transfer more to their kids.

The chapter also makes an important contribution to the question whether borrowing constraints for education are quantitatively important in determining access to college. Using data from the 1979 National Longitudinal Survey of Young Men (NLSY), I find that parental education has a significant impact on college enrolment, even after controlling for measures of pre-college ability such as AFQT-scores. According to my theoretical results, this suggests that parental resources have strong impact on their children's college decision, even if college enrolment gaps with respect to current income are small. Thus, the true fraction of the population that is adversely affected in their college decision by market imperfections may be much higher than the small impact of current income suggests.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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Part II

Chapters

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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Chapter 1

Accounting for the Changing Role of Family Income in Determining College Entry

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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1.1 Introduction

In the United States, the wage premium of college graduates relative to high school graduates increased by around 30 percent between 1980 and 2000 (Katz and Autor (1999)). This period was also characterized by a dramatic rise of college tuition fees and an amplification of the within-group earnings inequality. College participation rates stagnated, while the enrolment gaps between students from different family income groups widened (Ellwood and Kane (2000), Carneiro and Heckman (2003) and Kane (2006)).

This suggests that financial constraints prevent a larger share of low-income households from sending their children to college, leading to a sluggish adjustment of college participation despite the surge in the college premium (Kane (2006)). Whether this is true or not is subject to an ongoing debate in the empirical literature. Carneiro and Heckman (2002) and Carneiro and Heckman (2003) argue that short-term cash constraints around college age are binding only for a small fraction of households. They find that long-term factors (family background variables) which affect pre-college education can account for the main part of enrolment gaps by income. However, it is not clear to what extend long-term factors can account for the widening of the enrolment gaps observed over time. Belley and Lochner (2007) document that the impact of family income on college attendance rates increased dramatically between 1980 and 2000, even after controlling for family background. They also document that the enrolment patterns observable in the data are at variance with a simple model of college attendance, even if they allow for borrowing constraints. Hence, there remains considerable disagreement about the role of borrowing constraints (Kane (2006)).

In this paper, I want to shed further light on the role of financial constraints. In particular, I address the following two questions:

1. Are borrowing constraints quantitatively important in determining college entry?

2. As the economic environment has changed in the U.S. over the course of the last decades, have borrowing constraints become more limiting?

I answer these questions with the help of a computable overlapping generation model that endogenizes the college enrolment decisions. Borrowing by young households for college education is not permitted; they thus have to rely on parental transfers and public support in the form of subsidies in order to cover college expenses. This allows me to measure the fraction of adolescents that would like to attend college but cannot do so because of market imperfections.

In this paper, I generate parental transfers endogenously by assuming altruism on the side of parents. At the time their children enter college, parents face a trade-off between making transfers and own savings. Consequently, parental investment in their children's college education may be suboptimally low from the children's point of view. I find that this trade-off implies that a substantial fraction of 18 percent of young households is financially constrained

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

in their college entry decision. This holds despite the fact that college enrolment gaps across different family income groups appear to be narrow and broadly consistent with the empirical results documented in Carneiro and Heckman (2002). This shows that even when enrolment gaps are narrow, borrowing constraints may affect a large part of the population. The results thus help to resolve the disagreement in the empirical literature with respect to the quantitative importance of borrowing constraints.[1]

I then examine how the economy behaves if I increase the college premium, the tuition fees and the earnings inequality to values observable in the U.S. economy around 2000. I find that the model replicates the college enrolment patterns presented in Belley and Lochner (2007) very well. In particular, the model predicts (i) a slight increase in the number of college graduates, (ii) a substantial increment in the impact of family income on the college enrolment of young households, and a (iii) stable ability-enrolment pattern. The model predicts that the fraction of constrained households rose sharply from 18 percent to 40 percent between 1980 and 2000. The results thus show that all enrolment patterns can be explained within the same framework, and that these patterns are consistent with an increase in the number of constrained households.

Despite the sharp rise in the number of households affected, the model implies that the correlation of educational attainment across generations actually decreased. This is perhaps surprising, as the literature in general assumes that tighter borrowing constraints lead to a higher persistence of education across generations. Ellwood and Kane (2000) as well as Belley and Lochner (2007) document that the correlation between parental education and college enrolment of the child has become weaker over the course of the last decades.

The result that borrowing constraints became more limiting over time can be explained with the impact of a rise in earnings inequality on parental transfers behavior. The rise in the college premium (between-group inequality) makes college investment more profitable, even for low-ability youths. If parents of low-ability children receive a greater share of their total lifetime income from labor earnings, they accumulate disproportionately more precautionary savings in response to the increase in the within-group inequality, which I model as an increment in the variance of earnings shocks. This implies that they have to reduce their transfers accordingly, which results in a larger enrolment gap for low-ability students as only children from rich parents (who depend less on labor income) can make profit from the increase in the skill premium and invest in college. This is exactly what one observes in the data as well (Belley and Lochner (2007)).

[1]Many empirical papers document data patterns that could be interpreted as evidence for the fact that borrowing constraints are binding for a substantial fraction of the population. See for example Ellwood and Kane (2000) and Kane (2006) and the references herein. In contrast, papers by Cameron and Heckman (1998), Cameron and Heckman (2001), Carneiro and Heckman (2002) and Cameron and Taber (2004) argue that borrowing constraints do not play a major for college entry. Keane and Wolpin (2001) provide evidence for the fact that constraints exist and are tight, yet not binding. When comparing the data from National Longitudinal Survey of Young (NLSY), 1979 cohort, with the more recent 1997 cohort, Belley and Lochner (2007) document that the relationship between family income and education attainment changed over time.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Since earnings of high school graduates fluctuate more than the earnings of college graduates (Hubbard et al. (1995)) and earnings account for a bigger fraction of total income for high school graduates, this channel also helps to explain the degree of intergenerational persistence of educational attainment. In my framework, children of college graduated parents are – all other things equal – up to 5 percent more likely to enter college, because their parents need to provide less savings for their own future. Using transfers and savings data from the 1986 Survey of Consumer Finances (SCF), I find empirical support for this key prediction of the model: high school graduates save significantly more than college graduates during the last 20 years before retirement if one controls for wealth and income. In turn, college graduates in that age group provide significantly more transfers, all other things equal.

Understanding the behavior and the determinants of parental transfers is crucial for my results. More precisely, I build on Laitner (2001) and assume that old households ('parents') are altruistic and incorporate the utility of their descendants ('young households') in their maximization problem. As in Laitner (2001), I allow for imperfect altruism; parents may weight their children's utility less than their own utility. Indeed, the transfer flows generated by the model imply that parents consider their offspring's utility by 30 percent less than their own utility. In the model, I distinguish between two different levels of human capital ('college education' and 'high school') and endogenize college choice. Parental transfers can be used to finance college education, which is assumed to be costly.

I also allow for idiosyncratic labor income shocks, which enables me to analyze the effects of the rise of the within-group inequality that has been documented for the U.S. (Krueger and Perri (2006)). Incorporating inequality within generations and education levels also allows me to distinguish different ability levels.

I solve the model numerically and calibrate the parameters such that key features of the U.S. economy are matched. I then compare two different steady-state equilibria in order to evaluate changes over time. Since the accumulation of wealth (and thus also transfer flows) depend critically on the ratio of the interest rate to the subjective discount factor, I follow Aiyagari (1994) and Huggett (1996) and use the discipline of general equilibrium models to determine this ratio endogenously (see De Nardi (2004) and Cagetti and De Nardi (2006) for an overview over this strand of the literature).

An increasing number of papers implement altruism in computable life cycle models with endogenous education choice. Most recently, Gallipoli, Meghir and Violante (2007) (henceforth GMV (2007)) propose an OLG model with one-sided altruism and sequential education choice.[2] GMV (2007) introduce an aggregate production function where different types of human capital are not (necessarily) perfectly substitutable. They allow explicitly for changes in life cycle earnings and wealth profiles. When estimating the earnings process, they also

[2] Early papers analyzing the general equilibrium implications of education policies include Heckman, Lochner and Taber (1998) and Ábráhám (2004), who examines wage inequality and education policy in a general equilibrium OLG model with skill biased technological change.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

distinguish between permanent ability and idiosyncratic labor shocks. For their estimation, GMV (2007) use data from the Panel Study of Income Dynamics (PSID), the Current Population Survey (CPS) and the National Survey of Young (NLSY). With the help of their model, the authors analyze the impact of different education policies on the equilibrium distribution of earnings and education.

Cunha (2007) presents an incomplete markets, dynamic general equilibrium model of skill formation. He allows for ability formation over many periods of childhood and adolescence, considering the fact that skills at different stages may be complements and self-augmenting. He builds on work by Laitner (1992), who assumes two-sided altruism: families care both about their predecessors and their descendants.[3] Using his model, Cunha (2007) compares the equilibrium effects of different skill investment policies, focusing on how costly it is to delay investment in the early years (childhood) and to remediate in later years (adolescence). He finds that a policy that subsidizes early and late childhood investments dominates other policies in terms of welfare.

Similarly, Caucutt and Lochner (2004) and Restuccia and Urrutia (2004) both use computable frameworks with endogenous transfers to analyze the relative importance of early versus late credit constraints.[4] In this paper, I emphasize the various interactions between parental wealth accumulation over the life cycle and transfer behavior. I focus on short-run credit constraints for college education, thus abstracting from parental investment in early education. According to empirical work presented in Keane and Wolpin (2001), students finance at least 20 percent of their college expenses by receiving transfers from parents. In total, parental support for their children's college education is substantial. Gale and Scholz (1994) document that parental payments amounted to 35 billion dollar in 1986.

As in the recent work by Brown, Scholz and Seshadri (2007) (henceforth Brown et al. (2007)), I argue that analyzing the intra-family allocation of resources is key for assessing the significance of borrowing constraints for college education. Because the assumption of one-sided altruism implies that parents do not have access to their children's earnings, Brown et al. (2007) show that borrowing constraints may arise because the parent household may be poor relative to the child or care too little about the utility of the child to provide financial help. In Brown et al. (2007), parents choose transfers for education in a first stage, and cash transfers in a second stage. Parent and child households may thus disagree over the optimal timing of transfers as well as the total amount. As stressed by Brown et al. (2007), the potential for disagreement arises naturally in the context of U.S. college financial aid policy, since a student's federal assistance is determined based on their parent's presumed ability

[3]Under this assumption, parents and children pool their resources and solve the same maximization problem. Two-sided altruism thus implies that children provide transfers to their parents as well. However, there is little evidence for this in the data (Gale and Scholz (1994)).

[4]Compared to Restuccia and Urrutia (2004), Caucutt and Lochner (2004) allow for the accumulation of capital and cash transfers and depart from the assumption that early and late investments in education have a elasticity of substitution of 1.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

to pay. Parents are under no legal obligation to meet their expected contribution (Brown et al. (2007), p.3). Using the NLSY97 and in the Health and Retirement Survey (HRS), Brown et al. (2007) find that borrowing constraints for higher education are quantitatively important.

In this paper, I compare the quantitative predictions of a computable life cycle model with one-sided altruism and an endogenous education choice with the college enrolment pattern observable in the data. I find that the model is consistent with narrow enrolment gaps, after I control for long-run factors. Nonetheless, the model implies that a substantial fraction of young households is borrowing constrained in their college decision. I also show that within the context of my model, recent changes in the economic environment in the U.S. imply that the trade-off in the intra-family allocation of resources has worsened from the point of view of the child, leading to a larger fraction of young households that have to rely on external funding in order to pay for their college expenses.

The remainder of the paper is structured as follows. The model is presented in Section 2. Section 3 introduces the equilibrium definition, while the calibration is explained in Section 4. We discuss our results in Section 5. Finally, Section 6 concludes.

1.2 Model

I consider a life cycle economy with altruistic parents. As in Laitner (2001), altruism may be imperfect. Parents provide transfers to their children. They face constraints on their resources: all credit markets are closed, implying that they can neither borrow against their own future income nor against the future income of their descendants. I allow for idiosyncratic productivity shocks during working life. Moreover, I endogenize college choice by assuming that parental transfers can be used to pay for college education. These assumptions allow me to study the effects of an endogenously generated initial distribution of assets on college enrolment, and to analyze the determinants of the initial asset distribution in a realistic life cycle setting.

1.2.1 The Life Cycle of a Household

There is a continuum of agents with total measure one. I assume that the size of the population is constant over time. Let j denote the age of an agent, $j \in J = \{1, 2, ..., J^{\max}\}$. Agents enter the economy when they turn 23 (model period $j = 1$). Before this age, they belong to their parent household and depend on its economic decisions. During the first 40 years of their 'economic' life, agents work. This implies that the agents work up to age 62 (model period $J^{work} = 40$). Retirement takes place at the age of 63 ($j = 41$), which is mandatory. When agents turn 53 ($j = 31$), their children of age 23 form their own household. This implies a generational age gap of 30 years. It is assumed that there is one child household for each

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

parent household. Agents face a declining survival probability after their children leave home. Terminal age is 83 ($J^{\max} = 60$). Since annuity markets are closed by assumption, agents may leave some wealth upon the event of death. The remaining wealth of a deceased parent household is passed on to its child household.

1.2.2 Transfers

At age 53, a parent's household child becomes independent and forms its own household. Gale and Scholz (1994) report that the mean age of givers is 55 years in the 1983-1986 Survey of Consumer Finances. I assume that transfers are generated by one-sided altruism, that is, parents care about the lifetime well-being of their mature children, but not the other way round. I abstract from strategic interaction and assume that parents provide part of their own wealth as an initial endowment at the beginning of the economic life of the child household. Part of this endowment (or all of it) can be in form of investment in human capital. It is important to notice that the assumption of altruism implies that parents will combine education investment and financial transfers in such a way that the child's lifetime utility is maximized given the total amount of wealth that parents wish to pass on to their descendants. Put differently, children may not agree with their parents on the total amount which is being transferred, but certainly on the mix between human capital investment and financial transfers.[5]

The assumptions regarding the life cycle and the transfer behavior are summarized in Figure 1.1.

1.2.3 Labor Income Process

During each of the 40 periods of their working life, agents supply one unit of labor inelastically. The productivity of this labor unit of an j-year old agent is measured by $\varepsilon_j^e \eta^{j,e}$, where $\left\{\varepsilon_j^e\right\}_{j=1}^{J^w}$ is a deterministic age profile of average labor productivity of an agent with education level e:

$$e \in E = \{\text{highschool}(hs), \text{college}(col)\} \tag{1.1}$$

For retired agents, $\varepsilon_j^e = 0$.

$\eta^{j,e}$ describes the stochastic labor productivity status of a j-year old agent with education level e. Given the level of education e, I assume that the labor productivity process is identical and independent across agents (no aggregate productivity shocks) and that it follows a finite-state Markov process with stationary transition probabilities over time. More specifically,

$$Q(\eta^{hs}, N^{hs}) = \Pr(\eta^{j+1,hs} \in N^{hs} | \eta^{j,hs} = \eta^{hs}) \tag{1.2}$$

[5] In the following, I will use the terms 'financial transfers', 'inter vivos transfers' and 'inter vivos transfers' as labels for capital transfers which take place during lifetime of both donor and recipient.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

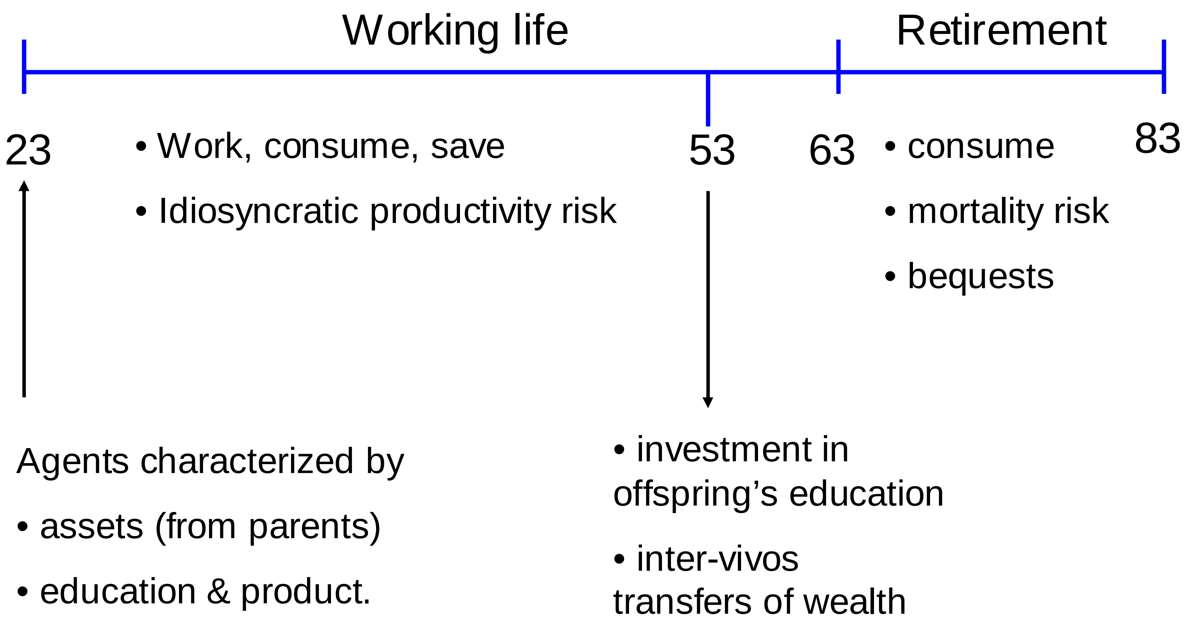

Figure 1.1: Life cycle and Generation Structure

for high-school graduates. $N^{hs} = \{\eta_1^{hs}, \eta_2^{hs}, ..., \eta_n^{hs}\}$ is the set of possible realizations of the productivity shock η^{hs}. Similarly, I express the stochastic labor productivity process for college graudates as

$$Q(\eta^{col}, N^{col}) = \Pr(\eta^{j+1,col} \in N^{col} | \eta^{j,col} = \eta^{col}) \tag{1.3}$$

with $N^{col} = \{\eta_1^{col}, \eta_2^{col}, ..., \eta_n^{col}\}$.

I assume that children of college graduates have - on average - productivity levels above average, while high school graduates draw shocks that are below average. Carneiro et al. (2006) show that maternal education has a strong positive impact on children's cognitive achievement. I interpret the initial draw as a proxy for ability during adolescence, that is, ability before college education or labor market entry occurs. In particular, I assume that the probability to dropout from college decreases with the level of the initial productivity shock. Consistent with empirical evidence regarding the intergenerational correlation of schooling, this and the the fact that the productivity in the first period of working life depends on parental education, implies that college education is positively correlated across generations. The parental education level influences only the initial draw of the productivity shock: From the second period onwards, the shocks evolve according to their respective stochastic process. More specifically, I assume that the initial shock is governed by the following transition matrices:

$$Q^{initial,hs}(i, i \in I = \{1, 2, ..., n\}) = \Pr(i, i \in \{1, 2, ..., n\} \, | \eta^{30,hs} = \eta^{hs}) \tag{1.4}$$

DOI: 10.2870/26812

$$Q^{initial,col}(i, i \in I = \{1, 2, ..., n\}) = \Pr(i, i \in \{1, 2, ..., n\} \, | \eta^{30,col} = \eta^{col}) \tag{1.5}$$

1.2.4 Investment in Education and Borrowing Constraints

I distinguish between two levels of education, high school and college.[6] Upon entering the economy, all households possess a high school degree. They (or their parents) decide on investing in college education, before any other economic action is taken. Investment in college education takes place at the beginning of the lifetime. College education requires large investments that are risky and lumpy. It is risky because there is a certain probability that the child drops out. In addition, the earnings stream is stochastic which increases the uncertainty. Dropout rates are high in the U.S., as well as in other OECD countries (see Akyol and Athreya (2005)). Consistent with evidence from the empirical literature, see e.g. Stinebrickner and Stinebrickner (2007), I assume that children with lower levels of ability are more likely to drop out. Since dropout rates are higher during the first years of the college studies (when returns to college education are low), dropouts face the same earnings process as high school graduates. Consequently, only students who actually graduate from college enjoy higher mean earnings during their working life. This implies that college education is an indivisible and lumpy investment.[7] Transfers and savings cannot be negative; parents are thus required to finance their children's college education out of their own resources.

1.2.5 Taxes and Social Security Benefits

During working life, households pay a proportional tax on their labor income. All households also pay a proportional tax on their capital income.

Tax revenue from labor income and capital income taxation is used by an infinitely lived government in order to finance pension benefits *pen*. I assume that pensions are independent of the employment history of a retiree.

1.3 The Households' Recursive Problem

I distinguish between young households (children) and parent households. I use a subscript y for young households and a subscript p for parental households.

1.3.1 Young households

When parents die, young households inherit the wealth of their parents. I assume that young households observe their parental wealth holdings. Therefore, I need to distinguish

[6] The share of high school dropouts is small in the data, see Rodriguez et al. (2002) who measure a share of 17 percent in the 1998 SCF.

[7] See Akyol and Athreya (2005) and the references cited therein.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute
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between child households with deceased parents and young households that are expecting to inherit. I make the following timing assumption: death takes place at the end of the period, after the consumption and savings decision has been made. Bequests are then distributed at the beginning of the next period. As in De Nardi (2004), annuity markets are closed by assumption, which implies that part of the bequests are left accidentally.

Young households with deceased parents

Consider a household during working age ($j \in J^w = \{1, ..., 30\}$) whose parent household is dead. At age j, this household consumes $c_{y,d}$ and has end-of-period wealth holdings of $a'_{y,d}$, where the subscript y, d indicates a young household with deceased parents. Given a discount factor β, a rate of return to capital r, a wage rate per efficiency unit of labor w, tax rates on labor income and capital income τ_w and τ_k, the optimization problem of this household reads as

$$V_{y,d}(s_{y,d}) = \max_{c_{y,d}, a'_{y,d}} \left\{ u(c_{y,d}) + \beta \sum_{\eta' \in N^e} V_{y,d}(s'_{y,d}) Q(\eta, \eta') \right\} \forall j \in \{1, ...30 - 1\} \tag{1.6}$$

where $V_{y,d}(.)$ is the value function of a young household with deceased parents and $s_{y,d}$ is the vector of state variables in period j, which is given by

$$s_{y,d} = (a_{y,d}, e, \eta^{j,e}, j) \tag{1.7}$$

Agents maximize (1.6) subject to the budget constraint[8]

$$a'_{y,d} = (1 + r(1 - \tau_k))a_{y,d} + (1 - \tau_w)\varepsilon^e_j \eta^{j,e} w - c_{y,d} \tag{1.8}$$

$$a'_{y,d} \geq 0$$

The state space $\mathbf{S}_{y,d}$ of an household of type y, d thus includes four variables: own asset holdings, $a_{y,d} \in \mathbb{R}_+$, education level, $e \in E$, stochastic productivity, $\eta^{j,e} \in N^{j,e}$, and age $j \in \{1, ..., 30\}$. Notice that $\mathbf{S}_{y,d} = \mathbb{R}_+ \times E \times N^e \times \{1, ..., 30\}$. Let $\mathbf{P}(E)$, $\mathbf{P}(N^e)$ and $\mathbf{P}\{1, ..., 30\}$ be the power sets of E, N^e and $\{1, ..., 30\}$, respectively, and let $\mathbf{B}(\mathbb{R}_+)$ the Borel σ-algebra of $\mathbb{R}_+$. It follows that $\mathcal{S}_{y,d} = \mathbf{B}(\mathbb{R}_+) \times \mathbf{P}(E) \times \mathbf{P}(N^e) \times \mathbf{P}(J^w)$ is a σ-algebra on $\mathbf{S}_{y,d}$ and that $\mathcal{M}_{y,d}$= $(\mathbf{S}_{y,d}, \mathcal{S}_{y,d})$ is a measurable space. I will assume that the value function $V_{y,d}$:$\mathbf{S}_{y,d} \rightarrow \mathbb{R}$

[8]Notice that for $j = 30$, the value function reads as

$$V_{y,d}(s_{y,d}) = \max_{c_{y,d}, a'_{y,d}} \left\{ u(c_{y,d}) + \beta \sum_i \sum_{\eta' \in N^e} V_{p,1}(s_{p,1}) Q(\eta, \eta') Q^{initial,e}(\eta, i) \right\}$$

When $j = 30$, child households become parent household in $j+1$. This implies that they observe their offspring 's initial productivity level which becomes part of their state vector $s_{p,1}$.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

and the policy functions $c_{y,d}$:$\mathbf{S}_{y,d} \rightarrow \mathbb{R}_{+}$ and $a'_{y,d}$:$\mathbf{S}_{y,d} \rightarrow \mathbb{R}_{+}$ are measurable with respect to $\mathcal{M}_{y,d}$.

Young households whose parents are alive

At any age $j \in \{1, ..., 30\}$, a household whose parents are still alive consumes $c_{y,a}$ and has end-of-period wealth holdings of $a'_{y,a}$, where y, a denotes a young household whose parents are alive. Its parent household has wealth holdings of $a^p_{y,a}$. Since the child does not know when the parent household dies, the value function is a weighted sum of the utility it receives if the parent household dies and the utility which is obtained if the parent continues to live for another period, where the parental survival probability ψ_{j+30} serves as a weight. The optimization problem can thus be described by the following functional equation:

$$V_{y,a}(s_{y,a}) = \max_{c_{y,a}, a'_{y,a}} \left\{ \begin{array}{c} u(c_{y,a}) + \beta(1 - \psi_{j+30}) \sum_{\eta' \in N^e} V_{y,d}(s'_{y,d}) Q(\eta, d\eta') \\ +\beta\psi_{j+30} \sum_{\eta' \in N^e} V_{y,a}(s'_{y,a}) Q(\eta, d\eta') \end{array} \right\} \tag{1.9}$$

$$\forall j \in \{1, ...30 - 1\}$$ [9]

where $V_{y,a}(s_{y,a})$ denotes the value function given the state vector $s_{y,a}$, and $s_{y,a}$ is described by

$$s_{y,a} = (a_{y,a}, a^{p\prime}_{y,a}, e, \eta^{j,e}, j) \tag{1.10}$$

Notice that children observe only their parents end-of-period asset holdings. This implies that the law of motion of parental asset holdings is not part of the information set of the child household.[10]

The household maximizes (1.9) subject to its current period budget constraint

$$a'_{y,a} = (1 + r(1 - \tau_k))a_{y,a} + (1 - \tau_w)\varepsilon^e_j \eta^{j,e} w - c_{y,a} \tag{1.11}$$

$$a'_{y,a} \geq 0$$

[9]If $j = 30$, the child household knows that its parent household will die for sure in the current period. The Bellman equation thus reads as

$$V_{y,a}(s_{y,a}) = \max_{c_{y,a}, a'_{y,a}} \left\{ u(c_{y,d}) + \beta \sum_i \sum_{\eta' \in N^e} V_{p,1}(s_{p,1}) Q(\eta, \eta') Q^{initial,e}(\eta, i) \right\}$$

[10]I also experimented with a model in which children use the policy function of their respective parents' problem in order to update their information about expected bequests. This adds another two variables to the child household's state space, namely the education and the productivity level of the parent households, thereby resulting in a dramatic increase in CPU time needed to solve the model. I found that parental asset holdings alone are sufficient to forecast future bequests. Including education and productivity did not change the child's behavior at all.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

If the parent household dies in period $j-1$, the flow budget constraint becomes

$$a'_{y,d} = (1 + r(1-\tau_k))(a_{y,a} + a^p_{y,a}) + (1-\tau_w)\varepsilon^e_j \eta^{j,e} w \ - c_{y,a} \tag{1.12}$$

$$a'_{y,d} \geq 0$$

Because a child household keeps track of its parents wealth holding, I need to extend the state space $\mathbf{S}_{y,a}$ by $a^p_{y,a} \in \mathbb{R}_+$. The state space contains now two continuous variables, and is given by $\mathbf{S}_{y,a} = \mathbb{R}_+ \times \mathbb{R}_+ \times E \times N^e \times \{1, ..., 30\}$. Similar to the problem of a child household with deceased parents given above, I define a measurable space $\mathcal{M}_{y,a}= (\mathbf{S}_{y,a}, \mathcal{S}_{y,a})$, with respect to which $V_{y,a} : \mathbf{S}_{y,a} \to \mathbb{R}$, $c_{y,a} : \mathbf{S}_{y,a} \to \mathbb{R}_+$ and $a'_{y,a} : \mathbf{S}_{y,a} \to \mathbb{R}_+$ are measurable.

1.3.2 Parent Households

Consider now a parent household, $31 \leq j \leq J^{\max}$. A parent household works during the first 10 years and is retired afterwards. The household faces a declining survival probability, $\psi_j < 1$. In the following, I define the parent household's problem in three different stages.

Parent Household, Working

$$V_{p,w}(s_{p,w}) = \max_{c_{p,w}, a'_{p,w}} \left\{ u(c_{p,w}) + \beta\psi_j \sum_{\eta' \in N^e} V_{p,w}(s'_{p,w}) Q(\eta, \eta') \right\} \forall j \in \{32, ...40\} \tag{1.13}$$

where $V_{p,w}(.)$ is the value function of a parent household who is working and $s_{p,w}$ is the vector of state variables in period j given by

$$s_{p,w} = (a_{p,w}, e, \eta^{j,e}, j) \tag{1.14}$$

Agents maximize (1.13) subject to the budget constraint

$$a'_{p,w} = (1 + r(1-\tau_k))a_{p,w} + (1-\tau_w)\varepsilon^e_j \eta^{j,e} w - c_{p,w} \tag{1.15}$$

$$a'_{p,w} \geq 0$$

The state space is given by $\mathbf{S}_{y,a} = \mathbb{R}_+ \times E \times N^e \times \{32, ...40\}$. I define a measurable space $\mathcal{M}_{p,w}= (\mathbf{S}_{p,w}, \mathcal{S}_{p,w})$, with respect to which $V_{p,w} : \mathbf{S}_{p,w} \to \mathbb{R}$, $c_{p,w} : \mathbf{S}_{p,w} \to \mathbb{R}_+$ and $a'_{p,w} : \mathbf{S}_{p,w} \to \mathbb{R}_+$ are measurable.

Parent Household, Retired

This household receives social security benefits, *pen*, and chooses consumption $c_{p,r}$ and its end-of-period wealth level $a'_{p,r}$. The optimization problem of this household can be written

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

in recursive formulation as follows:

$$V_{p,r}(s_{p,r}) = \max_{c_{p,r},a'_{p,r}} \left\{ u(c_{p,r}) + \beta\psi_j V_{p,r}(s'_{p,r}) \right\} \tag{1.16}$$

$$\forall j \in \{41, ...J^{\max} - 1\}$$

where $V_{p,r}(s_{p,r})$ is the value function, given the state vector $s_{p,r}$. It follows that

$$s_{p,r} = (a_{p,r}, j) \tag{1.17}$$

The household maximizes (1.16) subject to

$$a'_{p,r} = (1 + r(1 - \tau_k))a_{p,r} + pen - c_{p,r} \tag{1.18}$$

$$a'_{p,r} \geq 0$$

In the terminal period $J^{\max}$, (1.16) reduces to

$$V_{p,r}(s_{p,r}) = \max_{c_{p,r}} \{u(c_{p,r})\} \tag{1.19}$$

subject to

$$c_{p,r} \leq (1 + r(1 - \tau_k))a_{p,r} + pen \tag{1.20}$$

The state space is now given by $\mathbf{S}_{p,r} = \mathbb{R}_+ \times \{41, ..., J^{\max}\}$. I construct a measurable space $\mathcal{M}_{p,r}$= $(\mathbf{S}_{p,r}, \mathcal{S}_{p,r})$, with respect to which I define $V_{p,r}$:$\mathbf{S}_{p,r} \rightarrow \mathbb{R}$, $c_{p,r}$:$\mathbf{S}_{p,r} \rightarrow \mathbb{R}_+$ and $a'_{p,r}$:$\mathbf{S}_{p,r} \rightarrow \mathbb{R}_+$ to be measurable.

Parent Household, First Period

I assume that parents incorporate the discounted lifetime utility of their children in the first period of parenthood ($j = 31$). This assumption of one-sided altruism is also used in various other papers, e.g. Laitner (2001), Nishiyama (2002), and most recently Brown et al. (2007) and GMV (2007).

Parents choose their own savings $a'_{p,1}$ and the transfers to their child household in such a way that their total utility is maximized. Transfers can be in form of assets (tra) and investment in education (ed). Recall that the education level is a binary variable, that is, $ed \in \{0, 1\}$, where $ed = 0$ if parents choose not to send their children to college and $ed = 1$ if parents send their children to college. Expressed in terms of a Bellman equation, the decision problem of a parent household at $j = 31$ reads as

$$V_{p,1}(s_{p,1}) = \max_{c_{p,1},a'_{p,1},tra,ed} \left\{ \begin{array}{c} u(c_p) + \beta\psi_{31} \sum_{\eta' \in N^e} V_{p,w}(s'_{p,w})Q(\eta, \eta') \\ +\varsigma \left(E\left[V_{y,a}(s_{y,a})|ed = 1\right] + E\left[V_{y,a}(s_{y,a})|ed = 0\right]\right) \end{array} \right\} \tag{1.21}$$

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

where ς is the intergenerational discount factor. I allow for imperfect altruism, that is, $0 \leq \varsigma \leq 1$. If $\varsigma = 0$, parents care only about their own utility. The model thus nests a pure life cycle economy ($\varsigma = 0$) and a dynastic model ($\varsigma = 1$) as extreme cases. Both Laitner (2001) and Nishiyama (2002) show that the observable flow of transfers is consistent with an intermediate case. Clearly, the degree of altruism matters for parental transfer behavior. Notice that it influences only the total amount of resources which is transferred, but does not have any effect on the division into education investment and financial transfers.

$V_{p,1}(s_{p,1})$ is the value function for a given state vector $s_{p,1}$, where

$$s_{p,1} = (a_{p,1}, e, \eta^{31,e}, i) \tag{1.22}$$

Notice that the initial productivity level of a child i becomes part of the parent household's state space because the child may drop out before graduating. i determines the probability to drop out. Together with the fact that the income stream is stochastic, this implies that investment in college is risky. Therefore, whether parents invest in the children's education beyond high school depends on the difference between $E\left[V_{y,a}(s_{y,a})|ed = 1\right]$, the expected utility from investing, and $E\left[V_{y,a}(s_{y,a})|ed = 0\right]$, the value if they do not invest. More precisely, the expected utility from investing is given by

$$E\left[V_{y,a}(s_{y,a})|ed = 1\right] = \left\{ \begin{array}{c} \lambda(i)V_{y,a}(tra, a'_{p,1}, col, \eta^{1,col}, 1) \\ +(1-\lambda(i))V_{y,a}(tra, a'_{p,1}, hs, \eta^{1,hs}, 1) \end{array} \right\} \tag{1.23}$$

where $\lambda(i)$ is the probability that the child household completes college education successfully. The expected utility is thus a weighted average of the expected lifetime utility if the child completes education and of the expected value of the household if it does not complete education. If the child household enters college but does not complete college education, the child household faces the same value function as a child household which does not enter college education. The parental budget constraint is given by

$$a'_{p,1} = (1 + r(1-\tau_k))a_{p,1} + (1-\tau_w)\varepsilon_j^e\eta^{31,e}w + \nu_{|ed=1}(a_{p,1}, \varepsilon_j^e\eta^{31,e}w) - tra - \kappa_{|ed=1} - c_{p,1} \tag{1.24}$$

$$a'_{p,1} \geq 0$$

where ν denotes the college subsidy the household receives if $ed = 1$, κ denotes the fixed college expenses that the parent household pays. The subsidy level ν is a function of family resources available for college investment. In the U.S., most programs are targeted towards students of low income families. In this case, the amount of subsidies depends negatively on the amount of family resources (see e.g. Feldstein (1995)).

Note that children may also receive end-of-life bequests. Because average bequests are higher the more the parent saves in period $j = 31$, the value function of the child,$V_{y,a}(s_{y,a})$,

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

is increasing and concave in $a'_{p,1}$. Because the parent household incorporates $V_{y,a}(s_{y,a})$ in its decision problem in $j = 31$, it also incorporates the utility from leaving bequests. This establishes a trade-off between transferring resources in the form of inter vivos transfers or in the form of end-of-life bequests. Note that this mechanism would also work in the presence of a perfect annuity market.

Using the fact that the state space of parents in their first period is given by $\mathbf{S}_{p,1} = \mathbb{R}_+ \times E \times N^e \times \{1, 2, ..., i\}$, I construct a σ-algebra on $\mathbf{S}_{p,1}$ as $\mathcal{S}_{p,1} = \mathbf{B}(\mathbb{R}_+)\times\mathbf{P}(\{1, 2, ..., i\})$ $\times\mathbf{P}(E) \times \mathbf{P}(N^e)$ where $\mathbf{P}(\{1, 2, ..., i\})$ is the power set of $\{1, 2, ..., i\}$. $\mathcal{M}_{p,1}= (\mathbf{S}_{p,1}, \mathcal{S}_{p,1})$ is then a measurable space, which implies that $V_{p,1} :\mathbf{S}_{p,1} \to \mathbb{R}$, $c_{p,1} :\mathbf{S}_{p,1} \to \mathbb{R}_+$, $a'_{p,1} :\mathbf{S}_p \to \mathbb{R}_+$, $tra :\mathbf{S}_{p,1} \to \mathbb{R}_+$ and $ed :\mathbf{S}_{p,1} \to \{0, 1\}$ are measurable on $\mathcal{M}_{p,1}$.

1.3.3 The Firm's Problem

There is a continuum of firms, which I normalize to have total measure one. Firms are competitive and take all prices as given. Thus, I assume a single representative firm. This representative firm uses aggregate physical capital K and aggregate labor measured in efficiency units L to produce a single identical output good Y. The profit-maximizing conditions of the representative firm are

$$r + \delta = F_K(K, L) \tag{1.25}$$

$$w = F_L(K, L) \tag{1.26}$$

where $F(K, L)$ is a constant returns to scale production function.

1.3.4 The Government's Problem

The infinitely lived government administers the pension system and distributes college subsidies. The government finances pension benefits and subsidies by issuing a payroll tax on labor and capital income. I impose that the budget of the government has to be balanced in each period. Let Φ be a probability measure defined over the measurable spaces $\mathcal{M}_{y,d}$, $\mathcal{M}_{y,a}$, $\mathcal{M}_{p,1}$,$\mathcal{M}_{p,w}$ and $\mathcal{M}_{p,r}$, which result from the household problem as stated above.[11] The government computes old-age pension benefits, pen, as the average lifetime income of a high-school graduate times a social security replacement ratio:

$$pen = rep \frac{w \left(\int_{\mathbb{R}_+ \times \{hs\} \times N^{hs} \times J^w} \varepsilon_j^{hs} \eta^{j,hs} d\Phi + \int_{\mathbb{R}_+ \times \{hs\} \times N^{hs} \times J^w} \varepsilon_j^{hs} \eta^{j,hs} d\Phi \right)}{\int_{\mathbb{R}_+ \times \{hs\} \times N^{hs} \times J^w} d\Phi + \int_{\mathbb{R}_+ \times \{hs\} \times N^{hs} \times J^w} d\Phi} \tag{1.27}$$

[11]Notice that the total population size is normalized to one. The probability measure thus defines the number of people (or equivalently, the total population share) facing a specific endowment with state variables.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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I assume that tax rate levied on capital, τ_k, is determined exogenously. The government's problem thus reduces to adjusting tax rate on labor income τ_w such that budget is balanced:

$$\tau_w = \frac{pen\left(\int_{\mathbf{S}_{p,r}} d\Phi\right) + \Xi - \tau_k r K}{wL} \tag{1.28}$$

where the total amount of college subsidies Ξ is given by

$$\Xi = \int_{\mathbf{S}_{p,1}} \nu_{|ed=1} d\Phi \tag{1.29}$$

1.4 Definition of a Stationary Competitive Equilibrium

I now define the equilibrium that I study:

Definition 1 *Given a replacement rate, rep, and a tax rate for capital income, τ_k , a college subsidy rule ν, a Stationary Recursive Competitive Equilibrium is a set of functions $V_{y,d}(s_{y,d})$, $V_{y,a}(s_{y,a})$, $V_{p,1}(s_{p,1})$, $V_{p,w}(s_{p,w})$, $V_{p,r}(s_{p,r})$, $c_{y,d}(s_{y,d})$, $c_{y,a}(s_{y,a})$, $c_{p,1}(s_{p,1})$, $c_{p,w}(s_{p,w})$, $c_{p,r}(s_{p,r})$, $a'_{y,d}(s_{y,d})$, $a'_{y,a}(s_{y,a})$, $a'_{p,1}(s_{p,1})$, $a'_{p,w}(s_{p,w})$, $a'_{p,r}(s_{p,r})$, $tra(s_{p,1})$, $ed(s_{p,1})$, non-negative prices of physical capital and of effective labor, $\{r, w\}$, and set of probability measures on the state spaces of the respective household problem as defined in sections (1.3.1)-(1.3.2) such that the following hold:*

1. *Given prices and policies, $V_{y,d}(s_{y,d})$, $V_{y,a}(s_{y,a})$, $V_{p,1}(s_{p,1})$, $V_{p,w}(s_{p,w})$ and $V_p(s_p)$ are the solution to the household problem outlined in (1.3.1)-(1.3.2) with $c_{y,d}(s_{y,d})$, $c_{y,a}(s_{y,a})$, $c_{p,1}(s_{p,1})$, $c_{p,w}(s_{p,w})$, $c_p(s_p)$, $a'_{y,d}(s_{y,d})$, $a'_{y,a}(s_{y,a})$, $a'_{p,1}(s_{p,1})$, $a'_{p,w}(s_{p,w})$, $a'_p(s_p)$, $tra(s_{p,1})$, $ed(s_{p,1})$ being the associated policy functions.*

2. *The prices r and w solve the firm's problem (1.25) and (1.26).*

3. *The government policies satisfy (1.27), (1.28) and (1.29).*

4. *Markets for physical capital, labor in efficiency units and the consumption good clear:*

$$K = \left\{ \begin{array}{c} \int_{\mathbf{S}_{y,d}} a'_{y,d}(s_{y,d}) d\Phi + \int_{\mathbf{S}_{y,a}} a'_{y,a}(s_{y,a}) d\Phi \\ + \int_{\mathbf{S}_{p,1}} a'_{p,1}(s_{p,1}) d\Phi + \int_{\mathbf{S}_{p,w}} a'_{p,w}(s_{p,w}) d\Phi + \int_{\mathbf{S}_p} a'_p(s_p) d\Phi \end{array} \right\} \tag{1.30}$$

$$L = \left\{ \begin{array}{c} \int_{\mathbf{S}_{y,d}} \varepsilon_j^e \eta^{j,e} d\Phi + \int_{\mathbf{S}_{y,a}} \varepsilon_j^e \eta^{j,e} d\Phi \\ + \int_{\mathbf{S}_{p,1}} \varepsilon_j^e \eta^{j,e} d\Phi + \int_{\mathbf{S}_{p,w}} \varepsilon_j^e \eta^{j,e} d\Phi \end{array} \right\} \tag{1.31}$$

$$C + [K - (1-\delta)K] + T + I - \Xi = F(K, L) \tag{1.32}$$

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

where

$$C = \left\{ \begin{array}{c} \int_{\mathbf{S}_{y,d}} c_{y,d}(s_{y,d}) d\Phi + \int_{\mathbf{S}_{y,a}} c_{y,a}(s_{y,a}) d\Phi \\ + \int_{\mathbf{S}_{p,1}} c_{p,1}(s_{p,1}) d\Phi + \int_{\mathbf{S}_{p,w}} c_{p,w}(s_{p,w}) d\Phi + \int_{\mathbf{S}_{p}} c_{p}(s_{p}) d\Phi \end{array} \right\} \tag{1.33}$$

$$T = \int_{\mathbf{S}_{p,1}} tra(s_{p,1}) d\Phi \tag{1.34}$$

$$I = \kappa \int_{\mathbf{S}_{p,1}} ed(s_{p,1}) d\Phi - \nu \int_{\mathbf{S}_{p,1}} ed(s_{p,1}) d\Phi \tag{1.35}$$

5. *The Aggregate Law of Motion is stationary:*

$$\Phi = H(\Phi) \tag{1.36}$$

The function H is generated by the policy functions $a'_{y,d}(s_{y,d})$, $a'_{y,a}(s_{y,a})$, $a'_{p,1}(s_{p,1})$, $a'_{p}(s_p)$, $tra(s_{p,1})$, $ed(s_{p,1})$, the Markov process $Q(\eta^e, N^e)$ and the transmission matrix $Q^{initial,e}(i, i \in I = \{1, 2, ..., n\})$ and can be written explicitly as

(a) *For all sets $(\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J})$ with $\mathcal{J} = \{2, ..., 30\}$ such that $(\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}, \mathcal{J}) \in \mathcal{S}_{y,a}$, the measure of agents whose parents are alive is given by*

$$\Phi_a = \int_{\mathbf{S}_{y,a}} P_{y,a}(s_{y,a}, (\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J})) d\Phi_a \tag{1.37}$$

where $P_{y,a}(s_{y,a}, (\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J}))$

$$= \begin{cases} \psi_{(j+30)} \sum\limits_{\eta' \in \mathcal{N}^e} Q(\eta, \eta') & \text{if } a'_{y,a}(s_{y,a}) \in \mathcal{A},\ a'_p(s_p) \in \mathcal{A}^p,\ e = e' \in \mathcal{E},\ j+1 \in \mathcal{J} \\ 0 & \text{otherwise} \end{cases}$$

$P_{y,a}(s_{y,a}, (\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J}))$ is the transition function. It gives the probability that an agent with endowment $s_{y,a}$ at age j ends up in $j+1$ with asset holdings $a'_{y,a} \in \mathcal{A}$, productivity state $\eta' \in \mathcal{N}^e$ and parental asset holdings $a'_p \in \mathcal{A}^p$. The education level remains constant.

(b) *For all sets $(\mathcal{A}, \mathcal{E}, \mathcal{N}^e, \mathcal{J})$ with $\mathcal{J} = \{2, ..., 30\}$ such that $(\mathcal{A}, \mathcal{E}, \mathcal{N}, \mathcal{J}) \in \mathcal{S}_{y,d}$, the measure of agents with deceased parents is given by*

$$\Phi_d = \left\{ \begin{array}{c} \int_{\mathbf{S}_{y,d}} P_{y,d}(s_{y,d}, (\mathcal{A}, \mathcal{E}, \mathcal{N}^e, \mathcal{J})) d\Phi_d + \\ \int_{\mathbf{S}_{y,a}} (1 - \psi_{j+30}) P_{y,a}(s_{y,a}, (\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J})) d\Phi_a \end{array} \right\} \tag{1.38}$$

where $P_{y,d}(s_{y,d}, (\mathcal{A}, \mathcal{E}, \mathcal{N}^e, \mathcal{J}))$

$$= \begin{cases} \sum\limits_{\eta' \in \mathcal{N}^e} Q(\eta, \eta') & \text{if } a'_{y,a}(s_{y,a}) \in \mathcal{A},\ e = e' \in \mathcal{E},\ j+1 \in \mathcal{J} \\ 0 & \text{otherwise} \end{cases}$$

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

As fraction $(1-\psi_{j+30})$ *of parents dies in period* j*,* Φ_d *incorporates the measure of young agents whose parents died in the previous period.*

(c) *For all sets* $(\mathcal{A}, \mathcal{I}, \mathcal{J})$ *with* $\mathcal{J} = \{31\}$ *such that* $(\mathcal{A}, \mathcal{I}, \mathcal{J}) \in \mathcal{S}_{p,1}$*, the measure of parent households in* $j = 31$ *is given by*

$$\Phi_{p,1} = \left\{ \begin{array}{c} \int_{\mathbf{S}_{y,d}} P_{p,1}(s_{y,d}, (\mathcal{A}, \mathcal{I}, \mathcal{J}))d\Phi_d \\ + \int_{\mathbf{S}_{y,a}} P_{p,1}(s_{y,a}, (\mathcal{A}, \mathcal{I}, \mathcal{J}))d\Phi_a \end{array} \right\} \tag{1.39}$$

where $P_{p,1}(s_{y,d}, (\mathcal{A}, \mathcal{I}, \mathcal{J}))$

$$= \begin{cases} \sum_{i' \in \mathcal{I}} Q^{initial,e}(i, i') & \text{if } a'_{y,a}(s_{y,a}) \in \mathcal{A},\ j+1 \in \mathcal{J} \\ 0 & \text{otherwise} \end{cases}$$

and $P_{p,1}(s_{y,d}, (\mathcal{A}, \mathcal{I}, \mathcal{J}))$ *follows straightforwardly.*

$P_{p,1}(., (\mathcal{A}, \mathcal{I}, \mathcal{J}))$ *shows the transition from child households to parent households. The measure of parent households collects all child households.*

(d) *The measure of parent households while working is generated in a similar fashion.*

(e) *For all sets* $(\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J})$ *with* $\mathcal{J} = \{1\}$ *such that* $(\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}, \mathcal{J}) \in \mathcal{S}_{y,a}$*, the measure of agents in their first period is given by*

$$\Phi^{initial} = \int_{\mathbf{S}_{p,1}} P^{initial}_{p,1}(s_{p,1}, (\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J}))d\Phi_{p,1} \tag{1.40}$$

where $P^{initial}_{p,1}(s_{p,1}, (\mathcal{A}, \mathcal{A}^p, \mathcal{E}, \mathcal{N}^e, \mathcal{J}))$ *is given by* $a'_{p,1}(s_{p,1})$*,* $tra(s_{p,1})$ *and* $ed(s_{p,1})$ *where* $a'_{p,1}(s_{p,1}) \in \mathcal{A}$*,* $tra(s_{p,1}) \in \mathcal{A}^p$ *and* $ed(s_{p,1}) \in \mathcal{E}$*.*

(f) *The measure of agents during retirement is generated by the policy function* $a'_p(s_p)$ *where* $a'_p(s_p) \in \mathcal{A}$*.*

A few remarks regarding the equilibrium conditions are in order. (1.30) and (1.31) state that aggregate physical capital and labor measured in efficiency units follow from aggregating the respective holdings of each agent and weighting them appropriately. (1.32) requires that the good market clears, i.e. that the demand for goods, which is shown on the left-hand side, is equal to the supply of goods. The term $[K - (1-\delta)K]$ on the left-hand side determines the amount of investment that is necessary to keep the aggregate capital stock constant, whereas I and T are aggregate college expenditures and transfers in stationary state, respectively. (1.36) requires stationarity of the probability measure Φ. The function H is the transition function which determines the probability that an agent will end up with a certain combination of state variables tomorrow, given his endowment with state variables today. Notice that the stationarity condition requires that child households are (on average) 'identical' to their parents in the sense that they reproduce their parent household's distribution once they

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

become parents themselves. This in turn implies that the distribution of transfers and inheritances that child households receive is consistent with the distribution of transfers that is actually left by parent households. I present more details about the computational procedure in the appendix.

1.5 Parametrization and Calibration

I calibrate parameter values of the benchmark economy to represent relevant features of the U.S. economy as closely as possible. It will be assumed that the length of one unit of time in the model economy corresponds to a calendar year. The targets that I choose for the benchmark economy describe the U.S. economy around 1980. I therefore label this benchmark case 'economy 1980'. In order to compare the change of enrolment patterns over time, I define a second steady-state which I denote as 'economy 2000'.

1.5.1 Economy 1980

Technology, Demographics and Preferences

I assume that the utility from consumption in each period is given by $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$. Production is assumed to follow the aggregate production function $F(K, L) = K^{\alpha} L^{1-\alpha}$, where L is aggregate labor measured in efficiency units (see equation 1.31). By assumption, college graduates have a skill premium and supply more labor in efficiency units compared to high school graduates. Implicitly, this assumes that efficiency units supplied by high school and college graduates are perfect substitutes in the production process. GMV (2007) allow for imperfect substitutability. I set the capital share in income (α) equal to 0.36, as estimated by Prescott (1986). Following Imrohoroglu et. al. (1995) and Heer (2001), I assume that capital depreciates at an annual rate of 8 percent. The conditional survival probability ψ_j is taken from the National Vital Statistics Report, Vol. 53, No. 6 (2004) and refers to the conditional survival probability for the U.S. population. Only values between age 53 and age 82 are used. I assume that the survival probability is zero for agents at the age of 83. The survival probability for households that are younger than 53 years is assumed to be equal to 1.[12] The preference parameter γ determines the relative risk aversion and is the inverse relation to the intertemporal elasticity of substitution. I follow Attanasio (1999) and Gourinchas and Parker (2002) who estimate γ using consumption data and find a value of 1.5. This value is well in the interval of 1 to 3 commonly used in the literature.

The two main parameters that govern the accumulation of wealth and transfer behavior - the discount factor β and the intergenerational discount factor ς - are calibrated jointly such that the baseline economy is consistent with the wealth-income ratio and the relative size of intergenerational transfers in the U.S. economy in 1980. Gale and Scholz (1994) compute a

[12] The actual survival probability before 53 is close to 1. See the National Vital Statistics Report.

 DOI: 10.2870/26812

ratio of inter vivos transfers to total wealth of 0.28 percent from the 1983 and 1986 Survey of Consumer Finances. This number comprises financial non-college support to children. The resulting ς is 0.7, which implies that for the benchmark economy to be consistent with the transfer flows observable in the U.S. economy, a parent household would have to consider the utility of a child household 30 percent less than it considers its own utility. This is in line with results obtained from Nishiyama (2002) who uses an altruistic framework to explain the observable degree of wealth inequality in U.S. economy.

Earnings Process

I assume that the process that governs the productivity shocks $\eta^{j,e}$ follow an AR(1) process with persistence parameter ρ^{hs} for high school graduates and ρ^{col} for college graduates. The variance of the innovations are σ^{hs} and σ^{col}, respectively. These parameters are estimated by Hubbard et al. (1995)(HSZ in the following) from the 1982 to 1986 Panel Study of Income Dynamics (PSID). They find that high school graduates have a lower earnings persistence and a higher variance ($\rho^{hs} = 0.946$, $\sigma^{hs} = 0.025$) compared to college graduates ($\rho^{col} = 0.955$, $\sigma^{col} = 0.016$). It should be noted that both estimates are rather conservative as HSZ use the combined labor income of the husband and wife (if married) plus unemployment insurance for their estimates. When I approximate the earnings process with a four-state Markov process using the procedure proposed by Tauchen and Hussey (1991), I find that the transition matrices for high school and college graduates are nearly indistinguishable.

I also take the average age-efficiency profile ε_j^e from HSZ, which gives us an estimate of the college premium for different age groups. The authors find that earnings are more peaked for college families, which is in line with findings from other empirical studies. Different from the model estimated by HSZ, I endogenize the college enrolment decision. This implies that in equilibrium, college graduates are more likely to have positive deviations with the respect to the average age profile, because more productive children (measured in terms of their first draw from the productivity distribution) are more likely to attend college. This is not reflected in the estimation of the mean age-earnings profile of HSZ. I thus adjust the age profile for college graduates in the model downwards, such that the average college premium *after* selection coincides in both models. By estimating a fixed-effect model, GMV (2007) propose an alternative way of calibrating the earnings process.

For the economy 1980, I also adjust their estimates for the earnings variance. The reason is that HSZ estimate their model for the beginning of the 1980's. Parents who decide upon transfers in the beginning of the 1980's accumulated their wealth in the 1970's or even earlier. Gottschalk and Moffitt (1994) find that the variance of both permanent and transitory earnings increased by 40 percent between the two decades. For the economy 1980, I thus use a σ^{hs} of 0.015 and σ^{col} of 0.01.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

College Completion and Cost of College

I assume that the probability of college completion $\lambda(i)$ is an increasing function of the initial productivity state i. In particular, I assume

$$\lambda(i) = d + a(i-1) \tag{1.41}$$

$$d, a \geq 0$$

Recall that I approximate the AR(1) process with a 4-state Markov chain; I therefore have a grid with 4 points that represent the different productivity levels. Consequently, the parameter d governs the completion probability for child households with low ability ($i = 1$). d thus governs the expected return associated with college investment. I set d such that the college participation rate of low ability students with parents in the highest income quartile is 0.3. This is also the enrolment share of low-ability children from families in the highest income quartile in the NLSY79 as reported by Belley and Lochner (2007).[13] I use families from the highest income quartile as a calibration target because financial constraints are not very likely to have an impact on their college enrolment decision (Carneiro and Heckman (2002)). Instead, I impose that their decision is solely based on the expected return, which is governed by d. For $d = 0.32$, the benchmark steady-state replicates the enrolment share of high-income families with children of low ability. This implies that these students graduate with a probability of 32 percent.

Two additional parameters influence the college investment behavior, the tuition costs κ and the slope parameter a. I calibrate these parameters jointly such that the model is consistent with an overall dropout probability of 50 percent (Restuccia and Urrutia (2004)) and a fraction of college graduates of 25 percent. I obtain a κ of 0.95 and an a of 0.07. In line with U.S. evidence, the model implies that total college expenses are approximately equal to GDP per-capita(see e.g. Collegeboard (2005) or Gallipoli et al. (2007)). A slope parameter a of 0.07 implies that high-ability children have a 21 percent higher change of graduating from college than low-ability children.

Transmission of Initial Productivity

In the data, there is a high degree of persistence in economic outcomes across generations. Inheritability of genetic traits, the family environment and early education all matter for explaining different levels of pre-college ability levels Restuccia and Urrutia (2004). Following Keane and Wolpin (2001), I assume that the transmission of initial productivity levels depends

[13] Belley and Lochner (2007) use the Armed Forces Qualification Test (AFQT) as a proxy for ability. AFQT test scores are a widely used measure of cognitive achievement by social scientists using the NLSY and are strongly correlated with positive outcomes like education and post-school earnings. See their footnote 2 for further references

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

solely on the level of parental education. Technically, I generate a positive link by assuming that parents transmit part of their productivity shock at age $j = 30$ to their children, who enter the economy when parents turn to $j = 31$.

Because transmission depends on parental education, I define two separate transition matrices for parents with high school and college education, $Q^{initial,hs}$ and $Q^{initial,col}$. Let $p^{col}_{i^p,i^c} \forall \{1,...,4\}$ be an element of the transition matrix of college graduates. Then, $p^{col}_{i^p,i^c}$ is the probability that a college educated parent household of age $j = 30$ is of productivity i^p, while the child receives an initial productivity of i^c. In order to achieve a positive link across generations, it needs to be that $p^{col}_{i^p,i^c} \geq p^{hs}_{i^p,i^c}$ for 'high' levels of i^c and $p^{col}_{i^p,i^c} \leq p^{hs}_{i^p,i^c}$ for 'low' levels i^c. In addition, I require that $p_{i^p,i^c} > 0$ to ensure that there are non-trivial percentages in all productivity levels. Moreover, the probabilities in each row of the transition matrix have to sum to 1, $\sum_{i^c} p_{i^p,i^c} = 1$.

Limited by these conditions, I model both transition matrices as linear combinations between an identity matrix and a matrix which rows consist of an additive sequence. For college graduates, this sequence has starting value 0, increment $\frac{(n-1)n}{2}$ and n elements, where n is the number of productivity shocks. Let π be the weight of this matrix and $(1 - \pi)$ the weight of the identity matrix. Then, $p_{i^p,i^c} \geq 0$ requires $\pi \in (0, 1)$. π is calibrated such that the model reproduces the correlation of college education across generations. Data from NLSY 79 reported by Keane and Wolpin (2001), Table 4, suggests that this correlation is between 0.28 and 0.38, depending on the youth's level of completed schooling at age 16. The correlation of education college attainment is significantly weaker if I consider only parent-child pairs for which the children's schooling level at the age of 16 is similar. Since I do not model differences pre-tertiary education, I choose π such that the model implies a correlation of 0.31.

College Subsidies and Taxes

Parents who send their children to college receive a government subsidy $\nu_{|ed=1}(a_{p,1}, \varepsilon^e_j \eta^{j,e} w)$ for each unit of expenditure in college education. The subsidy is a function of current income and asset holdings. In the U.S., the calculation of the subsidy is based on an estimate of the student's family ability to pay the cost of college. This estimate is based on estimates of 'discretionary income' and 'available assets' Feldstein (1995). I approximate discretionary income as the sum of labor and capital income, net of taxes. Available assets are calculated as the difference between current wealth holdings and a wealth level that is deemed to maintain the current standard of living, which I approximate by the average asset holdings in the economy, called $\bar{a}$. These two measures are then combined by adding 12 percent of the available net assets to the discretionary income, see Feldstein (1995).

The key point of the exercise is that every extra dollar of savings raises the amount of available resources, which decreases the subsidy. Feldstein (1995) points out that this indirect savings tax may generate strong disincentives for the accumulation of wealth. For simplicity

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

and because this specification is common in the literature, I assume that the subsidy level is linearly decreasing in the level of parental resources:

$$\nu = \max(\nu_0 - \nu_1(\max(0, a_{p,1} - \overline{a}) + (1 - \tau_w)\, r a_{p,1}\, (1 - \tau_w)\, \varepsilon_j^e \eta^{j,e} w), 0) \tag{1.42}$$

$$\nu_0, \nu_1 \geq 0$$

I calibrate ν_0 and ν_1 such that (i) the ratio of college subsidies to total college expenses, the subsidy rate, is 0.4, as reported by the OECD (see Akyol and Athreya (2005), Figure 1) and (ii) the subsidy does not cover more than 50 percent of κ, the total college expenses an individual household has to pay, see Keane and Wolpin (2001). This implies estimates of ν_0 of 0.57 and of ν_1 of 0.1. Following De Nardi (2004), I use a capital income tax rate τ_K of 0.2 and a replacement rate for pension benefits of 0.4. Finally, I adjust the tax rate on labor income τ_w such that the government budget (1.28) is balanced. This results in a tax rate of 15 percent. The results are summarized in Table 1.2.

1.5.2 Economy 2000

I adjust the average college premium, the earnings process and the tuition fees in order to account for the increase in between-group inequality, within-group inequality and the doubling of the college expenses (in real terms, see Collegeboard (2005)). All other parameter values are left unchanged. The college premium increases by 30 percentage points (from 40 percent to 70 percent compared to our benchmark case (see Katz and Autor (1999)).

1.6 Results

In this section, I analyze the quantitative behavior of our benchmark economy. In particular, I use my model as a measurement tool in order to evaluate to what extend borrowing constraints are binding.

1.6.1 Economy 1980: How Important are Borrowing Constraints?

In this section, I show that the fraction of households that is borrowing constrained in their college decision is 18 percent, which is substantially higher than what estimates from the empirical literature suggest. Carneiro and Heckman (2002) find that at most 8 percent of the population are borrowing constrained in the short-run sense. I argue that the difference is due to the measurement of long-term factors and the fact that parents are imperfectly altruistic. If I apply their methodology to the data generated by the model, my results are broadly consistent with their findings.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

The Fraction of Constrained Households

In order to measure the fraction of constrained young households, I start with an experiment in which I allow parents to borrow up the total college expenses. I implement the loan as a transfer from the government to all parents before they decide on how much to invest in their children. In order to keep its budget balanced, the government in turn collects the resources from the child households. The debt contract takes the form of a redeemable loan, for which the annual redemption sum is fixed and independent of the child household's income.

Now, I 'force' parents to use the loan for their children, either in form of financial transfers or in form of college investment or both. Parents cannot use the additional resources for their own consumption. It is important to notice that this experiment is equivalent to a scenario where the child households are offered a loan directly, and where they decide themselves whether they want to invest in human capital or in financial assets.[14] If the total loan amount is transferred in form of financial assets, the net present value of the loan is zero by construction.[15]

I find that the second experiment raises the total college enrolment rate to 75 percent, an increase of 18 percentage points relative to the benchmark economy. From this it follows that the presence of borrowing constraints for college education is associated with a decrease in the college enrolment rates of 18 percent relative to an economy where enrolment is dictated solely by the expected value of going to college. This result exceeds the findings from the empirical literature considerably. Carneiro and Heckman (2002) conclude that the fraction of constrained households in the population is at most 8 percent. In the next two sections, I shed further light on the difference between my results and theirs. I show that once I apply their methodology to the data generated by my model, the results broadly coincide.

The result that borrowing constraints for higher education are quantitatively important is in line with empirical evidence provided by Brown et al. (2007). Based on the HRS and the NLSY97, Brown et al. (2007) find that financial aid has a positive and significant impact on college educational attainment when no (post-)schooling cash transfers are reported. When positive transfers are reported, this relationship disappears. Brown et al. (2007) interpret this as evidence for the fact that there is a significant fraction of families that are too poor, or not altruistic enough, to provide sufficient transfer to finance their children's education.

Enrolment Gap

I now examine how the model compares to the data as regards to enrolment gaps between income groups. For the 1980 economy, I compute the college enrolment rate by family income and ability level. Figure 1.3 plots the results.

[14]Because parents choose the optimal mix between financial transfers and college investment such that they maximize their own utility and their children's utility is part of their total utility, the parental decision about the optimal division of the loan coincides with the decision the offspring would take.

[15]I expect that low-ability children receive a greater share of the loan in terms of financial transfers.

The empirical counterpart is taken from Belley and Lochner (2007), Figure 2a, who study data from the NLSY79. Figure 1.4 shows their results. I find that - both in the model and in the data - college enrolment increases with ability level. In the model, this is an immediate consequence of the assumption that more able children have a higher likelihood to graduate from college, which makes college investment more profitable for their parents.

These plots also indicate a subsidiary, but quantitatively important role for family income in accounting for college entry, which one might think of as indicating the importance of borrowing constraints. In an influential paper, Carneiro and Heckman (2002) claim that enrolment gaps with respect to family income are not very informative about the strength of borrowing constraints. They argue that one needs to distinguish between short-term borrowing constraints, which are created by short-term cash-flow problems when a child is on the threshold of college enrolment, and long-term borrowing constraints related to a family's ability to finance education through a youth's childhood. Only the short-term constraints are of relevance for public policy in my framework, as they can be addressed directly with policy measures such as a different college subsidy scheme. Family income, which is measured when the child is on the threshold of college entry, thus captures short-term as well as long-term constraints.

Carneiro and Heckman control for long-term factors by including parental education and a set of other family related variables in addition to a measure of academic ability when computing the enrolment gaps. They find that gaps in college entry by family income narrow significantly after controlling for long-run borrowing constraints (see Figure 5 in their paper).

In Table 1.5, I report the enrolment gaps with respect to the highest income quartile generated by the baseline economy. Each column represents a different ability quartile. Panel A of Table 1.5 documents the enrolment gaps corresponding to Figure 1.3. Panel B and C give the enrolment gaps after controlling for the parental education level (high school or college, respectively).

In line with Carneiro and Heckman (2002), I find that enrolment gaps narrow after controlling for long-term factors, in my case ability and parental schooling. Table 1.5 reveals that enrolment gaps for children from college graduated parents differ very little across different income groups.

Carneiro and Heckman (2002) interpret these enrolment gaps as the fraction of the population that cannot attend college because of financial constraints. They conclude that at most 8 percent of the population is constrained in their college decision. I repeat their analysis and weight the enrolment gaps documented in Table 1.5 with the fraction of the total population in the respective ability and income quartile. I find that the maximum fraction constrained is 14 percent if I condition on high school education (Panel B) and 11 percent if I control for college education (Panel C). Without controlling for education, the estimated share would have been considerably higher (20 percent, panel A) which confirms that incorporating long-

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

term factors decreases the conjectured role of borrowing constraints, as argued by Carneiro and Heckman (2002).

Above I argued that removing the borrowing constraint for college enrolment leads to an 18 percent increase in the enrolment rate. Thus, the model-based estimate of the extent to which borrowing constraints adversely affect college entry is substantially higher than the econometric estimate derived from controlling for long-term factors. I will now show that this disparity is due to imperfect altruism on the part of parental households which implies that young and able households may receive insufficient transfers even if their parents could afford to send them to college.

The Role of Imperfect Altruism

In order to gauge the importance of imperfect altruism, I repeat the experiment from Section 1.6.1 but let parents decide how to spend the additional resources provided by the government. Thus, comparing this experiment to the 'forced' experiment reported in Table 2.3, allows me to check how imperfect altruism affects the extent of borrowing constraints for prospective college entrants. I will refer to this experiment as 'free disposal'. The fact that parents are imperfectly altruistic implies that parents weight the disutility the child suffers from repaying the loan less than their utility gain they obtain by using part of the loan for their own consumption purposes. I thus expect that parents do not provide the total loan amount to their children.[16] The 'free disposal' experiment therefore mainly illustrates the extend to which imperfect altruism biases our measured fraction of constrained families.

Table 2.3 reports the total share of students that engage in college education. I find that the fraction of college students in each cohort increase from 57 percent to 62 percent when I allow for borrowing. Compared to the increase of 18 percent that one could observe in the 'forced' experiment above, this share appears to be relatively small.

In order to understand the differences, it is interesting to compare the Figures 1.3, 1.5 and 1.6. I find that in the experiment with 'forced' credit (Figure 1.6), the enrolment rates increase not only for households from the lower end of the income distribution, but also for rich households. I do not observe this pattern in the 'free-disposal' experiment (Figure 1.5), which suggest that enrolment rates rise because the 'forced' experiment eliminates all effects of imperfect altruism. Hence, ignoring the possibility of *imperfect* altruism may bias the estimated fraction of constrained households downwards. The results show that, even though the average enrolment gap measured in the model is in line with empirical results by Carneiro and Heckman (2002), the true fraction of constrained households is much larger as even children from high-income family may not receive the sufficient amount of transfers needed to go to college.

[16]Because of imperfect capital markets, parents might also be borrowing constrained for their own consumption purposes. Since parents are already in an advanced stage of the life cycle when transfers take place, I do not expect constraints on parental consumption to be binding for a larger fraction of families.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

The Role of Parental Education as a Long-Run Factor

Conditioning on parental education has a significant impact on observable enrolment patterns, implying that there is a strong link between parental education and children's college attendance. Apart from the fact that college graduated parents are richer, they also have, by assumption, smarter children.

However, Table 1.6 documents that even after controlling for ability and family income quartile, offspring from college educated families have a 4.5 percent higher change of being enrolled in college than descendants from high school educated families (Table 1.6, first row). This difference stems from the fact that education not only determines the level of family income but also the level of parental wealth. In the empirical literature, family income is usually solely observed in a specific year. Wealth in turn is determined by permanent income, which may only be weakly related to the level of income around college age.

The second row of Table 1.6 accounts for this effect. Here, I compute the average difference between the enrolment rates of college graduates and high school graduates, controlling for the quartile of family income, ability and assets. The results of the first and the second row are extremely similar, suggesting that differences in asset holdings - after controlling for family income - do not explain the gap in college enrolment between children of differently educated parents.

The findings contribute to the debate in the literature on whether parental education should be used as a measure for long-term borrowing constraints (Carneiro and Heckman (2002), Kane (2006)). To the extent that parents can help financing their children's education with current income or accumulated assets, conditioning on parental education may lead to an understatement of the role of short-term constraints (Kane 2006, p. 1394). The results suggest that this is not the case; parental education seems to have an influence on college going, which is independent of the wealth effect.

Neither differences in parental endowment nor differences in children's ability explain fully why high school educated parents provide less support for their offspring's college education. Instead, the differences stem from different expectations about the future. High school graduates are exposed to a higher earnings risk and lower average earnings, even after the time their children left home. Indeed, I find that high school graduates have higher savings than college graduates at age 53, the age at which parent households decide about transfers.

In Tables 1.7 and 1.8, I compute average savings for different ability, income and wealth quartiles, differentiated by the education level of the household. The results convey a clear message: high school graduates at age 53 tend to save more than college graduates at this age.

Thus, in conclusion, I find that large fraction of borrowing constrained households measured in my model compared to the literature can be explained by (i) the fact that parents are imperfectly altruistic, which implies that even children from high-income families may

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

not receive enough parental funding and (ii) the high school educated parents save more and transfer less than their college educated counterparts, even if their children are equally well prepared for college.

1.6.2 Economy 2000: Have borrowing constraints become more limiting?

Have Borrowing Constraints Become more Limiting?

In order to analyze to what extent borrowing constraints have become more binding as the economic environment changed between 1980 and 2000, I repeat the 'free-disposal' as well as the 'forced' experiment for the 2000 economy. The 'free-disposal' experiment for the economy 2000 indicates that the share of college students increases from 60 percent to 85 percent, which is a change of 25 percentage points (see Table 2.3). This result is in stark contrast to the result for the economy 1980, for which enrolment increased by only 5 percentage points.

Comparison of the college enrolment rates for the two different economies, see Figures 1.5 and 1.9 reveals that the low-ability students make the difference. While these agents' college enrolment decisions are approximately unaffected by the provision of loans in the 1980 economy, this policy increases their enrolment rates significantly in the 2000 economy. This indicates that – due to the increase in the college premium – college education becomes more profitable for this group of students. As indicated by the enrolment patterns in the previous section, only rich parents are willing to take advantage of this and invest in their low-ability children. Despite the surge in the college premium, parents with lower income, instead, do not find it advantageous to transfer sufficient funds to their offspring.

Applying the 'forced' credit experiment to the economy 2000 reveals the full extent to which lack of parental transfers (and thus borrowing constraints) limit college enrolment. In this alternative experiment, enrolment goes up to approximately 100 percent. That is, around 40 percent of the population are constrained in their college decision, compared to 18 percent in the economy 1980.[17]

Thus, the recent changes in the economic environment in the U.S. generate a larger fraction of constrained households. In order to understand why, I present the changes in the enrolment patterns between 1980 and 2000 in the next section.

Enrolment Rates

I now analyze to what extend the increase in the college premium, the tuition fees and the variance of the productivity process have affected the college enrolment for different ability

[17] It is also interesting to note that the model implies that the share of students who drop out from college without a degree increased, albeit only slightly, when one compares the baseline economy to the economy 2000. This rise is an immediate consequence of the fact that the share of low-ability students increased. The findings thus provide an explanation for the changing dynamic between college enrolment and college completion, which is documented by Turner (2004). See Table 2.3

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

and family income quartiles. Figure 1.7 shows the enrolment rates obtained from our model economy 2000, while the empirical counterpart from the NLSY97 is displayed in Figure 1.8 (see Belley and Lochner (2007), Figure 2b). In line with their observations, I find that the role of ability did not change with respect to the economy 1980. Also consistent with the data, there are two striking differences between the economies of 1980 and 2000:

1. Enrolment rates are higher for the economy 2000. This suggests that in the aggregate, the rise in the rate of return on tertiary education more than outweighs the increase in risk and the higher price of tuition.

2. Enrolment gaps between different family income groups have widened over time, in particular for the low-ability students. This holds even after controlling for parental education (see Table 1.10).

To better understand the increase in the enrolment gap for low-ability students, I compute the share of college students from the lowest ability for the economy 1980 and the economy 2000. I find that this fraction has more than doubled from 1.8 percent to 5 percent (see Table 2.3). This increase could indicate that the number of high income families with low ability children rose since high income families are more prone to send their offspring to college. However, our results reveal that the number of families from the top income quartile that have children with low ability actually declined from 2.4 to 1.3 percent. Consequently, the rise of the fraction of low-ability college students must be due to the increase in the college premium which made college investment more attractive, even for low-ability students.

Next, I compute the average savings for different income, wealth and ability quartiles, using the policy functions and the steady-state distribution of agents generated by our economy 2000 for agents at age 53. The results are shown in Tables 1.10 and 1.11. If I compare the difference between high school and college graduates for 1980 (tables 1.7 and 1.8) with the differences in 2000, I find that high school graduated parents now save even more compared to their college graduated counterparts, all other things equal. The increase appears to be more pronounced for parents with children in the lowest ability quartile.

Strikingly, savings of high school graduates relative to college graduates increases, after controlling income and wealth. This is due to the increase in the variance of earnings shocks, which I use in order to simulate the increment in the within-group inequality. This rise in uncertainty has a stronger impact on high school graduates, as labor earnings comprise a bigger share of total income for that group. Therefore, the need for precautionary savings is higher for the high school group, which causes them to keep more resources to secure their own future. This result is reinforced by the fact that high school graduated parents are more likely to have low-ability children, which reduces the expected return from investing. In addition, the rise in tuition fees has made college expenses even more expensive, reducing the incentives for the poor to invest in their children.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

In conclusion, I find that the recent changes in the economic environment generate a stronger link between family income and college enrolment in the model, which is in line with the data. The model predicts that financial constraints have become more limiting over the course of time. In the model, this stems from the fact that the rise in the college premium implies that more young household are willing to go to college. Only the rich parents, however, can take advantage of this and invest. The others are hampered by the increase in within-group inequality, which requires more savings for their own future, and the increment of the tuition fees.

1.6.3 Testable Implications

A key insight from the analysis above is that, according to my model, parents at age 53 with high school education save more and transfer less to their offspring than college graduates at the same age. I will now examine to empirical relevance of this aspect of my analysis. I address this issue by computing education specific savings and transfers from the 1986 Survey of Consumer Finances (SCF).

The Trade-Off between Transfers and Savings in the Data

The SCF is a household survey conducted on a triennial basis. It consists of a cross-section of U.S. households, with the exception of the waves in 1983 and 1986 which contain repeated cross-sections. This allows me to observe household savings between 1983 and 1986. Moreover, the 1986 wave also ask extensively about household's transfer behavior, and has therefore become a standard reference with respect to parental inter-vivos transfers (see e.g. Gale and Scholz (1994)). I compute total transfers given by a household as the sum of all monetary transfers and college expenses, which are reported separately in the SCF.[18] I use savings in constant prices accumulated between 1983 and 1986. In order to be consistent with the model, I only consider those households that are between 45 and 65 years old, and that have at least one child. As Table 1.12 shows, college graduates have on average higher savings and transfer more resources (column 1), as one would expect from the fact that college graduates are on average more affluent and have higher income than high school graduates. However, if I introduce dummies for the asset quartile and the income quartile in order to control for wealth and income effects, I find that college graduates make more transfers, but they save considerably less than high school educated parents.[19] In line with the predictions of the model, this suggests that there is trade-off between savings and transfers, and that the split between the two is also determined by expectations about the future. This finding has important implications for the design of college subsidy rules. Dynarski

[18] The 1986 SCF only reports transfers if the transfer amount is above 3000 US-Dollar.

[19] The 1986 SCF does not include any measure for the academic ability of the offspring. However, one can show that the key predictions of Tables 1.7 and 1.8, still holds, even if one controls only for income and wealth

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

and Scott-Clayton (2006) and Kane (2006) argue that part of the enrolment gap can be explained by the complexity of existing system of distributing federal student aid, which disproportionately burdens youth from low-income and low-education families. They propose to implement simple, easily communicable aid programs. My results extend their argument: because financial aid is determined solely on the basis of actual family wealth and income, it adversely affects students from low-income families. Instead, college aid should also be based on expected future earnings.

The Drop in the Degree of Education Persistence

Another model implication that deserves further attention can be seen in Table 2.3. In the last column, I document the intergenerational correlation of educational attainment for the different economies. Interestingly, the results indicate that the degree of education persistence *decreased* as one moves from the economy 1980 to the economy 2000. This is perhaps surprising as the literature generally assumes that borrowing constraints lead to a *higher* degree of persistence, not the other way round (see Keane and Wolpin (2001), among others).

The fact that the link between parents and children in educational achievement weakened over time can also be seen from Table 1.6. Comparing the first and the second column, one finds that the role of parental education in predicting college entry declined over time, after controlling for ability, parental wealth and income. This is in line with recent empirical evidence. Both Ellwood and Kane (2000) and Belley and Lochner (2007), Table 3, show that the correlation of parental education and children's college attendance declined over time. They also include a proxy for academic ability in the regression, and control for the parental wealth and income quartile.

The decrease in the role of parental education in predicting college access stems from the fact that more high school educated parents are among the group that are able to afford to send their children to college. While the fraction of high school graduated parents that were either in the top three income quartiles and in the top three wealth quartiles of all parents was 53 percent in 1980, this fraction increased to 56 percent in 2000. This effect must be due to the increase in the instability of earnings, which raises wealth inequality among high school graduates.

This shows that the rise in precautionary savings can simultaneously explain the increase in the number of constrained households *and* the decline in the degree of the intergenerational persistence of education. On the one hand, precautionary savings decrease the willingness of parents to transfer resources to their offspring, leading to a greater fraction of constrained children. On the other hand, the increment in savings throughout the life cycle increases the fraction of high school graduated parents that possesses the necessary amount of resources to invest, which weakens the intergenerational correlation of education.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

1.7 Conclusion

The aim of this paper is to shed more light on the role of borrowing constraints in determining college enrolment. I also address the question to what extend the quantitative importance of borrowing constraints has changed over time. I propose a dynamic general equilibrium model with overlapping generations, in which households are organized into dynasties. Because of market incompleteness, borrowing against future earnings is not possible, which allows me to measure the fraction of households constrained in their college decision. Young households need to rely on parental transfers and public subsidies if they wish to attend college. A key feature is the assumption that parents provide transfers to their children because of altruism, that is, they consider their children's utility in their own maximization problem.

I calibrate the model such that it is consistent with key parameters of the U.S. economy. Once I increase the college premium, the tuition fees and the earnings inequality in order to simulate changes in the economic environment that occurred between 1980 and 2000, I find that the model is consistent with a rise in the enrolment gaps by levels of family income that are observed in the U.S. data (Belley and Lochner (2007)).

The assumption of one-sided altruism implies that parents face a trade-off between making transfers and saving resources for future consumption, since the parent households have no access to the future returns of the college investment. I find that the transfer flows generated by the model imply that parents are imperfectly altruistic. That is, parents weight their children's utility less than their own. From the point of view of a parent household, this lowers the expected return from investing in their children's education. I find that even children with rich parents may thus be constrained in their college going decision.

The model also predicts that - all other things equal - high school educated parents transfer less to their children and save more for their own future consumption than college educated parents. In the model, this is due to the fact that high school graduates foresee lower future earnings and higher uncertainty about the actual realization of the earnings process than college graduates. This forces them to save more to secure their own future consumption. I test this prediction using transfer and savings data from the 1986 Survey of Consumer Finances. The results support the predictions of the model: high school graduates transfer less and save more than their college educated counterparts, after controlling for wealth and income.

The model predicts that in 1980, before the economic changes occurred, around 18 percent of all households are financially constrained in their college decision. This is in sharp contrast to empirical evidence based on the NLSY79, which finds that the fraction of constrained households is at most 8 percent (Carneiro and Heckman (2002)). My results show that narrow enrolment gaps (after controlling for long-term factors) are consistent with a large fraction of households constrained in their college decision.

The model further predicts that the share of families that are financially constrained in

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

their college decision has risen dramatically over time. I document that this stems from the fact that the profitability of college education for low-ability students increased, but their parental willingness to provide resources did not keep pace with that. Parents with lower education levels, who are more severely affected by the increase in the within-group inequality, need more resources to secure their own future and are therefore not willing to provide more financial assistance. Again, this result stresses the importance of considering the determinants of parental transfers for analyzing college enrolment patterns.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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 DOI: 10.2870/26812

1.8 Appendix: Solution Algorithm

I solve the quantitative model using a nested fixed point algorithm with a successive approximation to the value function at its center. The outer loop searches for a fixed point in the interest rate, while the inner loop solves the dynamic program given by (1.6) - (1.16) using successive approximation to the value function. Notice that the inner loop is necessary because the hybrid model nests both the pure life cycle economy and a model with infinitely lived dynasties as special cases: the parental value function (1.21) contains the discounted future utility of the child and vice versa. I start with a guess for the parental value function, $V'_{p,1}$, solve the child's problem (1.9), giving $V'_{p,1}$ and compute an update for (1.21),$V''_{p,1}$. I continue iterating over (1.21)until convergence is achieved.

1.8.1 Approximating the Value Function

The model economy contains up to two continuous state variables, namely own assets and parents assets, the latter only if parents are alive. [20] Approximating the value function by means of discretization thus proves to be infeasible. Instead, I compute a linear approximation to the value function. I start with a discrete approximation D to the continuum of all possible asset holdings, $\{d_{1,}d_2, ...d_m\} \equiv D$. The value function is computed at all $d_i \in D$. By means of a simple grid search, I pick that element that gives the highest value of the value function, which I call d_{i^*}. The maximum is bracketed by d_{i^*-1} and d_{i^*+1}. To compute the optimal savings decision, I perform a golden section search on the interval spanned by the two boundary values. In-between values are computed by linear interpolation using d_{i^*-1}, d_{i^*+1} and d_{i^*}. For young agents with living parents, I span a two dimensional grid and use bi-linear interpolation.

This procedure has the advantage that is does not require the value function to be differentiable. Non-differentiabilities may arise because college investment is discretionary. In model period $j = 31$, only parents who are rich enough invest in their offspring's education, which induces a kink in the parental value function. This may also lead to convex parts in the curvature of the value function. Concavity, however, is a necessary prerequisite for the golden section search, which guarantees that the procedure actually picks a global maximum.

We achieve convexification by making the process of college skill accumulation probabilistic. In addition, parents do not only use education investment but also financial transfers in order to transfer resources across generations. Because financial transfers are perfectly divisible, they contribute to convexifying the parental value function. Intuitively, the divisibility of financial transfers allows parents to balance the total amount of resources transferred to the child. If college investment becomes profitable from a certain wealth level onwards, financial transfers are reduced, which causes the value function to increase only slightly. This helps to smooth out the kink introduced by the discrete nature of college investments.

[20] Since we approximate the income process with a Markov chain, all other state variables are discrete.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

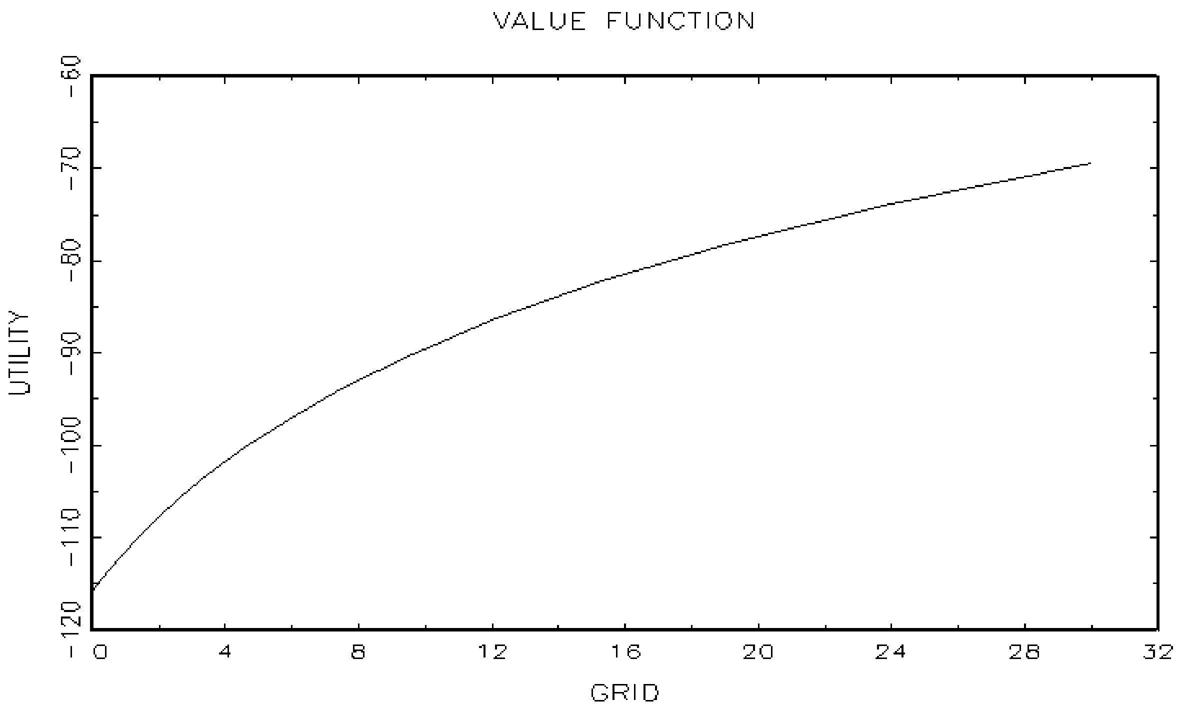

Figure 1.2: Interpolated value function for different levels of household wealth, after controlling for education, productivity and children's ability shock

The same argument applies to the savings of a parent household in model period $j = 31$. Parental savings increment parental wealth holdings, which are part of the child household's state space. Because parents decide about savings, monetary transfers and college investment simultaneously given their budget constraint in $j = 31$, investing in college thus reduces their savings and decreases the child households utility.

In total, when computing the approximation to the value function, I find that appears to be concave, as graph 1.2 shows. [21]

Since the state space involves two continuous variables for the case of agents with living parents, this procedure requires a bilinear interpolation. While linear interpolation is shape preserving, bilinear interpolation is generally not, as outlined in Judd (1998), Ch. 6. In order to avoid potential drawbacks of using an interpolation scheme which is not shape preserving, I use the fact that one of the continuous state variables is exogenously given. That is, when the policy functions for young agents are computed, their parental capital stock is fixed, and I compute $a'_j(a^1, \overline{a}^p, ..)$, $a'_j(a^2, \overline{a}^p, ..), ...$, by iterating over the capital grid. This implies that while computing the maximum, I only interpolate in one dimension and the problem remains concave. In order to save computation time, I exploit the fact that the value function is monotone increasing function of assets.

[21] This is not due to the approximation procedure, as linear interpolation is shape preserving.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

1.8.2 Computation of the Equilibrium

Using the policy functions which were computed previously, I can now solve for the equilibrium allocation. Computing an equilibrium involves the following steps:

1. Choose the policy parameters, that is, determine the social security replacement rate rep, the tax rate for capital income τ_k and a college subsidy rule ν.

2. Provide an initial guess for the aggregate (physical) capital stock K_0, the aggregate human capital stock H_0 and the labor tax rate τ_w. Given the guesses for K and H, use the first-order conditions from the firms problem to obtain the relative factor prices r and w.

3. Compute the optimal decision rules as outlined in the previous section.

4. Compute the time invariant measure Φ of agents over the state space.

5. Compute the aggregate asset holdings K_1 and the new human capital stock L_1 using (1.30) and (1.31). Given K_1 and L_1, update r, w and τ_w.

6. If $m = max(\left(\frac{K_1-K_0}{K_1}, \frac{L_1-L_0}{L_1}\right) < 10^{-3}$ stop; otherwise return to step 2 and replace K_0 with K_1 and L_0 with L_1.

In step 4, I find the time-invariant measure of agents Φ by iterating on the aggregate law of motion as defined in (1.36), as it is commonly done in models with an infinite time horizon. In the model, the measure of parents in their fist period of adulthood depends on the transition of children (because all parents were children one period before). In turn, the measure of children in their first period of life depends on the measure of their parents (because children receive transfers and education). Stationarity requires that the probability measure is constant over time. This implies that, for a given measure of parents, the measure of children exactly reproduces the measure of their own parents.

I approximate the measure of agents by means of a probability density function. [22] The density function is computed and stored on a finite set of grid points. Following Ríos-Rull and of Minneapolis Research Dept (1997), I choose a grid $D^{density}$ which is finer than the one used in the previous step for computing the decision rules, that is $D \subseteq D^{density}$. Choosing a finer grid for the density increases the precision with which the aggregate variables are computed, since the optimal asset choices are continuous.[23] Thus, the optimal choice will almost surely

[22]Heer and Maußner (2005) argue that approximating the time-invariant measure of agents with the help of a density function saves up to 40 percent of the CPU time with respect to an approximation using the distribution. This is because computing the distribution function requires to compute the inverse of the policy function.

[23]The gains in precision (as measured by aggregate excess demand) by doing so are enormous. The reason is that the aggregate good market clearing condition is just a weighted average of the individuals' budget constraints, where the weights are derived from the grid points of the density Φ. The finer the grid in Φ, the better will be the correspondence between the optimal policies and the resulting weights, leading to better aggregation results.

 DOI: 10.2870/26812

be off-grid. In order to map the optimal choices onto the grid, we introduce some kind of lottery. An individual with asset choice $a'(.) \in (a_i, a_{i+1})$ is interpreted as choosing asset holdings a_i with probability λ and asset holdings a_{i+1} with probability $(1-\lambda)$ where λ solves $a'(.) = \lambda a_i + (1-\lambda)a_{i+1}$. No lottery is needed for agents for which the lower bounds on asset holdings is binding, which is the case for a positive fraction of the population. I thus allocate the grid points such that there closer mashed in the neighborhood of the lower bound. This is achieved by choosing a grid points which are equally spaced in logarithms. I select the upper bound of $D^{density}$ and D such that it is never found to be binding.

I find the time invariant measure of agents Φ by iterating on the aggregate law of motion as defined in (1.36). Φ is is only stored on a finite grid, an individual with choice $a'(.)$ $\in (a_i, a_{i+1})$ is interpreted to choose asset holdings k_i with probability λ and asset holdings k_{i+1} with probability $(1-\lambda)$ where λ solves $a'(.) = \lambda a_i + (1-\lambda)a_{i+1}$. That is, we compute a piecewise linear approximation to the density function.

The forward recursion starts with an initial distribution of young agents in model period $j = 1$, $\Phi_1(A \times P_r \times A^p \times E \times \{1\})$. This requires an initial guess for the distribution of parents in model period $j = 31$. Using decision rule, one can then derive $\Phi_1(A \times P_r \times A^p \times E \times \{1\})$. In stationary equilibrium, this distribution needs to be identical with $\Phi_{31}(A \times P_r \times \{j = 31\})$, the distribution of agents in model period $j = 36$. Following Heer (2001), a uniform distribution is taken as an initial guess for $\Phi_{31}(A \times P_r \times \{j = 31\})$. The age-independent time-invariant distribution is computed using the decision rules derived from (1.6)-(1.16), where $\Phi_{31}(A \times P_r \times \{j = 31\})$ is updated until convergence.

As a check on the internal consistency, aggregate consumption, investment, transfers and output are computed in order to ensure that the good market clearing condition (1.32) is approximately satisfied.[24]

[24]Excess supply is typically less than 0.4% of total output.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

1.9 Appendix: Graphs

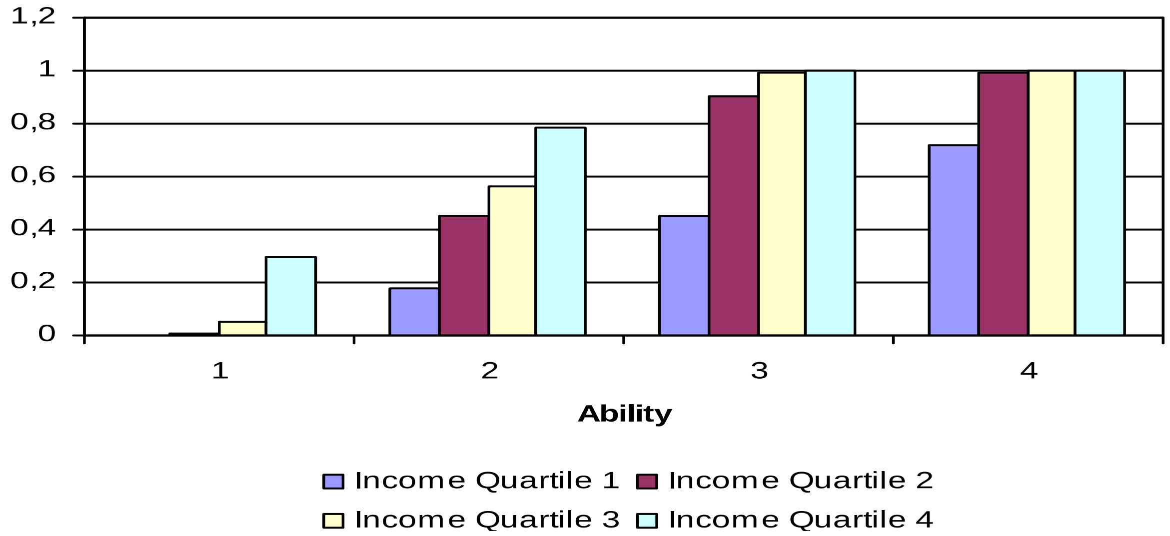

Figure 1.3: Enrolment Rates 1980

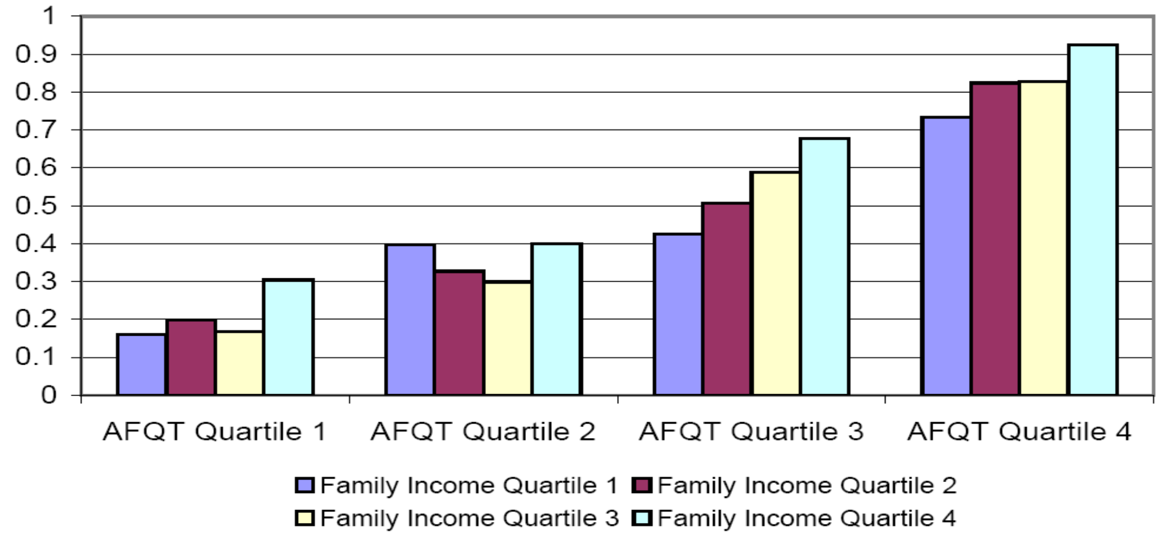

Figure 1.4: Enrolment Rates NLSY79 (Belley and Lochner (2007), Figure 2a)

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute
DOI: 10.2870/26812

Figure 1.5: Enrolment Rates Economy 1980, parents borrow.

Figure 1.6: Enrolment Rates Economy 1980, children borrow

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute
DOI: 10.2870/26812

Figure 1.7: Enrolment Rates 2000

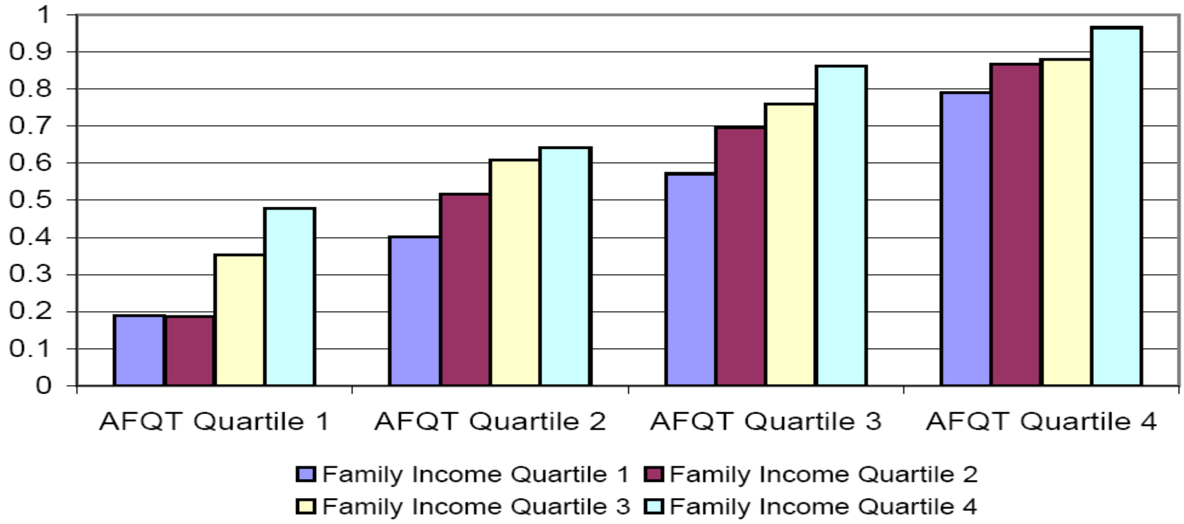

Figure 1.8: Enrolment Rates NLSY97 (Belley and Lochner (2007), Figure 2b)

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute
DOI: 10.2870/26812

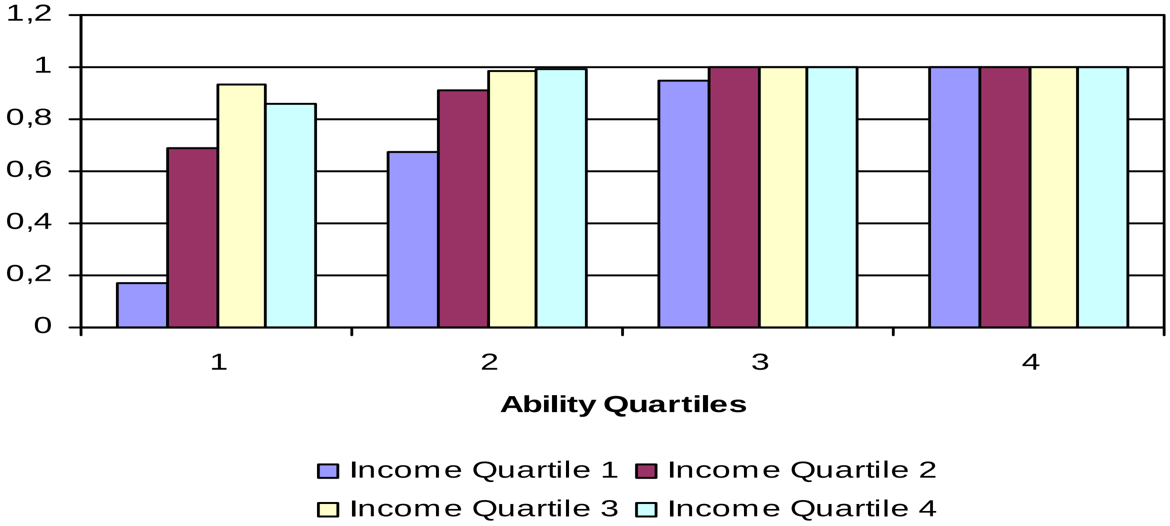

Figure 1.9: Enrolment Rates Economy 2000, parents borrow.

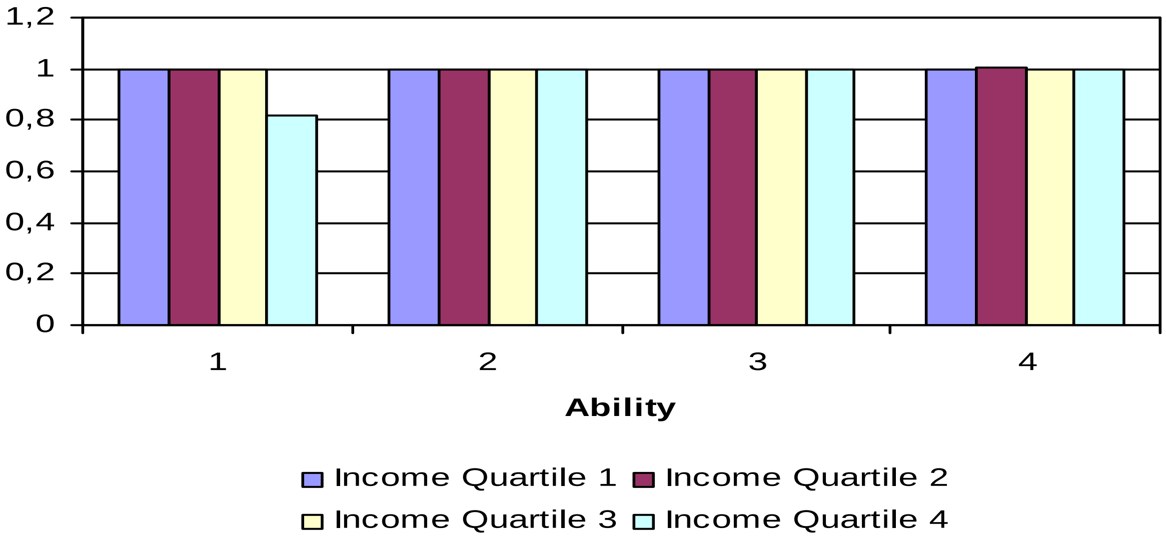

Figure 1.10: Enrolment Rates Economy 2000, children borrow.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

1.10 Appendix: Tables

Parameter	Description	Value
α	capital share of income	0.36
δ	capital depreciation rate	0.08
γ	risk aversion	1.5
ρ^{hs}	earnings persistence high school	0.946
σ^{hs}	variance shocks	0.015
ρ^{col}	earnings persistence college	0.955
σ^{col}	variance shocks	0.010
τ_K	capital income tax rate	0.2
rep	replacement ratio pensions	0.4

Table 1.1: Calibrated Parameters with Direct Empirical Counterpart for 'Economy 1980'

Parameter	Description	Value	Target	Target Value
β	discount factor	0.963	Wealth/Income	3.0
κ	cost of college	0.94	% coll. graduates	25
d	college completion rate for low-ability students	0.32	corresponding target in NLSY79	0.3
a	increment of college completion with ability	0.07	overall college completion rate	0.5
π	transmission initial productivity	0.83	intergenerational education persistence	0.3
τ_w	labor income tax	0.15	budget balanced	–
ς	intergen. discounting	0.7	financial transfers/wealth	0.028
ν_0	upper bound coll. subsidy	0.57	upper bound in data	0.5
ν_1	slope coll. subsidy	0.1	coll. subsidies/coll. expenses	0.4

Table 1.2: Parameters Without Direct Empirical Counterpart

Parameter	Description	Value 1980	2000
σ^{hs}	variance shocks	0.015	0.025
σ^{col}	variance earnings shocks	0.01	0.016
κ	cost of college	0.94	2.13

Table 1.3: Parameters characterizing the Economy 2000

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 1.4: *Enrolment Characteristics for Different Economies*

Economy	% enrolled	% drop out	% low ability	% corr. edu
1980	57	55	1.8	0.30
'free-disposal'	62	55	1.3	0.28
'forced'	75	56	8	0.22
2000	60	56	5	0.28
'free disposal'	85	57	16	0.18
'forced'	99	58	25	0.10

Notes: The Table shows the total enrolment rate, the total drop-out rate, the fraction of college students from the lowest ability quartile, and the intergenerational persistence of college education

Table 1.5: *Enrolment Gaps with Respect to the Top Income Quartile for Different Ability Quartiles, Economy 1980*

	Ability Quart. 1	Ability Quart. 2	Ability Quart. 3	Ability Quart. 4
		Panel A – All Parents		
income 4-1	0.29	0.61	0.55	0.28
income 4-2	0.29	0.33	0.09	0.005
income 4-3	0.24	0.22	0.003	0
		Panel B – High School Educated Parents		
income 4-1	0.23	0.45	0.54	0.28
income 4-2	0.23	0.18	0.1	0.007
income 4-3	0.18	0.09	0.002	-0.002
		Panel C – College Educated Parents		
income 4-1	–	–	–	–
income 4-2	0.86	0.06	-0.002	0
income 4-3	0.79	0.06	0	0

Notes: Enrolment gaps are computed for different ability quartiles, without controlling for parental education (panel A), only for children with high-school graduates parents (panel B) and for children with college graduated parents (panel C). An entry for 'income 4-1' of 0.29 indicates that the enrolment rate in the lowest income quartile is about 30 percentage points below the enrolment rate of the highest income quartile. A missing entry (–) indicates that there are no children with parents in this category.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 1.6: *Difference in College Enrolment Rates of College Graduated Parents vs. High School Graduated Parents*

	Economy 1980	Economy 2000
(a)	4.5	2.3
(b)	4.3	2

Notes: In (a), I control for the ability and income quartile and in (b) for ability, income and the wealth quartile. A value of '4.5' indicates that within this group, children with college educated parents are 4.5 percent more likely to enrol in college than youth from high school educated families.

Table 1.7: *Economy 1980: Average savings of high school graduates (model period $j = 31$), controlling for their wealth and income quartile, and the ability quartile of their children.*

		Ability 1	Ability 2	Ability 3	Ability 4
Wealth 1	Income 1	1.66	1.59	1.50	1.43
	Income 2	2.0	1.90	1.69	1.61
	Income 3	2.27	2.17	2.08	2.08
	Income 4	-	-	-	-
Wealth 2	Income 1	3.19	3.09	2.92	2.77
	Income 2	3.51	3.27	3.05	3.05
	Income 3	3.43	3.43	3.43	3.43
	Income 4	-	-	-	-
Wealth 3	Income 1	4.63	4.63	4.51	4.27
	Income 2	4.51	4.29	4.08	4.08
	Income 3	4.97	4.85	4.80	4.92
	Income 4	-	-	-	-
Wealth 4	Income 1	5.20	5.20	5.20	5.20
	Income 2	6.55	6.55	6.56	6.57
	Income 3	6.94	6.87	6.88	7.05
	Income 4	8.69	8.65	8.72	9.01

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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Table 1.8: *Economy 1980: Average savings of college graduates (model period $j = 31$), controlling for their wealth and income quartile, and the ability quartile of their children.*

		Ability 1	Ability 2	Ability 3	Ability 4
Wealth 1	Income 1	-	-	-	-
	Income 2	1.81	1.52	1.50	1.50
	Income 3	2.01	1.94	1.93	1.93
	Income 4	2.09	2.16	2.19	2.20
Wealth 2	Income 1	-	-	-	-
	Income 2	2.62	2.28	2.26	2.26
	Income 3	3.23	2.95	3.02	3.07
	Income 4	2.53	3.11	3.39	3.52
Wealth 3	Income 1	-	-	-	-
	Income 2	-	-	-	-
	Income 3	4.33	4.27	4.26	4.26
	Income 4	3.69	4.27	4.53	4.85
Wealth 4	Income 1	-	-	-	-
	Income 2	-	-	-	-
	Income 3	5.53	5.53	5.77	5.90
	Income 4	7.06	7.22	7.50	8.10

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 1.9: *Enrolment Gaps with Respect to the Top Income Quartile for Different Ability Quartiles, Economy 2000*

	Ability Quart. 1	Ability Quart. 2	Ability Quart. 3	Ability Quart. 4
		Panel A – All Parents		
income 4-1	0.78	0.81	0.61	0.36
income 4-2	0.67	0.45	0.09	0.03
income 4-3	0.59	0.33	0.01	0
		Panel B – High School Educated Parents		
income 4-1	0.72	0.72	0.60	0.36
income 4-2	0.62	0.36	0.09	0.03
income 4-3	0.54	0.27	0.01	-0.002
		Panel C – College Educated Parents		
income 4-1	–	–	–	–
income 4-2	–	–	–	–
income 4-3	0.12	0.007	0	0

Notes: Enrolment gaps are computed for different ability quartiles, without controlling for parental education (panel A), only for children with high-school graduates parents (panel B) and for children with college graduated parents (panel C). An entry for 'income 4-1' of 0.29 indicates that the enrolment rate in the lowest income quartile is about 30 percentage points below the enrolment rate of the highest income quartile. A missing entry (–) indicates that there are no children with parents in this category.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 1.10: *Economy 2000: Average savings of high school graduates (model period $j = 31$), controlling for their wealth and income quartile, and the ability quartile of their children.*

		Ability 1	Ability 2	Ability 3	Ability 4
Wealth 1	Income 1	1.78	1.71	1.55	1.34
	Income 2	2.16	2.02	1.75	1.44
	Income 3	2.39	2.11	1.79	1.67
	Income 4	-	-	-	-
Wealth 2	Income 1	3.61	3.16	2.78	2.83
	Income 2	4.24	3.75	3.31	3.31
	Income 3	4.17	3.68	3.35	3.57
	Income 4	-	-	-	-
Wealth 3	Income 1	5.48	5.14	4.82	4.82
	Income 2	5.35	4.96	4.61	4.64
	Income 3	5.82	5.44	5.30	5.72
	Income 4	-	-	-	-
Wealth 4	Income 1	6.68	6.27	5.90	5.90
	Income 2	7.58	7.43	7.44	7.82
	Income 3	7.95	7.75	7.79	8.26
	Income 4	10.48	10.47	10.59	10.95

Table 1.11: *Economy 2000: Average savings of college graduates (model period $j = 31$), controlling for their wealth and income quartile, and the ability quartile of their children.*

		Ability 1	Ability 2	Ability 3	Ability 4
Wealth 1	Income 1	-	-	-	-
	Income 2	-	-	-	-
	Income 3	1.64	1.61	1.61	1.61
	Income 4	1.42	1.80	1.93	1.99
Wealth 2	Income 1	-	-	-	-
	Income 2	-	-	-	-
	Income 3	2.67	3.09	3.12	3.17
	Income 4	2.81	3.24	3.42	3.64
Wealth 3	Income 1	-	-	-	-
	Income 2	-	-	-	-
	Income 3	4.27	4.83	4.87	5.31
	Income 4	4.40	4.97	5.03	5.53
Wealth 4	Income 1	-	-	-	-
	Income 2	-	-	-	-
	Income 3	5.20	5.85	5.90	6.48
	Income 4	7.85	8.52	8.66	9.14

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 1.12: *Average Savings and Transfers of High School and College Graduates (in 1983 US-Dollar)*

		no controls	controls
Savings	High School	14200	92334
	College	92200	81953
Transfers	High School	1330	7725
	College	11900	11100

Notes: All values are obtained through an OLS regression of savings or transfers on a set set of dummy variables. The first column only controls for the education level, while the second column also includes dummies for the wealth and income level. The results in the second column are predicted values for a household in the third income percentile the fourth wealth percentile. Regressions are weighted using the SCF frequency weights. All results are statistically significant at the 5% level

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Chapter 2

Why Do the Rich Save More? The Role of Housing

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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2.1 Introduction

In this paper, I analyze the determinants of the wealth-income gradient with educational attainment that is observable in the data. This gradient is very steep: using the 1989 wave of the Survey of Consumer Finances (SCF), I find the median college graduates near retirement age holds twice as much wealth (total net worth) as the median high school dropout.

Understanding the determinants of the wealth-income gap between two education groups is interesting for the following reason. The highest education level achieved by the household head can be seen as a proxy for the level of labor income along the life cycle.[1] The fact that wealth-income ratios near retirement are increasing with the educational attainment of the household head then implies that the income-rich hold disproportionately more wealth near retirement age, relative to their income. This is a puzzle with respect to the standard life cycle model, in which preferences are homothetic and homogenous across the population (Dynan et al. (2004)). Thus, understanding the wealth-income gradient is crucial for understanding the main determinants of wealth and income inequality.

The key point of this paper is to argue that when housing is introduced into the standard life cycle model of savings, the standard model can account for the wealth-income gradient that is observable in the data.

The inclusion of housing is motivated by the observation that when I control for housing in the 1989 SCF, a substantial part of the wealth-income gap disappears. Moreover, the fraction of households that own their home is substantially higher among better educated households.

In order to shed more light on the role of housing, I set up a computable life cycle model. Markets are incomplete, and household face idiosyncratic earnings shocks. Households receive utility from the consumption of housing services and non-housing consumption. Housing services can be acquired on the rental market or through owner-occupied housing. Importantly, preferences are homogenous across the population.

I show that a version of this model that is calibrated to match key features of the U.S. economy can generate a wealth-income gap between the median of two education groups, namely college graduates and high school dropouts, that is observable in the 1989 SCF. Housing accounts for a substantial fraction of the observable wealth-income gap between the two education groups: I find that a share of 25 percent of the total gap is due to the presence of housing in the model. Strikingly, introducing housing raises the retirement savings of the median college graduates.

Key for explaining the impact of housing is its interaction with the life cycle earnings profile of college graduates. In the data, the earnings profile of college graduates depicts a pronounced hump that peaks around the age 45 (see, e.g. Hubbard et al. (1995)). This pattern creates incentives to smooth out consumption along the life cycle by borrowing when young

[1] This has been frequently done in the literature, see for example Hubbard et al. (1995), Attanasio (1999), Cagetti (2003) or Dynan et al. (2004)

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

and accumulating savings for retirement. The dual role of housing as a consumption good and as collateral for financial debt helps college graduates to obtain a smoother consumption profile over the life cycle.

As a result, pre-retirement wealth holdings of college graduates increase when housing is introduced. Because the earnings profile of high school dropouts is relatively flat, the presence of housing in its function as consumption good, asset and collateral does not have any impact on pre-retirement wealth holdings. I show that the presence of uninsurable mortality risk works in the same direction and increases pre-retirement wealth holdings even further.

My paper is related to the previous literature in various dimensions. First, many of the features of the model can be found in the recent literature that studies the relationship between housing and wealth accumulation in computable frameworks. Examples include Fernández-Villaverde and Krueger (2005), who include durables to study the life cycle profiles of durable and non-durable consumption. Kiyotaki et al. (2007) study the impact of life cycle effects on house prices. Li and Yao (2007) analyze the impact on changes in house prices on life cycle savings behavior. Similarly, Yang (2008) analyzes the life cycle profiles of housing and non-housing consumption. Hintermaier and Koeniger (2008) study bankruptcy and debt portfolios of secured and unsecured debt in a life cycle framework.

Other papers study housing in frameworks with infinitely lived households. Both Martin and Gruber (2004) and Díaz and Luengo-Prado (2006) examine the role of housing and housing market imperfections in generating (cross-sectional) wealth inequality. Hintermaier and Koeniger (2007) analyze the impact of a spread between the borrowing and lending rate on durable and non-durable consumption.

All of these papers emphasize the importance of housing and its multiple roles for understanding consumption and savings pattern. As an additional contribution to this literature, I prove analytically that the joint role of housing as a consumption good and as an asset increases the demand for precautionary savings, compared to the one-asset case in which households invest in bonds only (see Aiyagari (1994)). I show that this rise occurs even in the absence of transaction costs, which make housing partially illiquid.A growing literature studies the consequences of this illiquidity of housing assets on wealth accumulation (see, among others, Grossman and Laroque (1990), Martin and Gruber (2004), Flavin and Nakagawa (2004), Díaz and Luengo-Prado (2006), Stokey (2007)).

Second, my results show that a standard life cycle model that is augmented by housing can generate a wealth-income gradient that is in line with empirical evidence. The model is standard in the sense that preferences are homogenous and individuals are fully rational. Cagetti (2003) and Hendricks (2007) find that the heterogeneity in wealth-to-income ratios is consistent with heterogeneity in time preference rates across different education groups. Bernheim et al. (2001) argue that that 'rules of thumb' or other less than fully rational decision processes, including behavioral rules, are more consistent with the observed heterogeneity

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

(also see Dynan et al. (2004)). Guner and Knowles (2007) highlight the role of marital instability in explaining wealth heterogeneity near retirement age. Scholz and Seshadri (2006) emphasize the importance of children for household wealth, while Yang (2005) finds that intergenerational links in terms of bequests are significant.

The rest of the paper is structured as follows. In the next section, I provide empirical evidence from the 1989 SCF. In section 3, I outline the model and provide all proofs. Section 4 presents the calibration. The results are discussed in section 5. Finally, the last section concludes.

2.2 Wealth Dispersion at Retirement Age: Empirical Evidence

In this section, I use the 1989 Survey of Consumer Finances to document that there is a wealth-income gradient with educational attainment near retirement age. I find that differences in wealth-to-income ratios are substantial: college graduates have twice as much wealth, relative to their income, compared to high school dropouts.

2.2.1 Data Description and Construction of Variables

In order to analyze the relationship between wealth and education, I use the 1989 wave of the SCF. The SCF is conducted on a triennial basis by the Federal Reserve System. Its primary purpose is to obtain detailed measures of all components of household wealth for U.S. households, which makes it to one of the major data sources for household wealth (Juster et al. (1999)). The other major household survey that contains detailed information on household wealth and earnings, the Panel Study of Income Dynamics (PSID), underestimates the value of home equity for all homeowners by 10 percent, compared to the SCF (Juster et al. (1999)). Juster et al. (1999) also find that the bias between SCF and PSID is increasing in household wealth.

Because wealth holdings are extremely positively skewed, the SCF combines a representative area-probability sample with a special over-sample of very high income households obtained using tax report data. In total, over 4000 households are contained in each cross-section. To make the statistics more representative for the overall U.S. population, I apply the SCF replicate weights. For a more detailed description of the SCF, see Bucks et al. (2006)

Wealth and income are defined as in the Federal Reserve Bulletins (see for example Bucks et al. (2006)).[2] In short, the wealth measure comprises financial assets (such as savings accounts, stock, bonds, individual retirement accounts) and non-financial assets (such as vehicles, housing) minus liabilities (such as mortgage credit, credit card debt). Respondent's

[2] More specifically, all variables are constructed using the SAS program provided by the Federal Reserve: http://www.federalreserve.gov/pubs/oss/oss2/bulletin.macro.txt

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

retirement accounts are included if they are quasi-liquid and if the respondent can borrow or make withdrawals.

For my analysis, I use the 1989 SCF which was collected before the surge of housing prices during the 1990s, which allows me to abstract from the impact of recent housing market developments on household wealth.[3]

2.2.2 Wealth-Income Gradient with Education?

In this section, I document that the wealth-income gradient with educational attainment is steep: near retirement, the median wealth-to-income ratio for college graduates is nearly 4 and thus twice as high as the respective ratio for high school dropouts (table 2.1).

I follow the seminal paper of Dynan et al. (2004) closely, who compute wealth-to-income ratios for households near retirement using the 1992 SCF and the 1989 PSID.[4] They find that wealth-income ratios are increasing with income (see their Table 9, page 38).

Following their approach, I restrict my analysis to households between age 51 and 61. This is done for two reasons. First, according to the life cycle hypothesis, agents' wealth holdings are highest in the period prior to retirement. Second, it simplifies the treatment of expectations. When young, wealth is much more affected by expectations about future earnings shocks (Hendricks (2007)). The wealth-income ratio can then be interpreted as a 'retirement savings' rate.

I restrict my analysis to the median wealth-income ratios for each education group as the median is less sensitive to outliers than the mean. This is particularly important because I use current income in the denominator.

Since the highest education level achieved by the household head is typically constant over the life cycle and thus not related to temporary income shocks, it proxies lifetime labor income, see Hubbard et al. (1995), Attanasio (1999), Cagetti (2003) or Dynan et al. (2004). My finding thus suggest that households with higher levels of lifetime income also hold more wealth near retirement, relative to their income. This is in line with results from the previous empirical literature, which finds that the income-rich have disproportionately more wealth near retirement (see Venti and Wise (2000), Dynan et al. (2004), Hendricks (2007)). Dynan et al. (2004) show that this is at variance with the standard life cycle model of savings, which predicts that wealth holdings near retirement are proportional to earnings.

[3] Sinai and Souleles (2007) document the trends in the life-cycle profiles of net worth and housing equity over time using the 1983 through 2004 SCF.

[4] Dynan et al. (2004) also compute savings rates for households with different levels of permanent income, using various waves from the Panel Study of Income Dynamics (PSID), the Consumer Expenditure Survey (CEX) and the SCF. They find that savings rates are higher for households with a higher level of permanent income, independently of dataset.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

2.2.3 The Role of Housing

In this section, I argue that there is a tight relationship between housing and the wealth-income gradient in the U.S. data.

Consider first the differences in the wealth-to-income ratio between homeowners and renters. For all education levels, near retirement homeowners hold more wealth relative to their income, see the second column of Table 2.1. The gap between homeowners and renters is particularly pronounced for high school dropouts: the median wealth-to-income ratio for renters in this education group is basically zero, while the respective ratio for homeowners is 3.28.

Second, the data also shows that the slope of the wealth-income gradient varies with the homeownership status. In column 3 of table 2.1, I compute the median wealth-to-income ratios for homeowners with different education levels. Strikingly, the gap between college graduates and high school dropouts is reduced to 1.3 when controlling for income, compared to a value of 2 for the overall population. Considering only homeowners with houses in the upper half of the distribution reduces the gap somewhat further.

Third, the share of homeowners is increasing with the educational attainment of the household head, see figure 2.1. Near retirement, almost all college graduates own the home they live in, while the fraction of high school dropouts that own their home is only about 50 percent.

The empirical evidence presented suggests that modeling housing may be important for understanding the wealth-income gradient with educational attainment. In the next section, I will include housing in a life cycle model.

2.3 Theory: Housing, Market Frictions and Wealth

I examine a quantitative life cycle model with idiosyncratic income risk and incomplete markets, similar to the seminal papers by Huggett (1996) and Huggett and Ventura (2000). Households derive utility from the consumption of housing services and non-housing consumption. Housing services can be derived from owner-occupied housing or may be acquired on the rental market. The setup is thus related to a growing literature that implements housing and its multiple functions in computable life cycle frameworks (see, for example, Gervais (2002), Fernández-Villaverde and Krueger (2005), Yang (2006) or Díaz and Luengo-Prado (2008), Li and Yao (2007) or Kiyotaki et al. (2007)). In this strand of the literature, housing serves simultaneously as a consumption good, as an asset to transfer resources across periods and as collateral for financial loans. Uncollateralized borrowing is not permitted.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

2.4 Economic Environment

The model is a partial equilibrium model where the interest rate is taken to be exogenous, therefore only the household sector is modeled.

2.4.1 Demographics

The first tw periods of its life, the household receives labor income. Labor supply is inelastic. Each household lives up to $tw + tr = J$ periods, where tr is the number of periods the agent is retired. I set $tw = 40$ and $tr = 20$. It is assumed that households enter the economy at the real-life age of 25. Mandatory retirement takes place at the age of 65. Individuals in each period $j < J = 60$ have a constant probability of surviving and living in period $j + 1$. I denote this probability as $\alpha_{j+1} \in [0, 1]$. $\alpha_{61} = 0$.

2.4.2 Households and Housing Technology

A household of age j derives utility from consumption of a nondurable good, c_j, and housing services s_j. Housing services can be acquired through the rental market or through homeownership. Households in $j = 1$ are an exception as they start with zero wealth holdings. Agents in the first period of life thus have to acquire housing services from the rental market.

The consumption of the non-durable good is continuous as well the consumption of housing services acquired through renting. In contrast, if households choose to own, they have to buy at least a home of minimum size $\underline{h}$. This assumption ensures that the down-payment constraint is binding for a positive fraction of the population.

Households Problem

Income

I assume that labor earnings are stochastic. The earnings of a household at age j are given by $\eta_j e_j$, where e_j is the average income and η_j describes the fluctuation around that mean.

In addition to labor earnings, the household receives income from physical capital, accumulated through savings in financial assets. Assets bear an non-stochastic after-tax interest rate of r. Households also receive transfers tr from the government. As in Hubbard et al. (1995), I assume that transfers are given by the following specification:

$$tr = \max\{0, \overline{c} - [a(1 + r) + \eta_j e_j]\} \tag{2.1}$$

$\overline{c}$ is defined as the minimum consumption level guaranteed by the government. Following the notation of Hubbard et al. (1995), I refer to $\overline{c}$ as the 'consumption floor'. Transfers are given by $\overline{c}$ minus all available resources. Thus, transfer payments reduce one by one for each dollar of assets or labor earnings. The transfer function thus captures the penalty on savings

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

which is implicit in many asset-based, means-tested transfer programs such as AFDC in the U.S. Hubbard et al. (1995) argue that asset-based means tested transfer are important for explaining why a substantial fraction of the population does not accumulate any wealth over their life cycle.

Total available household resources of working households are then given by

$$a(1+r) + \eta_j e_j + tr$$

Timing and Information

The timing of events in a given period is as follows. Households observe their idiosyncratic shock e. Households take their decision about consumption of housing services and the non-durable good, housing tenure, and eventually savings. I follow the timing convention applied in Fernández-Villaverde and Krueger (2005) and assume that housing is not transferred until the end of the period.[5] This implies that even if the household sells its home and uses the payment to finance other expenditure, it holds the home (and receives utility from the service flow) until the end of the period. For the same reason, changing house sizes does not influence the present period service flow. Finally, uncertainty about early death is revealed at the end of the period.

Working Household's Problem

The household allocates its resources between the consumption of non-housing goods and housing services such that total utility is maximized. At age j, the household maximizes

$$v(\eta_j, a_j, h_j, j) = \max_{c_j, a_{j+1}, h_{j+1}, z_{j+1}, f_j} \left\{ u(c_j, s_j) + \beta \alpha_{j+1} \sum_{e_{j+1}} \pi_{e_j, e_{j+1}} v(e_{j+1}, a_{j+1}, h_{j+1}, j+1) \right\} \tag{2.2}$$

such that

[5]Fernández-Villaverde and Krueger (2005) model durable consumption instead of housing.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

$$
\begin{aligned}
c_j + if_j + a_{j+1} + h_{j+1} + \nu(h_{j+1}, h_j, z_{j+1}) &= \eta_j e_j + (1+r)a_j + (1-\delta_h)h_j + tr \\
s_j &= (1-z_j)f_j + z_j h_j \\
h_{j+1} &\geq \underline{h} \\
z_{j+1} &= 0 \text{ if } h_{j+1} = 0 \\
z_{j+1} &= 1 \text{ if } h_{j+1} > 0 \\
c_j, f_j &\geq 0 \\
a_{j+1} &\geq -(1-\zeta)h_{j+1} \\
0 &\leq \zeta \leq 1 \\
a_1, h_1 &= 0 \\
j &\in \{1, tw-1\}
\end{aligned}
$$

Housing services can be acquired through renting or homeownership. z_j indicates whether the household is a homeowner or not. Per unit of rental housing f_j, the household pays a price i. Renting is not restricted, $f_j \geq 0$. However, owner-occupied housing is bounded from below by $\underline{h}$. If the household changes the tenure status or changes (owner-occupied) housing, transaction costs $\nu(h_{j+1}, h_j, z_{j+1})$ are incurred:

$$
\nu(h_{j+1}, h_j, z_{j+1}, \psi) = \begin{cases} \delta_h h_j & h_{j+1} = h_j \wedge z_{j+1} = 1 \\ \kappa_s(1-\delta_h)h_j + \kappa_b h_{j+1} & h_{j+1} \neq h_j \wedge z_{j+1} = 1 \\ \kappa_s(1-\delta_h)h_j & z_{j+1} = 0 \end{cases} \tag{2.3}
$$

If housing is not changed, the household is forced to pay for the maintenance of the house. Otherwise, transaction costs κ occur. Transaction costs are assumed to arise for selling κ_s the old home and for buying the new one κ_b.

The introduction of transaction costs makes housing partially illiquid. A growing literature studies the consequences of this illiquidity of housing assets on wealth accumulation (see, among others, Grossman and Laroque (1990), Martin and Gruber (2004), Flavin and Nakagawa (2004), Díaz and Luengo-Prado (2006), Stokey (2007)).

A homeowner can borrow up to a limit $(1-\zeta)h_{j+1}$, where ζ specifies the collateral constraint. Notice that the down payment requirement is given by ζ, while the maximum loan-to-value ratio is given by $(1-\zeta)$. ζ parametrizes both of these constraints.

Retired Household‘s Problem

The maximization problem of a retired household is similar to the problem of the working household, with the difference that retired households receive social security benefits *pen*

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

instead of labor income. Hence, income is certain. A retired household's problem is given by the Bellman equation:

$$v(a_j, h_j, j) = \max_{c_j, a_{j+1}, h_{j+1}, z_{j+1}, f_j} \{u(c_j, s_j) + \beta\alpha_{j+1} v(a_{j+1}, h_{j+1}, j+1)\} \tag{2.4}$$

such that

$$\begin{aligned}
c_j + if_j + a_{j+1} + h_{j+1} + \nu(h_{j+1}, h_j, z_{j+1}, \psi) &= pen + (1+r)a_j + (1-\delta_h)h_j \\
s_j &= (1-z_j)f_j + z_j h_j \\
z_{j+1} &= 0 \text{ if } h_{j+1} = 0 \\
z_{j+1} &= 1 \text{ if } h_{j+1} \geq 0 \\
c_j, f_j &\geq 0 \\
h_{j+1} &\geq \underline{h} \\
a_{j+1} &\geq -(1-\zeta)h_{j+1} \\
0 &\leq \zeta \leq 1 \\
j &\in \{tw, J-1\}
\end{aligned}$$

Because I do not model intended bequests, the continuation value is zero for $j = J$, which implies that $a_{J+1} = h_{J+1} = 0$.

Transaction costs $\nu(h_{j+1}, h_j, z_{j+1})$ are as specified in equation (3.2).

2.4.3 The One-Asset Economy as a Benchmark Case

The aim of this paper is to quantify the role of housing in generating wealth inequality across earnings groups. In order to evaluate the relative contribution of housing, I compare the predictions of my model to the classical life cycle framework where households receive idiosyncratic earnings shocks, borrowing is not permitted and housing is not part of the utility function. Because the only means of saving is a risk-free bond in this standard setup, I call this economy the 'one-asset economy'. This model has been studied extensively in the literature (see, among others, Hubbard et al. (1995), Huggett (1996), Huggett and Ventura (2000)).

Consider the one-asset economy first. In this economy, households maximize

$$v(\eta_j, a_j, j) = \max_{c_j, a_{j+1}} \left\{ u(c_j) + \beta\alpha_{j+1} \sum_{e_{j+1}} \pi_{e_j, e_{j+1}} v(e_{j+1}, a_{j+1}, j+1) \right\} \tag{2.5}$$

subject to

$$c_j + a_{j+1} = \eta_j e_j + (1+r)a_j \tag{2.6}$$

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

I argue that the outcome of this economy does not change, even if I allow for housing services in the utility function but continue to abstract from housing as an asset. In this economy, housing services have be purchased on the renting market. Therefore, I label this economy as 'one-asset economy with renting'.

In the one-asset economy with renting, individuals maximize

$$v(\eta_j, a_j, j) = \max_{c_j, a_{j+1}, f_j} \left\{ u(c_j, s_j) + \beta\alpha_{j+1} \sum_{e_{j+1}} \pi_{e_j, e_{j+1}} v(e_{j+1}, a_{j+1}, j+1) \right\} \tag{2.7}$$

subject to

$$c_j + if_j + a_{j+1} = \eta_j e_j + (1+r)a_j \tag{2.8}$$

Assumption 1 *The current period utility function $U(c_j, s_j)$ is twice continuously differentiable*

Proposition 2 *Let the earnings process in every period j be given by $\eta_j e_j$ and let the rental rate i be constant. Assumption 1 holds. Then, at every age j, asset holdings a_j and total consumption expenditures (c_j or $c_j + if_j$, respectively) will identical for the one-asset economies with and without renting, as given by the optimization problems (2.5) and (2.7).*

Proof. I show that the solution to Euler-Equation for non-housing consumption c_j does not depend on s_j in the one-asset economy with renting.

The Euler is given by

$$U_c(c_j, s_j) = (1+r)\beta E_j(U_c(c_{j+1}, s_{j+1})) \tag{2.9}$$

which is can be written as

$$U_c(c_j, s_j) - (1+r)\beta E_j(U_c(c_{j+1}, s_{j+1})) = 0 \tag{2.10}$$

which I label as EE. I show that $\frac{dEE}{ds} = 0$, which means

$$U_{cs}(c_j, s_j) - (1+r)\beta E_j(U_{cs}(c_{j+1}, s_{j+1})) = 0 \tag{2.11}$$

which is the case if

$$U_{cs}(c_j, s_j) = (1+r)\beta E_j(U_{cs}(c_{j+1}, s_{j+1})) \tag{2.12}$$

The optimal solution to problem 2.7 will also satisfy

$$U_s(c_j, s_j) = (1+r)\beta E_j(U_s(c_{j+1}, s_{j+1})) \tag{2.13}$$

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

if the rental price i is constant over time, i.e. $i_t = i_{t+1}$ which implies that

$$U_{sc}(c_j, s_j) = (1+r)\beta E_j(U_{sc}(c_{j+1}, s_{j+1})) \tag{2.14}$$

Under assumption 1, Young's theorem applies, which states that $U_{sc}(c_j, s_j) = U_{cs}(c_j, s_j)$ and $E_j(U_{cs}(c_{j+1}, s_{j+1})) = E_j(U_{sc}(c_{j+1}, s_{j+1}))$ at the optimal solution. Hence, at the optimal solution, condition 2.13 holds and thus also condition 2.11. Therefore, the Euler-Equation 2.9 does not change with s and its solution is valid for any s. Thus, condition 2.9 also holds for $s = 0$, which is the optimal solution if s is not part of the utility function, i.e. for problem 2.5. Therefore, the Euler equation for problem 2.5 and problem 2.7 are identical, and thus also their optimal solution with respect to assets and consumption expenditures.

■

Remark 3 *Proposition 2 holds only if borrowing constraints are not binding.*

Intuitively, savings in form of assets (a_j) reflects the wish to postpone consumption to later periods and is thus the result of a trade-off between different periods. As long as prices are constant, adding housing to the utility function affects only the absolute utility level but not the trade-off between the utility of different periods.

The impact of housing as an asset on wealth profiles over the life cycle can now be evaluated by comparing the benchmark economy with the one-asset economy with renting. Proposition 2 ensures me that these results could have also be obtained by using a standard life cycle model in which housing does not even enter the utility function.

This will prove to be very important in the next section, where I argue that the dual role of housing as a consumption good and as an asset increases precautionary savings in the presence of earnings uncertainty.

However, for this to be interesting, it clearly needs to be the case that some households will prefer to live in owner-occupied housing rather than obtaining housing services on the rental market. The next section sheds more light on the housing tenure decision, which is an important trade-off in the model.

2.4.4 Renting Housing Services vs. Owner-Occupied Housing

Assuming that collateral constraints are not binding, the first order condition for housing assets gives the net costs of owner-occupied housing expressed in units of the consumption good:

$$\frac{E_j(U_h(c_{j+1}, h_{j+1}))}{E_j(U_c(c_{j+1}, h_{j+1}))} = r + \delta_h \tag{2.15}$$

Here, I used the relationship $s_j = (1 - z_j)f_j + z_j h_j$ with $z_j = 1$. Households will only prefer owning to renting if $r + \delta_h < i$. It is important to notice that this condition is necessary,

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

but not sufficient to guarantee homeownership. This is because owner-occupied housing is associated with additional costs in the model, such as transaction costs and indivisibilities.[6]

The condition $r + \delta_h < i$ can be motivated by assuming that rental housing depreciates at a different rate the owner-occupied housing. In this world, the equilibrium price per rental unit would be $i = r + \delta_f$ where δ_f is the depreciation rate of rental housing.[7] Starting with Henderson and Ioannides (1983), part of the literature has assumed that rental housing depreciates at a higher rate compared to owner-occupied housing, $\delta_h < \delta_f$ (see, among others, Díaz and Luengo-Prado (2006), Díaz and Luengo-Prado (2008), Chambers et al. (2007)).[8] This can be motivated with moral hazard issues, as renters may be less concerned about the maintenance of the housing units than homeowners.

Renting households choose the number of housing units that equalizes the intra-period marginal utility from housing to their intra-period marginal utility from non-durable consumption.

$$\left.\frac{\partial U(c_j, f_j)}{\partial c_j}\right|_{z_j=0} (r + \delta_f) = \left.\frac{\partial U(c_j, f_j)}{\partial f_j}\right|_{z_j=0} \tag{2.16}$$

In the following, I will assume that δ_f is such that owner-occupied housing is preferred to renting.

2.4.5 Precautionary Savings and Housing

In this section, I argue that introducing housing as an asset increase the demand for precautionary saving compared to the one-asset economy with renting. This is due to the fact that housing serves a dual role as a consumption good and as an investment good. I show that this increases the volatility of aggregate consumption and therefore leads to more demand for precautionary saving.

For simplicity, I abstract from down payment constraints and transaction costs.

Assumption 2 *Call total household consumption $g(c, h)$ or $g(c, s)$, respectively. Let $g'(c, h) > 0$, $g''(c, h) < 0$ and $g_{c_h} > 0$ and $g_{h_c} > 0$.*

Assumption 3 *Households' utility is given by $U(g(c, h))$ with $U' > 0$, $U'' < 0$, and $U''' > 0$, i.e. households are prudent.*

[6] On the other hand, it is also associated with benefits, since it serves as a collateral for financial debt.

[7] To see this, consider that rental housing is provided by a financial intermediary, which receives deposits from the household sector, issues loans to the households and rents capital to firms. Profit maximization and zero profits in equilibrium implies that $i_s = r + \delta_f$ (Gervais (2002)). This shows that owning can be strictly preferred to renting even in a general equilibrium setting.

[8] Kiyotaki et al. (2007) present an alternative way to make owner-occupied housing preferred to renting: they assume that households owner-occupied housing yields higher utility.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Assumption 4 *Period $j's$ earnings are given by $y_j = \overline{y_j} + \widetilde{y_j}$ where $var(\epsilon) = \sigma_\epsilon^2$. Without loss of generality, I assume that $\widetilde{y_j}$ either equals $-\epsilon$ or ϵ with probability* 0.5 *each. Let* $|\epsilon| > 0$

Now compare the maximal attainable aggregate consumption level in the one-asset economy with renting and in the benchmark case.

Definition 4 *Let $g_j(u,h)^*$ be the aggregate consumption level that solves 2.5, given 2.6 in period j. Similarly, let $g_j(u,s)^{**}$ be the aggregate consumption level that solves 2.7, given 2.8 in period j.*

Lemma 5 *Given definition 4 and assumption 4, it follows that $g_j(u,h)^* \leq g_j(u,h)^{**}$.*

Proof. When housing is an asset, households choose their optimal amount of housing at age j such that $\frac{E_j(U_h(c_{j+1},h_{j+1}))}{E_j(U_c(c_{j+1},h_{j+1}))} = r + \delta_h$, while the optimal condition for renting is given by $\frac{U_s(c_{j+1},s_{j+1})}{U_c(c_{j+1},s_{j+1})} = r + \delta_h$. That is, they are equal in expectations: $\frac{E_j(U_h(c_{j+1},h_{j+1}))}{E_j(U_c(c_{j+1},h_{j+1}))} = \frac{U_s(c_{j+1},s_{j+1})}{U_c(c_{j+1},s_{j+1})}$ However, $\frac{U_h(c_{j+1},h_{j+1})}{U_c(c_{j+1},h_{j+1})} = \frac{U_s(c_{j+1},s_{j+1})}{U_c(c_{j+1},s_{j+1})}$ iff $\epsilon = 0$, which contradicts the assumptions. ■

From this we get that:

Proposition 6 *Assume that δ_h and r are equal to zero. Introducing housing as an asset increases the amount of precautionary saving, for a given variance of earnings process.*

Proof. When housing serves as an asset, savings are determined implicitly from the Euler equation:

$$\beta E_j(U_h(g(c_{j+1},h_{j+1}))g_h(c_{j+1},h_{j+1})) + \beta E_j(U_c(g(c_{j+1},h_{j+1}))g_c(c_{j+1},h_{j+1})) = U_c(g(c_j,h_j))g_c(c_j,h_j) \tag{2.17}$$

Without housing as an asset, the Euler equation is given as:

$$\beta E_j(U_c(g(c_{j+1},s_{j+1}))g_c(c_{j+1},s_{j+1})) = U_c(g(c_j,s_j))g_c(c_j,s_j) \tag{2.18}$$

Savings will be larger if the l.h.s. of 2.17 exceeds the l.h.s. of 2.18. Since the first term of 2.17 is positive given assumptions 3 and 2, it is sufficient to show that

$$E_j(U_c(g(c_{j+1},h_{j+1}))g_c(c_{j+1},h_{j+1})) > E_j(U_c(g(c_{j+1},s_{j+1}))g_c(c_{j+1},s_{j+1})) \tag{2.19}$$

The optimal solution has to satisfy

$$E_j(U_c(g^*(c_{j+1},h_{j+1}))g_c^*(c_{j+1},h_{j+1})) > E_j(U_c(g^{**}(c_{j+1},s_{j+1}))g_c^{**}(c_{j+1},s_{j+1})) \tag{2.20}$$

From lemma 5 and assumption 3, $U_c(g^*(c_{j+1},h_{j+1})) \geq U_c(g^{**}(c_{j+1},s_{j+1}))$ for all realizations of ϵ, for some $U_c(g^*(c_{j+1},h_{j+1})) > U_c(g^{**}(c_{j+1},s_{j+1}))$. Therefore, $E_j(U_c(g^*(c_{j+1},h_{j+1}) > E_j(U_c(g^{**}(c_{j+1},s_{j+1})))$.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Now, distinguish two possible cases that may appear at different realizations of ϵ: (i) $g_c^*(c_{j+1}, h_{j+1}) \geq g_c^{**}(c_{j+1}, s_{j+1})$ and (ii) $g_c^*(c_{j+1}, h_{j+1}) < g_c^{**}(c_{j+1}, s_{j+1})$.

If (i), condition 2.19 is fulfilled, because of concavity of U.

In order to analyze case (ii), I define $\Delta = g^{**}(c_{j+1}, s_{j+1}) - g^*(c_{j+1}, h_{j+1})$ and $\Delta_c = g_c^{**}(c_{j+1}, s_{j+1}) - g_c^*(c_{j+1}, h_{j+1})$. By concavity of U, condition 2.19 is fulfilled if $\Delta \geq \Delta_c$. From lemma 5, $\Delta > 0$ if $\Delta_c > 0$. Notice that by definition, $g^{**}(c_{j+1}, s_{j+1}) = \int_0^{s^{**}} \int_0^{c^{**}} g_c^{**}(c_{j+1}, s_{j+1}) dcds$ and $g^*(c_{j+1}, h_{j+1}) = \int_0^{h^*} \int_0^{c^*} g_c^*(c_{j+1}, h_{j+1}) dcdh$. Hence, $\Delta > \Delta_c$ if $\Delta > 0$. ■

Remark 7 *The amount of additional precautionary saving is decreasing in both* δ_h *and* r

Thus, the dual role of housing as an asset and as a consumption good results in higher precautionary saving compared to a standard model where housing as an asset is absent. It is important to notice that the assumptions made about the functional form of both g and U are quite general; for example, a large part of the literature assumes that aggregate consumption is computed using a Cobb-Douglas functional form with constant returns to scale (see Fernández-Villaverde and Krueger (2005) or Yang (2006) and the references cited therein). These authors also assume that homeowners decide upon their housing stock one period before the actual consumption takes place.

The rise in precautionary saving does not depend on the illiquidity of housing caused by transaction costs, which studied in Grossman and Laroque (1990), Martin and Gruber (2004), Flavin and Nakagawa (2004) and most recently, Stokey (2007). As argued by Martin and Gruber (2004), the illiquidity of housing may either increase or reduce precautionary saving.

In the present model, the impact of housing on precautionary saving arises simply because homeowners are forced to decide upon their housing consumption one period before. Proposition 6 thus embodies an important contribution to this literature.

2.5 Parametrization and Calibration

In this section, I describe the parametrization of the utility function and the calibration of all model parameters. I focus on two education groups, namely college graduates and high school dropouts. This is because the wealth-income gap between these groups is the most pronounced (see section 2.2). Restricting the attention to two education groups also greatly helps to reduce computation time.[9]

[9] In addition, there is a clear-cut distinction between high school dropouts and college graduates when calibrating the earnings process. When comparing high school graduates and college graduates, the treatment of households whose head attended college but did not graduate is not clear.

 DOI: 10.2870/26812

2.5.1 Preferences

I assume that preferences are identical for the different education groups. Period utility function is assumed to be of CRRA type:

$$u(c,s) = \frac{(g(c,s))^{1-\theta}}{1-\theta}$$

where $g(.,.)$ is an aggregator function of the service flows from housing and the composite consumption. I choose an aggregator of the CES type

$$g(c,s) = [\phi c^{-\gamma} + (1-\phi)s^{-\gamma}]^{-\frac{1}{\gamma}} \tag{2.21}$$

The elasticity of substitution between nondurable consumption and housing is thus given by $\varpi = \frac{1}{1+\gamma}$. If $-1 < \gamma < 0$, housing and nondurable consumption are substitutes with $\varpi > 1$. If $0 < \gamma < \infty$, the two goods are complements and $\varpi < 1$. As γ approaches 0, we are in the Cobb-Douglas case.

Together with the optimality condition (2.16), this implies that the optimal level of housing services for renters is given by

$$s = \left(\frac{\phi}{1-\phi}\right)^{\frac{1}{-\gamma-1}} c$$

Davis and Ortalo-Magne (2007) provide evidence from the 1980, 1990, and 2000 Decennial Census of Housing that the expenditure share on housing is constant over time and across U.S. metropolitan areas. They conclude that households have Cobb-Douglas preferences for housing and numeraire consumption. Fernández-Villaverde and Krueger (2005) review the empirical micro literature that provides estimates for γ and they find that most of the estimates presented are not significantly different from zero. Consequently, they compute aggregate consumption using a Cobb-Douglas form (also see Yang (2006) and many others). I follow their example and use a Cobb-Douglas specification as well.

Under this specification, ϕ is the share of non-housing consumption in total utility. This implies that ϕ is the total share of non-housing consumption in total expenditures.[10] I set ϕ equal to 0.7.

For the coefficient of relative risk aversion, θ, I use value of 1.5, which is taken from Attanasio (1999) and Gourinchas and Parker (2002), who estimate it from consumption data. It is also well in the range of 1 to 3, which is commonly used in the literature.

The aim of my paper is to evaluate to what extend the model can account for the wealth-income gradient. To this extend, I calibrate the discount factor β such that my model replicates the wealth-income ratio for college graduates, which is observed in the U.S., taking all other parameters as given. Since the same value of β is also used for high school dropouts,

[10] This holds in a world without imperfections.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

any gap in the wealth-to-income ratio must be endogenously generated by the mechanics of the model.

2.5.2 Earnings Process

I assume that the process that governs the productivity shocks $\eta^{j,e}$ follows an AR(1) process with persistence parameter ρ^{hs} for high school dropouts and ρ^{col} for college graduates. The variance of the innovations are σ^{hs} and σ^{col}, respectively.

I follow Hubbard et al. (1995) (HSZ in the following) when calibrating the uncertainty of the earnings process. As HSZ, I am primarily interested in uninsured risk, that is, risk faced by households conditional on existing insurance coverage. HSZ thus include unemployment insurance and use the combined labor income of the husband and wife (if married) as their measure of "earnings".

Examing the 1982 to 1986 Panel Study of Income Dynamics (PSID), HSZ find that high school dropouts have a higher variance ($\rho^{hs} = 0.955$, $\sigma^{hs} = 0.033$) compared to college graduates ($\rho^{col} = 0.955$, $\sigma^{col} = 0.016$). It should be noted that both estimates are rather conservative as HSZ use the combined labor income of the husband and wife (if married) plus unemployment insurance for their estimates. I approximate the earnings process with a eight-state Markov process using the procedure proposed by Tauchen and Hussey (1991).

I also take the average age-efficiency profile ε_j^e from HSZ. The authors find that earnings are more peaked for college families, which is in line with findings from other empirical studies. Figure 2.2 depicts the earnings profiles for high school dropouts and college graduates.

2.5.3 Housing Technology

I assume that the depreciation rate of owner-occupied housing is $\delta_h = 0.08$. This value is taken from Fernández-Villaverde and Krueger (2005) who use data from 2000 comprehensive revision of NIPA and Fixed Assets and Consumer Durable Goods of the Bureau of Economic Analysis to match investment shares of output and capital-output ratios.[11]

The depreciation rate of rental housing δ_f and the minimum housing size $\underline{h}$ are picked jointly to match the share of homeowners of high school dropouts (50 percent) and college graduates (87 percent) found in the 1989 SCF. This results in $\delta_f = 0.095$ and $\underline{h} = 0.5$.

The interest rate for financial assets is set exogenously to $r = 0.045$.

2.5.4 Market Imperfections

Martin (2003) estimates that the transaction costs of buying a new home are between 7 and 11 percent of the home value. This figure comprises agent fees, transfer fees, appraisal and inspection fees. Martin and Gruber (2004) find that the costs for selling property are in the

[11] Note that their investment shares also include consumer durables other than housing.

 DOI: 10.2870/26812

same range. I take a conservative choice with a value of 7.5 for both the costs of buying and selling.

Campbell and Hercowitz (2005) estimate the average equity share for mortgage loans using the 1983, the 1995 and 2001 SCF. They find that at the beginning of the 1980's, shortly after financial liberalization took place, the average equity share was approximately 0.23. It declined to 0.1756 in 1995 and 0.1749 in 2001. Campbell and Hercowitz (2005) conclude that the reform of the household credit market was largely completed in 1995.

For the calibration of the down-payment value ζ, I take an average of the 0.23 and 0.17 and set $\zeta = 0.2$, which is the parameter value commonly used in the housing literature (see e.g. Gervais (2002) or Yang (2006)).

2.5.5 Welfare System

The consumption floor is measured to be 7000 US-Dollars (Hubbard et al. (1995)). This corresponds to $\underline{c} = 0.20$ in my economy if I express the consumption floor measured by Hubbard et al. (1995) in units of the average labor earnings of a high school dropout.

Hubbard et al. (1995) also estimate that the elderly and the non-elderly receive the same consumption floor. I thus set the annual retirement benefits *pen* to 0.20, which would correspond to a replacement rate of about 45 percent of the average income in the economy. A similar value of the replacement rate is also used in the related papers of De Nardi (2004) and Yang (2006).

2.6 Results

I find that model fully accounts for the wealth-income gap between the median college graduate and the median high school dropout observable in the data. This can be seen by comparing columns 1 and 2 of table 2.3. In fact, the model generates a wealth-income gradient with educational attainment that is even steeper than the one that is observable in the data. This stems from the fact that the wealth-income ratio for high school dropouts is smaller in the model than in the data (1.6 instead of 2). By calibration, the model reproduces the wealth-income ratio for college graduates that is observable in the data.

Given the success of the benchmark economy, it is interesting to assess the importance of housing in generating inequality across income groups. I thus eliminate housing as an asset and re-compute the wealth-income ratios for the two different education groups, keeping all other parameter values fixed to their benchmark values. In this one-asset economy, households can accumulate wealth only in form of bonds. The economy is thus similar to the models presented the seminal papers of Huggett (1996) or Huggett and Ventura (2000).

Comparing columns 2 and 3 of table 2.3 reveals that removing housing reduces the wealth-income gap generated by the model from 2.4 to 2. Interestingly, the decline stems only from

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

the decrease in the wealth-income ratio of college graduates, while the wealth-income ratio of high school dropouts remains unchanged. This suggests that introducing housing into the standard life cycle framework primarily affects retirement savings of the income-rich.

Wealth Holdings of Renters and Homeowners

The model is also able to replicate another prominent pattern observable in the data, namely the fact that wealth holdings near retirement vary widely with the ownership status. In line with the data, I find that the gradient between homeowners and renters is more pronounced for high school dropouts (the second and the third panel of table 2.3. Around 50 percent of all high school dropouts rent their housing services between the age of 51 and 61, which implies that the median household among the high school dropouts is a renter as well. Since the share of homeowners is considerably larger (in the model: about 99 percent), the median household with college education is a homeowner. If housing drives a wedge between the wealth holdings of renters and homeowners, it may also contribute to the wealth-income gradient observable between education groups.

Notice, however, that homeowners must be richer than renters by construction: owner-occupied housing is preferred to renting, therefore only the unfortunate with a sequence of bad earnings shocks will remain renters. These are also the ones with low wealth-income ratios near retirement.

The Role of Social Security Benefits

In this context, it is also interesting to take a closer look at the role of social security benefits. In the model as well as in the U.S., retirement benefits are not proportional to social security taxes paid. Thus, retirement benefits make up a small fraction of earnings for high earners and a high fraction of the earnings of low earners. Consequently, high earner save at a higher rate before retirement than low-earnings. Huggett and Ventura (2000) find that this feature of the social security system is capable of generating differences in savings rates within age groups. Hendricks (2007) argues that implementing social security benefits may generate a wealth-income gap between lifetime income groups that is even larger than the observable gap in the data.

In order to measure the relative contribution of social security in my benchmark economy with housing, I set $rep = 0$, which implies that there are no retirement benefits at all. Thus, the only way households can survive during retirement is by accumulating wealth during working life and by living off this wealth during retirement. The computational experiment shows that setting $rep = 0$ reduces the gap between the income-rich and the income-poor: the wealth-income ratio of high school dropouts doubles and increases from 1.6 to 3.3, whereas the wealth-income ratio of college graduates increases only mildly from 4 to 4.8 (column four).

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

This shows that retirement benefits indeed have an important impact on the wealth holdings of the income-poor. However, social security can only partly account for the wealth holdings of the poor: even after the removal of the social security system, the wealth-income gap still amounts to 1.5.

Removing housing in addition to social security reduces the wealth-income gap generated by the model even further, from 1.5 to 1 (column five). This shows that housing has an impact on the wealth-income gradient, independently of social security. Again, removing housing mainly affects retirement savings of college graduates. This suggests that housing is essential for explaining the wealth holdings of the income-rich, while social security helps to account for the low wealth holdings of the income-poor.

In essence, these experiments show that introducing housing raises the wealth-income gap by about 25 percent, which is substantial. In the next section, I will shed more light on the precise mechanisms that make income-rich households hold more wealth in the presence of housing as an asset.

As an important contribution to the literature, my results show that a standard life cycle model that is augmented by housing can generate a wealth-income gradient that is in line with empirical evidence. The model is standard in the sense that preferences are homogenous and individuals are fully rational. Cagetti (2003) and Hendricks (2007) find that the heterogeneity in wealth-to-income ratios can be explained by heterogeneity in time preference rates. Bernheim et al. (2001) argue that that 'rules of thumb' or other less than fully rational decision processes, including behavioral rules, are more consistent with the observed heterogeneity (also see Dynan et al. (2004)). Guner and Knowles (2007) highlight the role of marital instability in explaining wealth heterogeneity near retirement age. Scholz and Seshadri (2006) emphasize the importance of children for household wealth, while Yang (2005) finds that intergenerational links in terms of bequests are significant. The results in this paper suggests that housing might play an important role for explaining wealth heterogeneity across income groups.

2.7 Decomposition: Housing and Wealth Holdings Near Retirement Age

In this section, I decompose the total impact of housing on generating wealth heterogeneity across education groups. Three mechanisms are important. The first mechanism increases the wealth-income ratio of college graduates because their hump-shaped earnings profile interacts with the multiple role of housing as an asset, as consumption good and as collateral. For the second mechanism, the presence of uninsurable mortality risk is important. I show that uninsurable mortality risk further raise the gap between college graduates and high school dropouts. And third, as shown theoretically in section 2.4.5, the dual role of housing as an

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

asset and as a consumption good increases the demand for precautionary saving.

2.7.1 The Role of Consumption Smoothing

College graduates and high school dropouts do not only differ in the level of their earnings, but also in the shape of their life cycle earnings profile. Figure 2.2 shows that earnings of college graduates depict a pronounced hump with a peak around age 47, while the earnings profile of high school dropouts is relatively flat.

The impact of this difference on pre-retirement wealth holdings is illustrated in figures 2.3 - 2.6. Here, I plot the life cycle wealth profiles for total wealth, distinguishing an economy with and without housing.[12] To isolate the impact of the life cycle earnings profile, I abstract from earnings uncertainty and mortality risk when computing the graphs.

Strikingly, the graphs for high school dropouts coincide, independently of the presence of housing. However, for college graduates, there is a marked difference in the pre-retirement wealth holdings, depending on whether I consider the one-asset economy or the benchmark model with housing.

The impact of housing can also be seen from the life cycle profiles of total (aggregate) consumption. Total consumption is computed according to the consumption aggregator (equation 2.21).[13] Figures 2.8-2.9 illustrate how households distribute their aggregate consumption over the life cycle. In the economy without housing, total consumption of college graduates is considerably more hump-shaped. However, there is no difference between the consumption profile in the economy with housing and without housing for high school dropouts.

The impact housing has on the wealth and the consumption profile of college graduates results from its dual role as a consumption good and collateral for financial loans. Because the earnings profile of college graduates follows a pronounced hump-shape, college graduates accumulate housing capital by issuing financial loans early in life. This increases their total consumption early in life when earnings are low. As a result, their overall life cycle consumption profile becomes smoother.

Put differently, without housing, borrowing constraints are more binding at the beginning of the life cycle, consumption follows income more closely, which results in lower pre-retirement wealth holdings, because hum-shaped consumption profiles results in less resources during retirement, when income is low. Binding borrowing constraints are often mentioned as a reason for the hump in consumption expenditures, which are observable in the data (see Browning and Crossley (2001) for an overview over the literature).

It is important to notice that the predictions of the model are in line with empirical ev-

[12] Proposition 2 states that the one-asset economies with and without renting are identical in terms of the resulting life cycle profile of wealth.

[13] By assumption, it is aggregate consumption that households value in their utility maximization problem. Households use wealth to distribute their aggregate consumption in such a way over the life cycle that their total utility is maximized.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

idence derived from micro data. First, Attanasio (1999), Fernández-Villaverde and Krueger (2004) and Fernández-Villaverde and Krueger (2007) all find that consumption profiles for households with higher education level are more hump-shaped. Fernández-Villaverde and Krueger (2004) further distinguish between durable (mainly housing) and non-durable consumption. They point out that household's non-durable expenditures are more hump-shaped for individuals with higher education level, whereas durable expenditures are fairly stable over the life cycle, independent of the education level. Yang (2008) obtains similar results.[14] Second, Dynan and Kohn (2007) document that household debt relative to income is increasing with the education level. This hints to the fact that households with higher education accumulate more debt in order to obtain a smooth consumption profile.

To illustrate how the different shape of the earnings profile leads to a gradient in the wealth-income ratio with educational attainment, I compute the wealth-income ratios that correspond to figures 2.3 - 2.6. The results are shown in columns one and two of table 2.4. Housing raises the wealth-income gap between college and high school dropouts by about 0.25.[15]

So far, I have studied the impact of housing in the absence of mortality risk. In the next section, I show that introducing mortality risk amplifies the impact of housing on the difference in the wealth holdings between the education groups even further.

2.7.2 The Influence of Mortality Risk

Introducing mortality risk reduces wealth holdings near retirement for both education groups, independently of whether I consider the economy with or without housing. This can be seen from comparing the life cycle wealth profiles that are presented in figures 2.11 - 2.14 to the ones from the previous section (figures 2.3 - 2.6). In both cases, I abstract from earnings uncertainty.

Intuitively, the reduction in total wealth holdings when introducing mortality risk makes sense: the presence of mortality risk reduces the subjective discount factor, as individuals face a positive probability of not surviving to enjoy the fruits of their savings, they discount their future more heavily.[16]

Interestingly, the impact of mortality risk on pre-retirement wealth holdings is weaker in the economy with housing. In order to understand why this is the case, recall from the previous section that the interaction between the hump-shaped earnings profile of college

[14] Notice that consumption is not directly observable, only consumption expenditures.

[15] Notice that wealth-income ratios for high school dropouts in the economy with and without housing do not coincide, even though their respective wealth holdings do. This is due to the definition of income, which incorporates labor and capital income. Because households in the one-asset economy hold only financial assets that bear interest, the income of the median household is higher in the one-asset economy, which explains why the median wealth-income ratio is lower.

[16] See Hansen and Imrohoroglu (2008) for an excellent recent treatment of the consequences of uninsurable mortality risk. Feigenbaum (2008) provides another excellent overview over the literature.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

graduates and the dual role of housing as a consumption good and collateral for financial loans increased pre-retirement wealth holdings because borrowing constraints became less tight at the beginning of the life cycle. Because mortality risk affects both college graduates and high school dropouts, housing increases wealth holdings for both education groups.

The impact of mortality risk is quite similar: because mortality risk is increasing with age, subjective discount factors are decreasing when individuals grow older. Consequently, the presence of lifetime uncertainty raises the demand for consumption during working life, which makes borrowing constraints more binding at the beginning of the life cycle. This is when the collateral function of housing comes in handy: it allows households to increase their consumption when needed. As a result, consumption tracks income less closely, which implies that households accumulate more retirement wealth.

How housing and mortality risk interact in shaping the consumption profiles can be seen in figures 2.16-2.17. As the graphs show, total life cycle consumption is much more hump-shaped in the absence of housing. Recently, Hansen and Imrohoroglu (2008) and Feigenbaum (2008) argue that mortality risk is an important for explaining the hump-shaped consumption profile which is observable in the data. My paper contributes to this literature by pointing out the importance of housing: if housing is considered in the analysis as well, the impact of mortality risk on the shape of the aggregate consumption profile may be less pronounced.

2.7.3 The Role of Housing Market Imperfections

So far, I have abstracted from the existence of market imperfections related to housing, such as down payment requirement and transaction costs. This allowed me to isolate the effect of housing on pre-retirement wealth holdings. Introducing housing market imperfections makes borrowing constraints more binding and reduces the scope of housing. Clearly, this has negative consequences for wealth holdings near retirement, which can be seen from figures 2.19 and 2.20, where I plot the life cycle wealth profiles for the economy with housing and with housing market frictions.[17] Comparing these graphs to the figures in 2.11 and 2.14 reveals that wealth holdings near retirement age decrease particularly strongly for college graduates. This makes sense, as college graduates depend heavily on consumption smoothing, due to the shape of the earnings process. The wealth-income ratios for the different economies confirm this finding: the gap in the wealth-income ratio between college graduates and high school dropouts is higher for the economy without housing market imperfections (table 2.4).

Hence, during a period of financial liberalization, when housing market imperfections become less tight, we should observe an increase in the wealth-income gradient with educational attainment. Interestingly, this is indeed the case. Sinai and Souleles (2007) document the trends in the life-cycle profiles of net worth and housing equity over time using the 1983 through 2004 SCF. They find that wealth inequality with housing wealth has increased over

[17]Market imperfections are as outlined in calibration section.

time.

In the next section, I will show that adding earnings uncertainty increases the wealth-income ratio of college graduates even further.

2.7.4 Housing and Precautionary Savings

Earnings inequality and housing interact in generating inequality between college graduates and high school dropouts. To see this, consider the different effects introducing earnings uncertainty has in an economy with and without housing. In the economy with housing, introducing earnings uncertainty raises the wealth-income ratio of college graduates, whereas in the one-asset economy, earnings uncertainty decreases the wealth-income ratio for college graduates. For high school dropouts, the effect is positive, independently of the presence of housing. In total, the gap between the two education groups increases, when both housing and earnings uncertainty are present.

These observations can be explained by the differences in earnings process. Recall from the calibration section that the AR(1) process that governs idiosyncratic earnings risk has the same (high) persistence parameter $\rho = 0.955$ for both high school dropouts and college graduates. However, the standard errors of the innovations is much higher for high school dropouts. This results in higher demand for precautionary saving for high school dropouts, all other things equal.

In the housing model, the median high school dropout is a renter. By proposition 2, the wealth holdings of renters are identical to wealth holdings of the one-asset economy. Consequently, introducing earnings uncertainty increases wealth-income ratios in both economies, and the median wealth-income ratio for high school dropouts coincides for both cases.

For college graduates, things are different. The high persistence of earnings shocks makes borrowing constraints tighter for the median household. Thus, the consumption profile becomes more hump-shaped, and savings for retirement declines. In the housing economy, the median college graduate is a homeowner. Therefore, wealth holdings will differ for college graduates in one-asset economy with respect to the housing economy. In particular, we know from proposition 6 that homeowners have a higher demand for precautionary saving for a given level of earnings uncertainty. This works against the above effect and borrowing constraints at the beginning of economic life are less tight. As a result, introducing earnings uncertainty in the one-asset case reduces wealth holdings near retirement age, while it increases wealth holdings in the housing case.

In essence, the interaction between life cycle effects and precautionary savings induced by housing is able to generate a gap in the wealth-income ratio between college graduates and high school dropouts that is consistent with the data.

The interaction of earnings uncertainty and life cycle effects on increasing wealth inequality can also be seen from life cycle wealth profiles plotted in figures 2.21-2.26. Clearly, total

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

wealth holdings are higher in the economy with housing, compared to the economy where households can save only in bonds. If I remove market imperfections (i.e. I set $\zeta = 1$ and $tc = 0$), the difference between the housing economy and the one-asset case becomes even more pronounced.

This finding contributes to the literature that looks at the impact of housing on household wealth inequality in the U.S. (Martin and Gruber (2004), Díaz and Luengo-Prado (2006)). I find that introducing housing can indeed raise wealth heterogeneity, due to the joint impact of life cycle effects and precautionary savings. Both Martin and Gruber (2004) and Díaz and Luengo-Prado (2006) analyze the impact of housing in models with infinitely-lived households. They conclude that housing and market imperfections related to housing contribute only very little to explaining wealth heterogeneity. This points to the fact that life cycle effects for understanding the role of housing.[18]

2.7.5 Market Imperfections and the Wealth-Income Gap between Homeowners and Renters

Housing market imperfections matter for explaining another important dimension of the data. As shown in the section 2.2, wealth-income ratios differ not only for households with different education levels, but also for households with the same education group but different homeownership status. In particular, the data shows that the wealth-income gradient with educational attainment is less steep for homeowners than for the overall population. The baseline economy reproduces this pattern fairly well (see column 2 of table 2.3).

Eliminating transaction costs and the down payment requirement raises the gap between homeowners considerably. This is shown in table 2.4, column five. There are two mechanisms at play. First, removing market imperfections increases the wealth holdings near retirement for homeowners, because it facilitates consumption smoothing. This was shown in the previous section. Second, without market imperfections, lower income households can get access to housing.[19]

Because housing market frictions are not binding for college graduates (essentially everybody owns a home in the pre-retirement stage), the first effect increases the wealth-income ratio of this group. The opposite is true for high school dropouts: wealth holdings relative to income decrease for the median homeowner with high school degree, because without frictions, also poorer households can afford to buy a home. In total, the wealth-income gap

[18]Introducing transaction costs and down payment requirements to my model (as in the benchmark calibration) decreases the impact of housing considerably. The lesson from this exercise is that the choice of the benchmark case plays an important role for evaluating the impact of transaction costs on household's savings behavior. Choosing the standard one-asset model instead of the housing economy as a benchmark case may seriously bias the estimated impact of transaction costs on wealth holdings upwards. Therefore, this paper makes an important contribution to the literature that analyzes the consequences of the illiquidity of housing wealth.

[19]Recall that owner-occupied housing is preferred. Therefore, only those households who cannot afford to buy a home remain renters.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

between the homeowners of the two education groups more than doubles after the removal of the constraints, and exceeds the observed value in the data by a big factor.

2.8 Conclusion

I analyze the determinants of the wealth-income gradient with educational attainment that is observable in the data. This gradient is very steep: using the 1989 wave of the Survey of Consumer Finances (SCF), I find the median college graduates near retirement age holds twice as much wealth as the median high school dropout. In this paper, I argue that housing plays an important role for explaining the wealth-income gradient that is observable in the data.

In order to shed more light on the role of housing, I set up a computable life cycle model. Markets are incomplete, and household face idiosyncratic earnings shocks. Households receive utility from the consumption of housing services and non-housing consumption. In total, housing serves as a consumption good, asset and collateral for financial loans.

I show that a version of this model that is calibrated to match key features of the U.S. economy can generate a wealth-income gap between the median of two education groups, namely college graduates and high school dropouts, that is observable in the 1989 SCF. Housing accounts for a substantial fraction of the observable wealth-income gap between the two education groups: I find that a share of 25 percent of the total gap is due to the presence of housing in the model. Strikingly, introducing housing raises the retirement savings of the median college graduates.

This paper provides a natural framework for studying the impact of financial market liberalization on the development of homeownership ratios and savings behavior along the life cycle. I leave this extension for future research.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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European University Institute DOI: 10.2870/26812

Table 2.1: *1989 SCF: Median Wealth/Income for Different Education Groups*

	All	Renters	Homeowners	Homeowners (>median)
No High-School	2	0.22	3.05	3.9
High-School	2.97	0.19	3.54	4.35
Some College	2.71	0.14	3.12	4.08
College Graduate	3.97	1.45	4.35	4.80

Notes: The data is weighted using the SCF sample weights.

2.9 Appendix: Graphs and Tables

Table 2.2: *2004 SCF: Median Net Worth*

	Homeowners	Renters	Owner-Renter Gap
No High School	100620	100	100500
High School	173400	3970	170000
Some College	258300	2220	256000
College	614200	46540	570000

Notes: The data is weighted using the SCF sample weights.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 2.3: *Median Wealth/Income for High School Dropouts and College Graduates, Aged 51-61*

	Data	Baseline	One-Asset	No Social Security	One-Asset,no Social Security
			Median Wealth/Income - Total Population		
No High School	2	1.6	1.6	3.3	3.45
College Grad.	3.97	4.01	3.6	4.85	4.54
			Median Wealth/Income - Renter		
No High School	0.22	0.53	–	–	–
College Grad.	1.45	1.03	–	–	–
			Median Wealth/Income - Homeowner		
No High School	3.12	3.3	–	–	–
College Grad.	4.35	4.04	–	–	–

Notes: The column 'Data' refers to the 1989 SCF. 'Baseline': parameter values as outlined in the text. 'One-Asset': Only financial assets, no housing. 'No Social Security': Baseline economy without retirement benefits (rep=0). 'One-Asset Economy': One-Asset Economy without retirement benefits.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 2.4: *Median Wealth/Income for High School Dropouts and College Graduates, Aged 51-61*

	No Uncert.	One-Asset No Uncert.	Mort. Risk	One-Asset Mort. Risk	Mort.Risk Fric.	Baseline No Fric.
			Median Wealth/Income - Total Population			
No High School	1.74	1.44	1.36	1.14	1.44	2.58
College Grad.	4.36	3.88	3.90	3.45	3.80	4.55
			Median Wealth/Income - Renter			
No High School	–	–	–	–	–	1.21
College Grad.	–	–	–	–	–	–
			Median Wealth/Income - Homeowner			
No High School	1.74	–	1.36	–	1.44	2.58
College Grad.	4.36	–	3.90	–	3.80	4.55

Notes: 'No Uncertainty': As in baseline, but no earnings uncertainty, no mortality risk and no trans.costs/down payment req.. Notice that there is no heterogeneity and everybody is homeowner. 'One-Asset Economy, no uncertainty': No housing, no earnings uncertainty, no mortality risk. 'Mortality risk': As before, but with mortality risk.'One Asset, Mortality risk': As before, but with mortality risk. 'Mortality risk, Frictions':Housing, no earnings uncertainty, mortality risk, housing market frictions, 'Baseline, no frictions': Benchmark economy, but no housing market frictions (trans.costs/down payment req.)

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

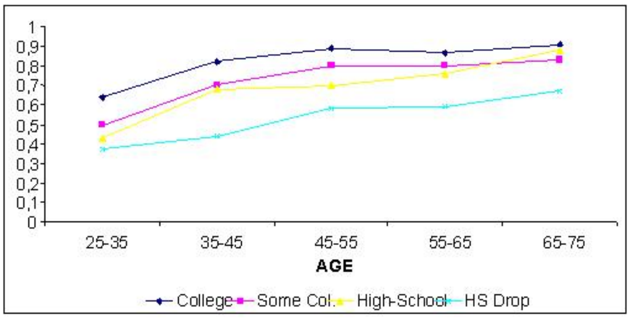

Figure 2.1: 1989 SCF: Homeownership Rates for Different Education over the Life Cycle

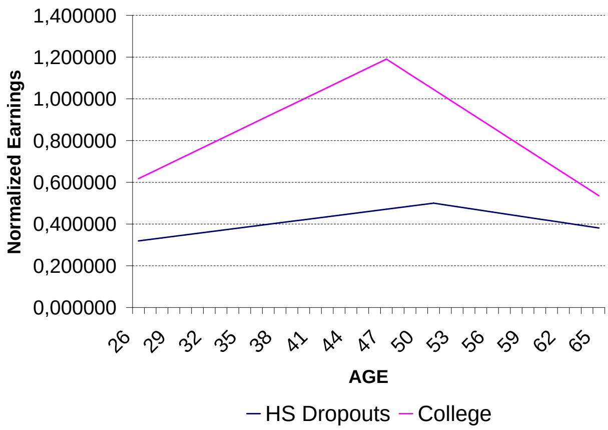

Figure 2.2: Normalized Life Cycle Earnings Profiles, from Hubbard et al. (1995)

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

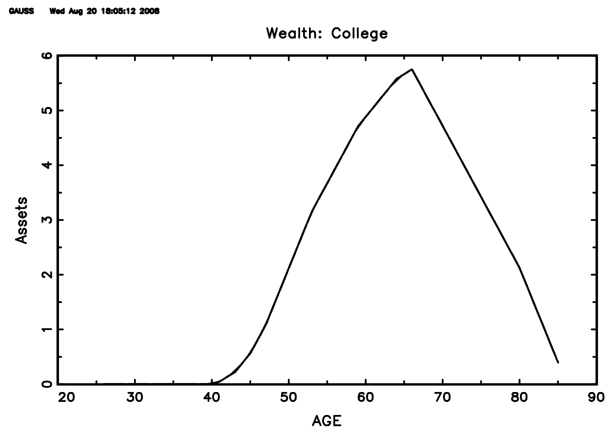

Figure 2.3: Wealth Holdings Economy Without Earnings Uncertainty and Without Housing, College Graduates

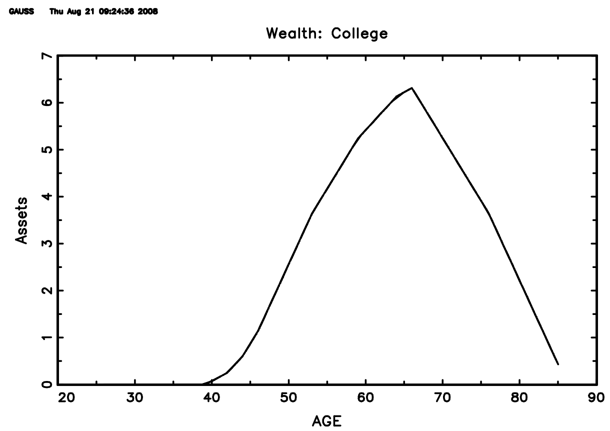

Figure 2.4: Wealth Holdings Economy Without Earnings Uncertainty and With Housing, College Graduates

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

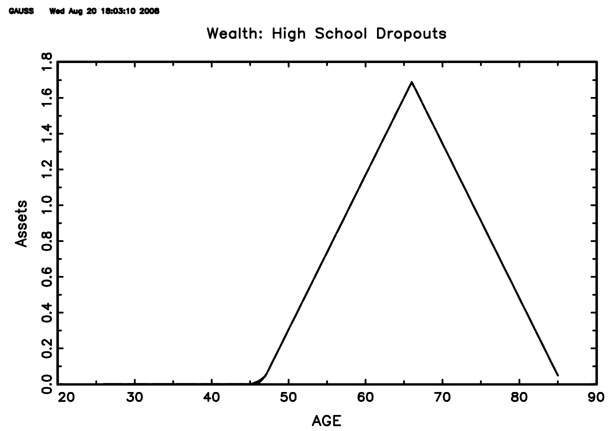

Figure 2.5: Wealth Holdings Economy Without Earnings Uncertainty and Without Housing, High School Dropouts

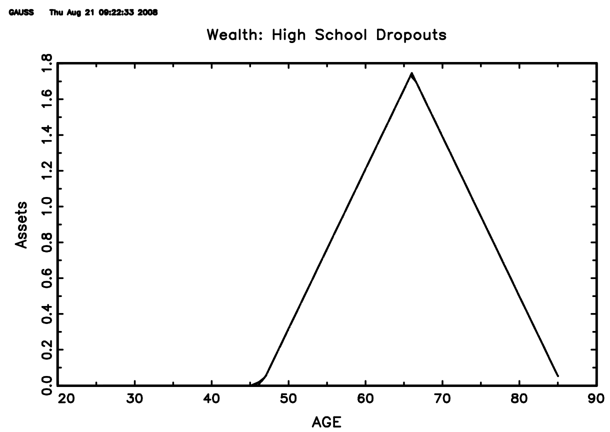

Figure 2.6: Wealth Holdings Economy Without Earnings Uncertainty and With Housing, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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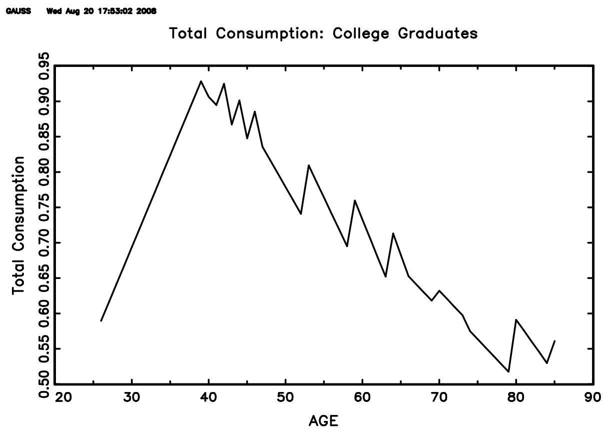

Figure 2.7: Aggregate Consumption, Economy Without Earnings Uncertainty and Without Housing, College Graduates

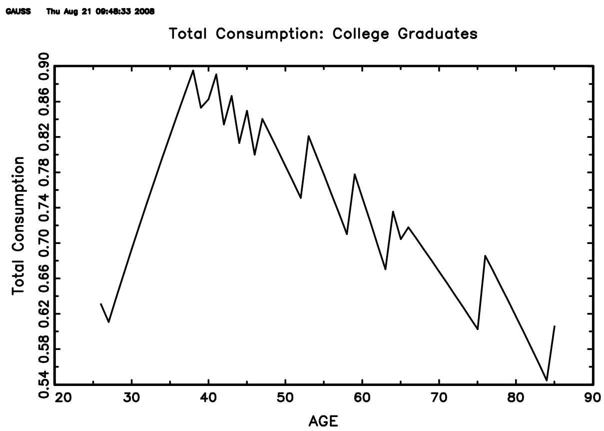

Figure 2.8: Aggregate Consumption, Economy Without Earnings Uncertainty and With Housing, College Graduates

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

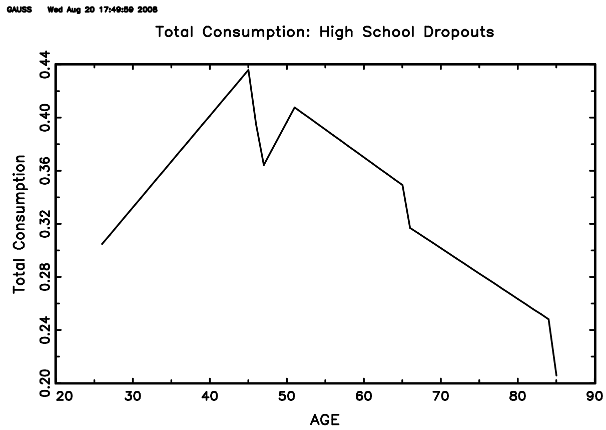

Figure 2.9: Aggregate Consumption, Economy Without Earnings Uncertainty and Without Housing, High School Dropouts

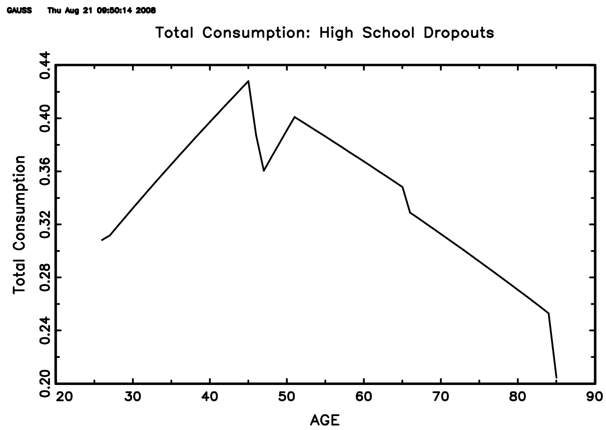

Figure 2.10: Aggregate Consumption, Economy Without Earnings Uncertainty and With Housing, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

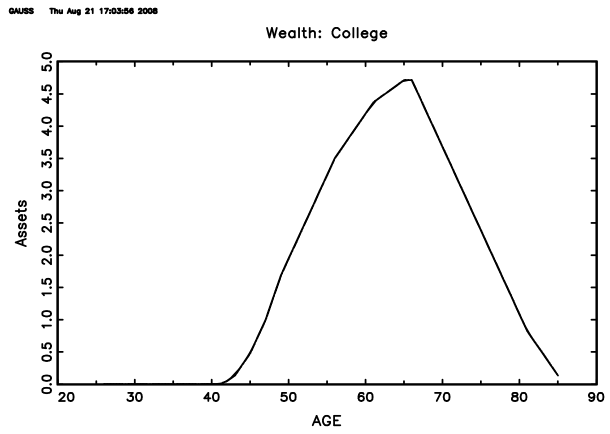

Figure 2.11: Wealth Holdings Economy Without Earnings Uncertainty and Without Housing, College Graduates

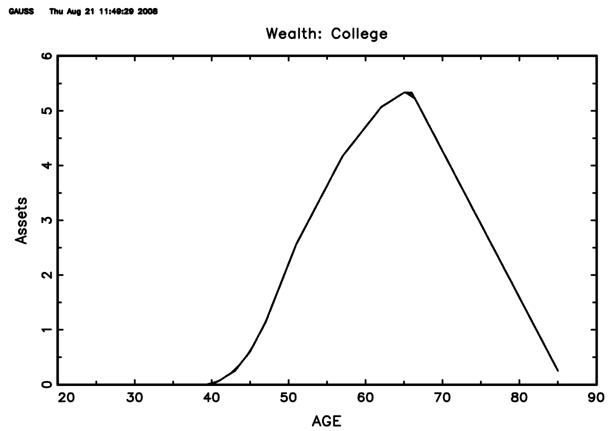

Figure 2.12: Wealth Holdings Economy Without Earnings Uncertainty and With Housing, College Graduates

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

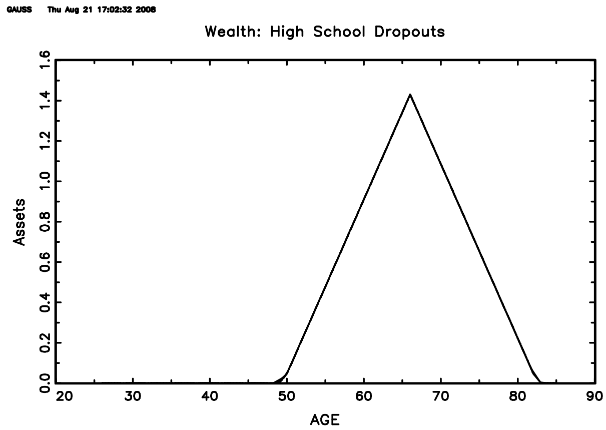

Figure 2.13: Wealth Holdings Economy Without Earnings Uncertainty and Without Housing, High School Dropouts

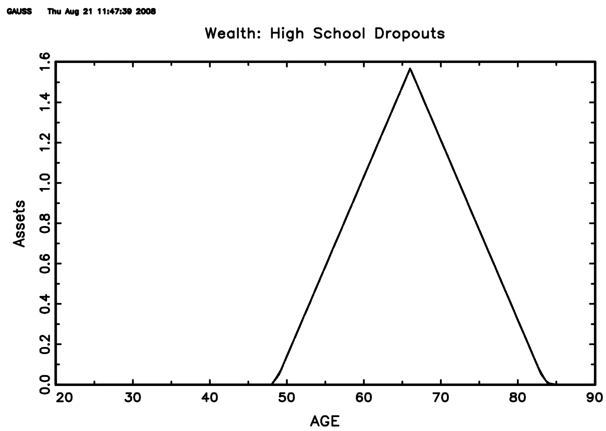

Figure 2.14: Wealth Holdings Economy Without Earnings Uncertainty and With Housing, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

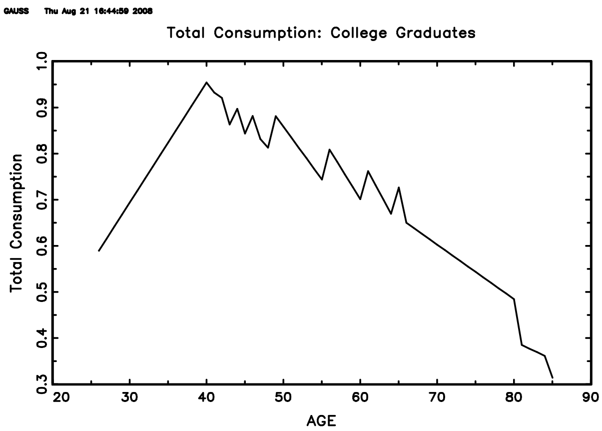

Figure 2.15: Aggregate Consumption, Economy Without Earnings Uncertainty and Without Housing, College Graduates

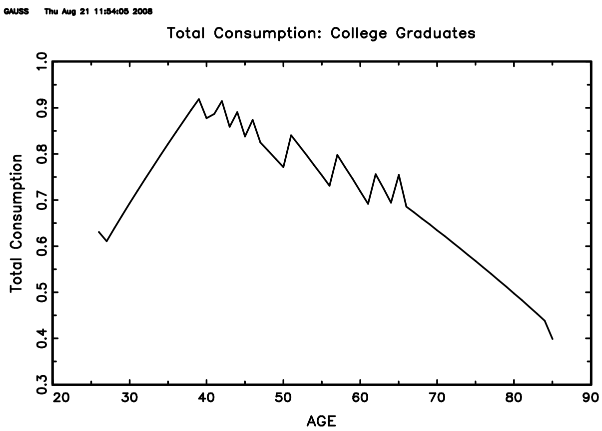

Figure 2.16: Aggregate Consumption, Economy Without Earnings Uncertainty and With Housing, College Graduates

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

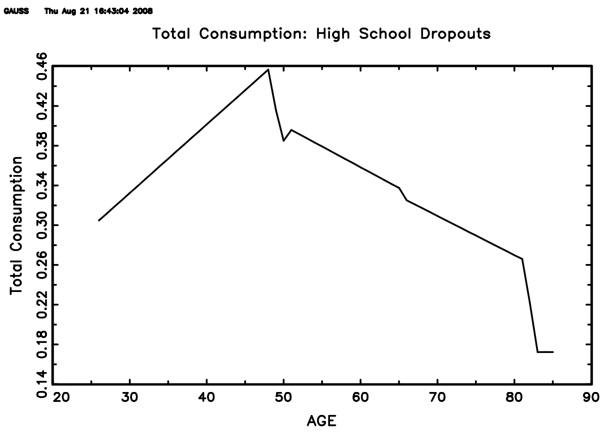

Figure 2.17: Aggregate Consumption, Economy Without Earnings Uncertainty and Without Housing, High School Dropouts

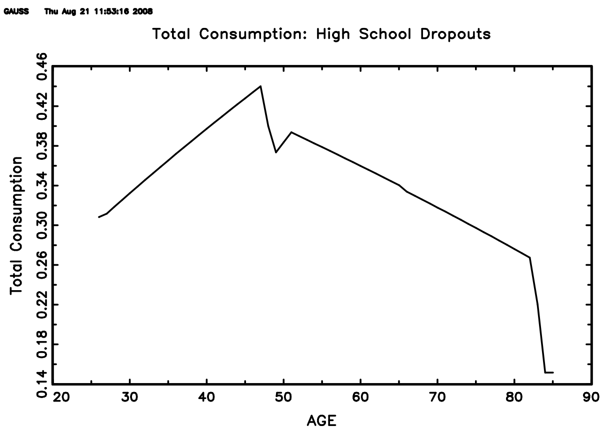

Figure 2.18: Aggregate Consumption, Economy Without Earnings Uncertainty and With Housing, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

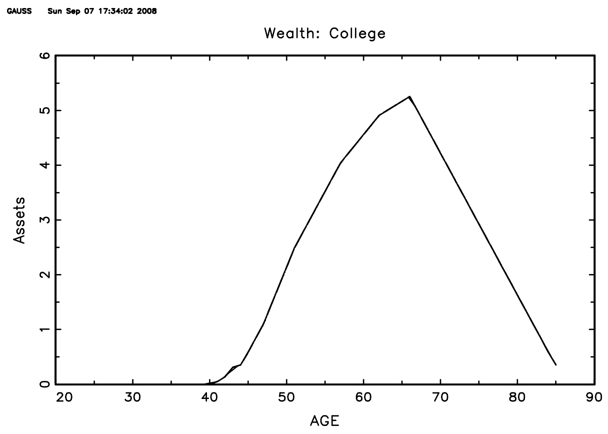

Figure 2.19: Total Wealth, Economy Without Earnings Uncertainty and With Housing and Housing Market Frictions, College Graduates

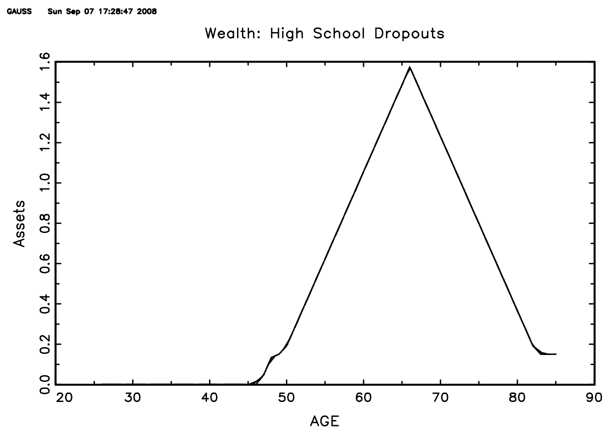

Figure 2.20: Total Wealth, Economy Without Earnings Uncertainty and With Housing and Housing Market Frictions, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

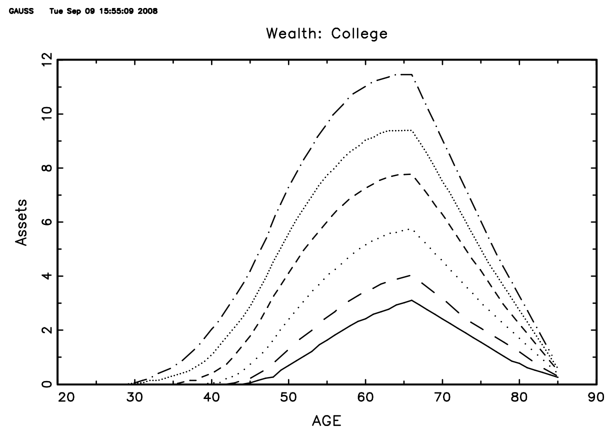

Figure 2.21: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. Baseline Economy, College Graduates

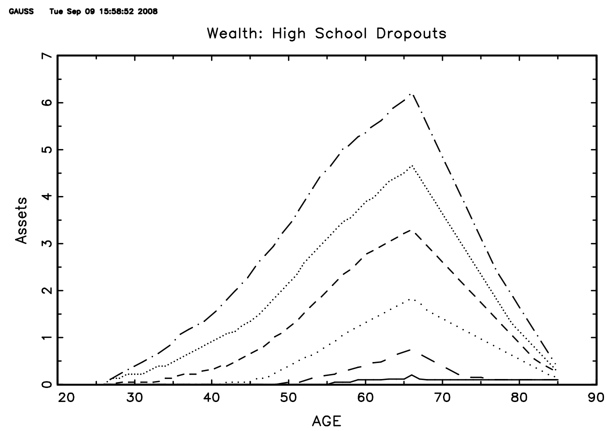

Figure 2.22: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. Baseline Economy, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

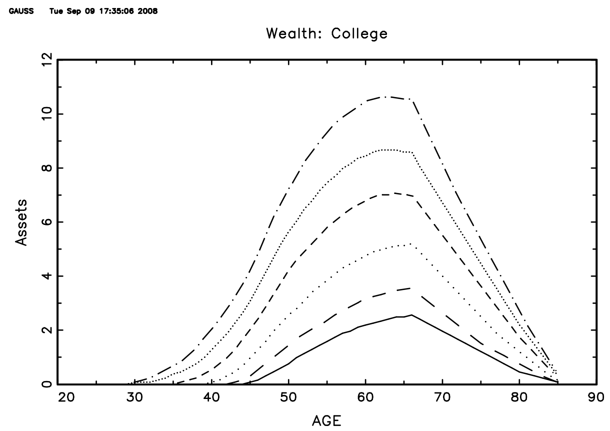

Figure 2.23: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. One-Asset Economy, College Graduates

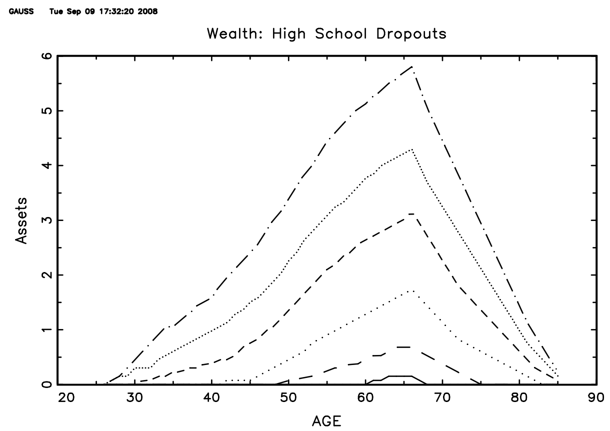

Figure 2.24: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. One-Asset Economy, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

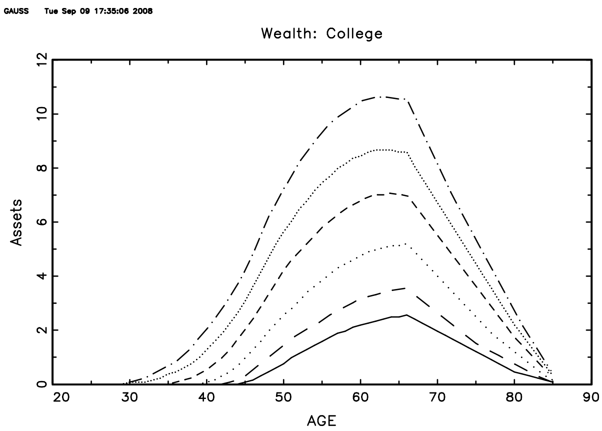

Figure 2.25: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. One-Asset Economy, College Graduates

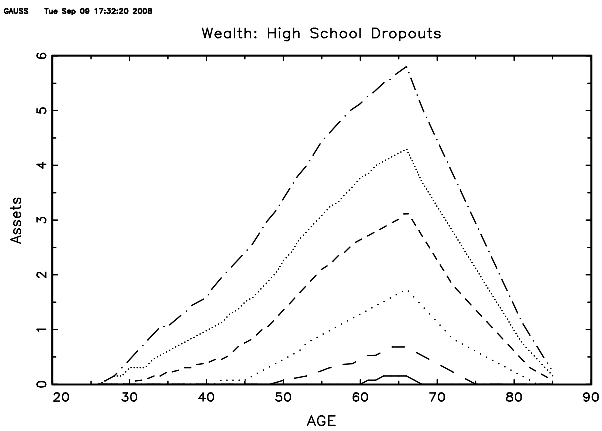

Figure 2.26: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. One-Asset Economy, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute
DOI: 10.2870/26812

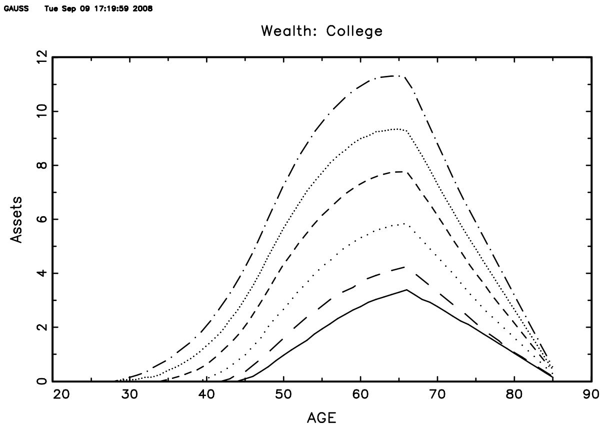

Figure 2.27: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. Housing Economy, No Frictions, College Graduates

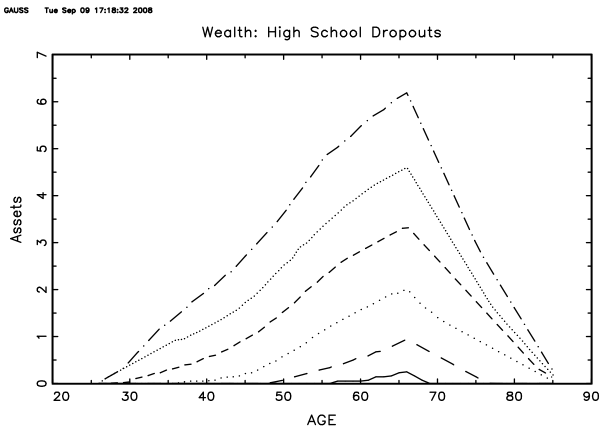

Figure 2.28: Total Wealth for 10th, 25th, 50th, 75th, 90th, 99th percentile. Housing Economy, No Frictions, High School Dropouts

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Chapter 3

Parental Transfers and Parental Income: Does the Future Matter More Than the Present?

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

3.1 Introduction

In this paper, I present a model of parental transfers that is based on the assumption of one sided altruism. I use this model to study the link between parental expectations about their future resources and their present transfer behavior. In the context of my model, I show that parents who expect to receive more income in the future are willing to transfer more to their offspring already today, all other things equal. The same is true for the degree of uncertainty: parents who face less uncertainty about their future income are more willing to support their children, because they have lower demand for precautionary saving, ceteris paribus.

I use data from the 1983 and the 1986 Survey of Consumer Finances (SCF) to analyze whether these theoretical predictions receive empirical support. Using the SCF has several advantages: in the 1986 interview, households are asked detailed questions about the amount of transfers they had given and received between 1983 and 1986. Moreover, households that were interviewed in 1986 were already interviewed in 1983, which allows me to control for their income and wealth before the transfer has taken place.

In line with the theoretical predictions, I find that households with higher education level transfer more to their children, for a given level of their income and wealth in 1983. For this exercise, I use the fact that in the data, better educated households have higher mean earnings profile and lower uncertainty about their earnings than lower educated households (see, for example, Hubbard et al. (1995)). The SCF provides information about parental support for their offspring's college education as well as information about financial transfers, which are not tied towards college expenditures. Interestingly, I find that the impact of parental education on total transfers is entirely driven by a strong relationship between parental education and parental support for their children's college education.

In order to shed more light on the role the parental future plays for explaining college entry, I additionally use data from the 1979 National Longitudinal Survey of Young Men (NLSY). The NLSY allows me to control for the ability of the children by using the test results from the Armed Forces Qualification Test (AFQT). Clearly, pre-college ability is an important determinant of college enrolment and thus also for parental transfers for their children's college education.

I find that parental education has a significant impact on college enrolment, even after controlling for the AFQT-scores. Previously, this has been interpreted as a sign that AFQT-scores do not completely capture the complexity of pre-college abiliy. Therefore, parental education and other variables that capture the long-term transmission of ability within the family turn out to be significant (see Carneiro and Heckman (2002)). The theoretical results in this paper complement this interpretation by showing that the impact of parental education on college enrolment could at least partly be due to the brighter earnings prospects of better educated parents.

The same picture arises if I control for future income, i.e. income that was received by the

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

parents after the college decision had taken place. My results even suggest that the college enrolment gaps with respect to future income are more pronounced than with respect to current income.

In essence, I find that the observable transfer behavior is in line with the predictions of one-sided altruism, in the sense that there appears to be a strong link between future endowment and current parental transfer decisions. Interpreted in this way, the observable college enrolment gaps with respect to family income suggest that borrowing constraints for college education are quantitatively much more important than previously thought. This result thus contributes to the literature that tries to assess whether borrowing constraints are important for a significant fraction of the population (see Belley and Lochner (2007), Carneiro and Heckman (2002), Carneiro and Heckman (2003) or Ellwood and Kane (2000), among others).

3.2 Transfers in a Framework with One-Sided Altruism

Households in the economy consists of parents and children. In the model, parents live for three periods. I assume that the utility of parents depends only on their offsprings' first period utility. Thus, I do not model the life cycle of children in greater detail. In each period, parents are characterized by their current period income y_t^p and their assets a_t^p, which were accumulated in the previous periods. We can think of the three periods as three different stages of working life: young, middle-aged and pre-retirement. I assume that transfers take place in the second period (middle-aged), which is consistent with empirical evidence. Gale and Scholz (1994) find that the mean age of parents that give inter-vivos transfers is around 50. With an age gap of 30, children are around 20 when their parents turn 50, which is the age when most children leave home and start their economic life, or invest in their college education.

All households receive utility from their current-period consumption, which is denoted as c_t^p. Because parents are altruistic, they also incorporate the utility of their children in their maximization problem. Financial support from parents is denoted by t^p. t^p can take the form of either direct transfers or human capital investment, e.g. investment in college education. Gale and Scholz (1994) show that both kind of transfers are quantitatively very important in the U.S. economy. For simplicity, I assume that parents decide only about the total sum of transferred to their children and that transfers enter the budget constraint of the child household linearly: $c^d = y^d + t^p$. By doing so, I implicitly assume that there are no returns to education and that there are no other inputs to the formation of human capital other than parental transfers. Another important input often mentioned in the human capital literature is (pre-college) ability of the child (see e.g. Becker and Tomes (1979) or Becker and Tomes (1986) for a treatment of human capital theory).

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Abstracting from ability does not harm the main aim of this theoretical section; however, ability will become important in the empirical section.[1]

Parents maximize their total lifetime utility which given by:

$$U = \max \left\{ u(c_1^p) + \beta E[u(c_2^p)] + \beta^2 E[u(c_3^p)] + \lambda u(c^d) \right\} \tag{3.1}$$

such that

$$\begin{aligned} c_1^p + a_1^p &= y_1^p \\ c_2^p + a_2^p + t^p &= Ey_2^p + (1+r)a_1^p \\ c_3^p &= Ey_3^p + (1+r)a_2^p \\ c^d &= y^d + t^p \\ c_t^p, c^d &\geq 0 \end{aligned}$$

I assume that the utility function is the same for parents and their children. It is important to notice that the above problem implies that altruism is one-sided, implying that parents incorporate the utility of their children, but not the other way round. If altruism was two-sided, parents and children would combine their resources and choose their consumption path jointly, such that the utility of the overall family is maximized (see Laitner (1992)). A case in which two-sided altruism could have a significant impact on the amount transferred are human capital investments, like tuition fees for schools or colleges. These investments typically enhance the future earnings prospects of the child, but require financial support from the parents if credit markets to finance human capital investments are absent. With two-sided altruism, parents know that their children will compensate them in the future, in case the parents need it. With one-sided altruism, however, parents have no access to the return generated by their investment. If they face bad earnings prospects, this lowers their willingness to invest in their children's education.

This intuition is formalized in the following two propositions.

Assumption 5 *Assume that $u_c > 0$, $u_{cc} < 0$ and $u_{ccc} > 0$*

[1] Giving more structure to the human capital production function would become important if one wanted to study the relationship between financial transfers and human capital investment. See Brown et al. (2007) for an interesting recent paper in this direction. Brown et al. (2007) distinguish two stages at which transfers are given. First, parents invest in their children's human capital. Later, in a second stage, parents decide on financial transfers. Because the second decision is based on the economic performance of the kid, parents have an incentive to invest more in human capital, on the expense of financial transfers.

 DOI: 10.2870/26812

Assumption 6 *Earnings in period j are given by $y_j = \overline{y_j} + \widetilde{y_j}$ where*

$$\widetilde{y_j} = \begin{cases} -\epsilon \text{with prob. } 0.5 \\ \epsilon \text{with prob. } 0.5 \end{cases} \tag{3.2}$$

with $0 < \epsilon < \overline{y_j}$ and $\sigma_y^2 = \epsilon^2$

Proposition 8 *Let $c_2^{p^*}(a_1^p, y_2^p, y^d, Ey_3^p)$, $a_2^{p^*}(a_1^p, y_2^p, y^d, Ey_3^p)$ and $t^{p^*}(a_1^p, y_2^p, y^d, Ey_3^p)$ be the optimal level of consumption, savings and transfers are the solution to the parental problem 3.1, given a_1^p, y^d, Ey_3^p and y_2^p. Then, if assumption 5 holds, $\frac{dt^{p^*}}{dEy_3^p} > 0$, $\frac{dc_2^{p^*}}{dEy_3^p} > 0$ and $\frac{da_2^{p^*}}{dEy_3^p} < 0$*

Proof. Suppose not and $\frac{dt^{p^*}}{dEy_3^p} < 0$, $\frac{dc_2^{p^*}}{dEy_3^p} < 0$ and $\frac{da_2^{p^*}}{dEy_3^p} > 0$. Now consider $Ey_{3'}^p > Ey_3^p$. Let $c_2^{p^{**}}$, $a_2^{p^{**}}$ and $t^{p^{**}}$ the optimal solutions to problem 3.1, given $Ey_{3'}^p$. Then, $c_2^{p^{**}} < c_2^{p^*}$, $a_2^{p^{**}} > a_2^{p^*}$ and $t^{p^{**}} < t^{p^*}$. Optimality implies that

$$\lambda u'(y^d + t^{p^*}) = (1+r)\beta u'(Ey_3^p + (1+r)a_2^{p^*} = u'(c_2^{p^*})) \tag{3.3}$$

$$\lambda u'(y^d + t^{p^{**}}) = (1+r)\beta u'(Ey_{3'}^p + (1+r)a_2^{p^{**}} = u'(c_2^{p^{**}})) \tag{3.4}$$

Assumption 5 together with $Ey_{3'}^p > Ey_3^p$ and $a_2^{p^{**}} > a_2^{p^*}$ implies that $u'(Ey_{3'}^p + (1+r)a_2^{p^{**}} < u'(Ey_3^p + (1+r)a_2^{p^*}$. However, $c_2^{p^{**}} < c_2^{p^*}$ and $t^{p^{**}} < t^{p^*}$ imply that $u'(c_2^{p^{**}})) > u'(c_2^{p^*}))$ and $u'(y^d + t^{p^{**}}) > u'(y^d + t^{p^*})$, and the condition 3.4 cannot hold. ■

Proposition 9 *An increase in parental earnings uncertainty reduces transfers to their children: $\frac{dt^p}{d\sigma_y^2} < 0$*

Proof. Transfers in period 2 reduce savings and therefore consumption in the following period. Thus,

$$c_3^p = Ey_3^p + (1+r)(y_2^p + -c_2^p - t^p) + (1+r)(a_1^p)) \tag{3.5}$$

Thus, the FOC for t^p is given as follows:

$$(1+r)\beta u'(Ey_3^p + (1+r)(y_2^p + (1+r)(a_1^p - c_2^p - t^p)) = \lambda^p u'(y^d + t^p) \tag{3.6}$$

Total differentiating with respect to ϵ yields

$$\lambda^p u''(y^d + t^p)\frac{dt^p}{d\epsilon} = \frac{1}{2}[u''(\overline{y_3} + \epsilon + (1+r)a_2^p)(-\frac{dt^p}{d\epsilon} + 1) + u''(\overline{y_3} - \epsilon + (1+r)a_2^p)(-\frac{dt^p}{d\epsilon} - 1))] \tag{3.7}$$

and thus

$$\frac{dt^p}{d\epsilon} = \frac{\frac{1}{2}u''(\overline{y_3} + \epsilon + (1+r)a_2^p) - u''(\overline{y_3} - \epsilon + (1+r)a_2^p)}{\lambda^p u''(y^d + t^p) + \frac{1}{2}u''(\overline{y_3} + \epsilon + (1+r)a_2^p) + u''(\overline{y_j} - \epsilon + (1+r)a_2^p)} \tag{3.8}$$

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

The denominator of this expression is unambiguously negative (because of concavity of u, see assumption 5), while the nominator is positive if and only if

$$u''(\overline{y_j} + \epsilon + (1+r)a_2^p) - u''(\overline{y_j} - \epsilon + (1+r)a_2^p) \tag{3.9}$$

is positive. For arbitrary $\epsilon > 0$, this is true if and only if $u_{ccc} > 0$ (prudence), which I assume in Assumption (5). ■

3.3 SCF

I analyze the empirical relevance of propositions 8 and 9 with the help of the 1983 and the 1986 wave of the Survey of Consumer Finances (SCF). The SCF contains interviews from a random sample of 3,824 U.S. households in 1983, along with a supplemental survey of 438 high-income households. In 1986, 2,822 of these households were reinterviewed, including 359 in the high-income sample.

The SCF contains detailed data on wealth, income, demographic variables, and transfers. In 1986, each household head was also asked if he or she contributed 3,000 US-Dollar or more to other households in 1983 − 85. If so, the amount given and the relationship of the recipient household(s) to the respondent were elicited. Similar questions were asked about transfers received from other households. Respondents were also asked separately to report any college expenses they paid on behalf of children.

Gale and Scholz (1994) were among the first to use the SCF for the study of intra-family transfers. Gale and Scholz (1994) also compare estimates of aggregate amount of transfers from the SCF to other sources. They find that SCF estimates of educational expenses are very similar to those reported by other sources. Estimates of financial transfers appear to be somewhat lower, Gale and Scholz (1994) conjecture that this may be due to the censoring of transfers at 3000 US-Dollar.

Gale and Scholz (1994) also provide detailed summary statistics on financial transfers and education expenses reported in the SCF (see their tables 1 − 3, Gale and Scholz (1994) pp. 3 − 8. About 10 percent of all households gave 3000 Dollar or more to other households in 1983 − 1985. The average transfer amount is around 16,000 Dollars. Most transfers reported are gifts from parents to their children (75 percent). Transfers for education are somewhat more widespread: about 12 percent of the households that were interviewed in 1986 supported their children's college education in the last 3 years. The average amount was around 10,000 Dollars. Givers are on average 55 years old (total sample: 48 years) and wealthier than the sample average.

In the following, I restrict my analysis to households who provide a valid wealth observation in both years and whose household head is between 45 and 55 years old at the time of the second interview. I also require that households have at least one child. Since the wealth

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

distribution is very skewed in the U.S. (see Rodriguez et al. (2002) and the savings motives of the very rich are not well understood, I further restrict my analysis to households at the 90th percentile or below in order to eliminate the super-rich.

3.3.1 Findings

Transfers: First, consider the total amount of inter-vivos transfers, which is given by the sum of college expenses and all other financial transfers, not tied to college education. The first column of table 3.1 reports the results of a Tobit model. The amount of total transfers is treated as a left-censored variables with censoring-limit of zero. In line with the predictions of the theoretical part, I find that transfers are increasing in the current level of income. If we take parental education as a proxy for the earnings prospects, there is evidence that good earnings prospects have a positive impact on transfers, all other things equal, as parents with higher education level are willing to give more to their kids, given their income and their level of wealth.

It is also interesting to analyze the two different components, namely college support and financial transfers, separately. The second column of table 3.1 reports the results for parental support for college education. Strikingly, the results are almost identical to those of the first column, where I analyzed college support and financial transfers together. Consequently, when I use only financial transfers as a dependent variable instead, I find that all estimated coefficients are insignificant (third column of table 3.1).

This suggests that current and future parental income affect the amount of total transfers given to the child mainly through educational expenditures. This suggests that educational expenses by parents on behalf of their children can be very well explained by one-sided altruism. I see this result as an important contribution to the literature that studies the determinants of parental transfers (see Laitner (1997) for a comprehensive overview over this strand of the literature, more recently, Brown et al. (2007) for a model that incorporates both education and cash transfers.)[2]

Given that there appears to be a tight link between parental future income and their willingness to provide college expenses, I will now shed further light on this issue. More specifically, human capital theory predicts that parental investments in their children's education are also governed by their children's ability, as children with higher ability presumably have a higher expected return to education. College educated parents, in turn, can be expected have children with higher ability. If this is the case, this could explain why they also invest more in the college education of their offspring, compared to lower educated parents.

[2]With respect to financial inter-vivos transfers, McGarry (1997) finds that the existence of estate tax accounts for 30 percent of the total amount of inter-vivos transfers. That is, parents use inter-vivos transfers in order to avoid estate taxes. In turn, this suggests that bequests and inter-vivos transfers should be studied in the same framework. By definition, expectations about the parental future, which are studied in this paper, cannot say anything about end-of-life bequests.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

In this case, it would be the ability of the children and not the better earnings prospects of their parents that could explain why college educated parents transfer more to their children.

In order to evaluate the relative importance of ability and of parental earnings prospects, I control for the intra-family transmission of ability. I do so by restricting my analysis to families that have at least one child in college. I argue that this controls for the intra-family transmission of ability: if one child has the ability to go to college, this should be true for its siblings as well.[3] I then analyze to what extend the total number of children is related to expectations about future income. If the total number of children in college is independent of the parental education level, I argue that expectations about future income do not matter for determining the parental willingness to provide transfers, all other things equal. If not, I interpret this as evidence for the fact that differences in the expectations about future earnings matter. This is indeed the case, as table 3.2 shows. Here, I regress the number of children that attend college between 1983 and 1986 on income, wealth and parental education dummies and the total number of children. I find that college graduates that have at least one child in college send significantly more additional children to college than high school graduates or high school dropouts. Since all families in the sample have at least one child in college, I argue that the intra-family transmission of ability is not important for explaining why college graduates spend more for their children's education. Instead, I take this result as evidence that the better earnings prospects of college graduated parents allow them to invest more in their children.

In the next section, I shed more light on the relationship by studying the NLSY which allows me to measure the ability of children in a more direct way.

3.4 Expectations about Future Income and Enrolment Gaps

In the U.S., college education can be very costly, and a substantial part of the total college expenses are paid by transfers coming from parents (Gale and Scholz (1994), Keane and Wolpin (2001) and the references cited therein). Propositions 8 and 9 thus imply that parents who expect less income in their future and who face a higher degree of uncertainty are more reluctant to invest in their children's human capital. In this section, I use the 1979 National Survey of Young Men (NLSY79) to shed more light on the relationship between college enrolment and future parental income.

I find that there is indeed a positive relationship between college attendance and income outlook: children of parents who expect more income in the future with less uncertainty are more likely to attend college. This holds even after controlling for various other factors, such as parental education, family background and distance from college. These factors are sometimes also called 'long-term' factors, while current income is viewed as a 'short-term

[3] This assumes that the intra-family transmission of pre-college ability is the same for all children, i.e. parents do not discriminate when investing in pre-college education.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

factor' (Carneiro and Heckman (2002)). The reason is that current parental income can influence their ability to pay for their children's education only in the current period, while the long-term factors are supposed to capture all other factors that may generate a link between family background and educational attainment.

I argue that many of these family background variables are also good predictors for future income of parents. Therefore, the impact of family background variables may not only reflect the influence of past events on college attainment of the offspring (e.g. parents with higher education level investing more in their children's early education, which also makes college going more likely) but also their expectations about the future (e.g. parents with higher education level investing more in their offspring's higher education because they expect more income in the future).

I view this as an important contribution to the debate about the extend to which financial constraints for college education are binding (see, for example, Carneiro and Heckman (2002), Carneiro and Heckman (2003) or Ellwood and Kane (2000)).

3.4.1 Data

The data are from the 1979 cohort of the NLSY. The NLSY consists of 12,686 individuals, approximately half of them male, who were between 14 and 21 age years old as of January 1, 1979. The sample contains a core random sample and oversamples of blacks, Hispanics and "disadvantaged" whites, and members of the military. Interviews were first conducted in 1979 and have been conducted annually since then. This analysis is based on the white males in the core sample who have a valid observation for the Armed Forces Qualification Test (AFQT) in 1980 and a valid family income observation in 1979 or at age 17 (at the latest in 1982). This leaves 2,654 individuals for the analysis. The fact that the NLSY79 contains detailed information about the pre-academic ability of the respondents makes it a very valuable survey for my purposes.

For each survey year, the NLSY79 provides a created variable entitled "Total Net Family Income", which will be used as an income measure in this study. This variable is designed to provide researchers with a summary variable of all the income received in the household. The creation of the income variable differs among the years: in the survey years from 1979 to 1986, which were the early years when many of the NLSY79 respondents were younger and living in the parental household, the interviews obtained income from all household members related by blood or marriage. From 1987 onwards, only income from the respondents (and not from their parents) was used to calculate the total net family income. Since I am only interested in the relationship between parental income and college enrolment of their kids, I disregard any data that is taken after 1986.

Schooling data is collected in the NLSY79 in event history form. It includes highest grade attended and completed at each interview date, as well as dates and titles of degrees obtained.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

I measure college enrolment at age 21.

3.4.2 Results

College enrolment gaps with respect to current family income

I start with analyzing the link between current family income and college enrolment. With the term current family income, I label the parental income that is measured in 1979 (or at the age of 17), that is, approximately at the time when the college decision is taken.

Whether there is a link between college enrolment and current income has been the subject of a heated debate in the literature (see Belley and Lochner (2007), Carneiro and Heckman (2002), Carneiro and Heckman (2003) or Ellwood and Kane (2000), among others). The main concern of this strand of the literature is to what extend college students are financially constrained in their college decision. If number of college students with affluent parents is significantly higher, this is generally seen as a sign for the existence of some market imperfectness that prevents students from poorer families to enrol in college.

Following the previous literature, I analyze to what extend there are differences in the college enrolment rates between the different family income quartiles. Carneiro and Heckman (2002) argue that students whose parents' have income in the highest income quartile are unlikely to be affected by financial frictions. Significant gaps in the enrolment rates between students whose parents belong to different family income groups would be interpreted as a sign for the importance of financial frictions.

Moreover, I compute enrolment gaps separately for different levels of pre-college ability. This is necessary because families with higher income are more likely to have children with higher pre-college ability, e.g. because of higher preferences for education, genetic transmission or because they have more resources available for investment in early education. Human capital theory predicts that children with higher ability have higher expected return from college education, and are therefore more likely to enrol in college. I use the result of the Armed Forces Qualification Test (AFQT) as a proxy for pre-college ability and compute the enrolment gaps separately for different AFQT-terciles. The AFQT-results are a widely used proxy for pre-college abiliy in the literature. See Carneiro and Heckman (2002) and Belley and Lochner (2007) for a discussion of the AFQT and for further references.

Even after controlling for pre-college ability, I observe that enrolment gaps with respect to family income are substantial. This holds for all levels of pre-college abiliy, as well as for students of 4-year colleges and 2-year colleges together (tables 3.3 and 3.4). This suggests that family income plays an important role in determining college entry, which is frequently interpreted as evidence for the fact that borrowing constraints must be binding for a substantial part of the population (Ellwood and Kane (2000)).

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

The role of long-run factors

Carneiro and Heckman (2002) and Carneiro and Heckman (2003) argue that conditioning on some measure of pre-college ability (such as AFQT) is not enough. They instead propose to control for a host of other factors, such as parental education, family situation during childhood, rural versus urban environment etc. in order to better account for pre-college ability, which they call long-run factors as opposed to the current income, which they label as a short-run factor.

Carneiro and Heckman (2002) and Carneiro and Heckman (2003) argue that these variables are determinants of academic preparedness of a student. Their impact might have occurred a long time ago in the past (therefore their name long-term factors). Hence, Because the current observation of family income is likely to be correlated with some of these long-term factors as well, one would expect to find a weaker link between family income and college enrolment.

This is indeed the case. Comparing tables 3.3 and 3.4 and 3.5 and 3.6 reveals that enrolment gaps are much smaller, after these long-term factors are incorporated.

Carneiro and Heckman (2002) and Carneiro and Heckman (2003) interpret this finding as a sign that the long-term background has more weight in determining college entry, not the current income situation at the time college entry takes place. They conclude that this result suggests that borrowing constraints, which only affect the current budget available for college investment, cannot be quantitatively important for a large share of the population.

With respect to strong impact parental education has on determining college entry, propositions 8 and 9 offer a different interpretation: they suggest that better educated parents expect more resources with a lower degree of uncertainty, and are thus more willing to support their children's college education.

In the next section, I provide more evidence for the importance of future resources in determing college entry.

Future income and enrolment gaps

I now turn to the importance of future income. Propositions 8 and 9 suggest that not only current income, but also expectations about future resources should have an impact on enrolment gaps, if children depend on parental support in order to finance their college education.

This is indeed the case. 3.7 and 3.8 show that college enrolment gaps with respect to family income in 1986, the last year for which I have information about parental income, are substantial. This is true for both students of all colleges and for students of 4-year colleges only. Strikingly, once I incorporate future income into my regressions, the remaining enrolment gaps with respect to current income vanish. This suggests that future income plays an important role in determining college enrolment. In light of proposition 8, this hints to the fact that parental support for college education matters, and that students whose parents

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

have better income prospects receive better funding from their parents.

So far, I have implicitly assumed that parents have full information about their future earnings. In reality, however, there may be some uncertainty about the future level of earnings. Given their current characteristics, parents may form expectations about their income in the future. Some characteristics may be more valuable for forecasting income than others. This is suggested by the t-values that are displayed for the parental characteristics in table 3.9. For example, college education of the father shows an outstanding strong impact on future income. Hence, college educated fathers should face the lowest degree of uncertainty about their future income prospects. According to proposition 9, college educated fathers should thus be more prone to provide transfers to their children.

This is indeed the case. Despite the fact that income in 1986 is highly positively correlated with the education level of the father, introducing future income increases the measured impact of father's education on college enrolment (compare tables 3.7 and 3.8 to tables 3.5 and 3.6). I interpret this as evidence for the empirical relevance of proposition 9.[4]

In summary, these findings suggest that there is a strong link between expected parental resources and college enrolment of their children. This is in line with the predictions of the theoretical model. In the model, the positive link between the future earnings and college going arises because of one-sided altruism and borrowing constraints.[5]

In a companion paper, I develop a more structural framework which is based on the assumption of one-sided altruistic parents and on imperfect capital markets. I use this model as a measurement tool in order to evaluate to what extend borrowing constraints for college enrolment are binding in the U.S. economy.

3.5 Conclusion

In this paper, I present a model of parental transfers that is based on the assumption of one-sided altruism. I use this model to analytically study the link between parental expectations about their future resources and their present transfer behavior. In the context of my model, I show that parents with a brighter earnings prospects are willing to transfer more to their offspring already today, all other things equal.

I use data from the 1983 and the 1986 Survey of Consumer Finances (SCF) to analyze whether these theoretical predictions receive empirical support. In line with the theoretical

[4] Notice that the impact of mother's education becomes weaker after future earnings are introduced, despite the fact that mother's education is only a bad predictor for future income (see table 3.9) and that there is a strong influence of mother's education on children's cognitive achievement (see, for example, Carneiro et al. (2007)). I interpret this as additional evidence for the fact that the strong impact of father's education is mainly because it signals lower uncertainty

[5] The model only analyzes the determinants of parental transfers in a general context and thus does not mention borrowing constraints for college education explicitly. However, in order to get a link between parental transfers and college enrolment, it is sufficient to assume that students cannot get funding from other sources than their parents.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

predictions, I find that households whose head has a higher education level transfer more to their children, for a given level of their income and wealth. If better educated individuals have higher mean earnings profile and lower uncertainty about their earnings as suggested by the empirical literature, this suggests that households with better earnings prospects do indeed transfer more to their kids.

The chapter also makes an important contribution to the question whether borrowing constraints for education are quantitatively important in determining access to college. Using data from the 1979 National Longitudinal Survey of Young Men (NLSY), I find that parental education has a significant impact on college enrolment, even after controlling for measures of pre-college ability such as AFQT-scores. According to my theoretical results, this suggests that parental resources have strong impact on their children's college decision, even if college enrolment gaps with respect to current income are small. Thus, the true fraction of the population that is adversely affected in their college decision by market imperfections may be much higher than the small impact of current income suggests.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

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Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

3.6 Appendix: Figures and Tables

Table 3.1: Tobit Regression, Various Forms of Parental Support, 1983 and 1986 Survey of Consumer Finances

	(1) Total Transfers	(2) College Ex.	(3) Fin. Transfers
Income (1983)	0.0634	0.0499	0.0520
	(1.87)	(1.75)	(1.82)
Wealth (1983)	0.00111	0.000755	0.000616
	(0.90)	(0.82)	(0.58)
high school	10001.1	10574.6	4792.0
	(2.56)	(2.40)	(1.05)
college	20470.8	21695.2	6461.1
	(4.30)	(4.16)	(1.19)
number of child.	389.2	318.7	617.9
	(0.77)	(0.59)	(0.77)
Constant	-19720.7	-21602.6	-35836.9
	(-4.09)	(-3.97)	(-4.42)
Observations	453	453	453

t statistics in parentheses. All regressions use information of households with at least one child, with household head that is between 45 and 55 years old, and with savings in the lower 90th-percentile of the distribution.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 3.2: Regression: Future Income and College Investment, SCF

	Number of Children in College
Number of child.	0.121
	(4.53)
Income (1983)	0.000000637
	(2.13)
Wealth (1983)	-1.07e-08
	(-1.32)
High School	0.245
	(0.96)
College	0.461
	(1.78)
Constant	1.449
	(5.04)
Observations	136

t statistics in parentheses. All regressions use information of households with at least one child, and of which the household head is between 45 and 55 years old.

Table 3.3: College Enrolment Gaps, 4-Year College, 1979 NLSY

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3
Income quartile 1 - 4	-0.00726	-0.133	-0.297
	(-0.42)	(-3.64)	(-5.35)
Income quartile 2 - 4	0.00758	-0.0887	-0.208
	(0.42)	(-2.64)	(-4.71)
Income quartile 3 - 4	0.00243	-0.119	-0.156
	(0.12)	(-3.43)	(-3.80)
Constant	0.0227	0.241	0.644
	(1.44)	(9.79)	(24.04)
Observations	899	864	876

t statistics in parentheses. 'Income quartile 1 - 4' measures the difference in the college enrolment rate between children whose parental income is the first income quartile with respect to children whose parents' have income in the highest income quartile.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 3.4: Regression College Enrolment Rates

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3
Income quartile 1 - 4	-0.0259	-0.247	-0.235
	(-1.00)	(-5.86)	(-4.34)
Income quartile 2 - 4	0.0189	-0.186	-0.192
	(0.70)	(-4.81)	(-4.44)
Income quartile 3 - 4	-0.000214	-0.208	-0.146
	(-0.01)	(-5.23)	(-3.64)
Constant	0.0568	0.394	0.731
	(2.42)	(13.93)	(27.94)
Observations	899	864	876

t statistics in parentheses. 'Income quartile 1 - 4' measures the difference in the college enrolment rate between children whose parental income is the first income quartile with respect to children whose parents' are in the highest income quartile.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 3.5: College Enrolment Gaps for Different AFQT-Scores, 1979 NLSY, 4-year college

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3
Income quartile 1 - 4	0.00827	-0.0799	-0.126
	(0.37)	(-1.82)	(-2.02)
Income quartile 2 - 4	0.0254	-0.0239	-0.104
	(1.13)	(-0.64)	(-2.17)
Income quartile 3 - 4	0.00196	-0.0863	-0.0689
	(0.09)	(-2.38)	(-1.62)
Highest grade comp., father	-0.00158	0.00222	0.0190
	(-0.67)	(0.36)	(2.02)
Highest grade comp., mother	0.00241	0.000877	0.00473
	(0.98)	(0.12)	(0.44)
College, father	0.0868	0.120	0.0629
	(2.28)	(2.27)	(1.02)
College, mother	-0.0659	0.171	0.133
	(-1.40)	(2.60)	(2.08)
Grew up in south	-0.0206	-0.0266	0.0887
	(-1.31)	(-0.74)	(1.71)
Intact family	0.0265	0.0355	0.0499
	(1.91)	(1.01)	(1.06)
Number of siblings (1979)	-0.00491	-0.00482	-0.0319
	(-1.85)	(-0.75)	(-3.53)
Constant	0.00857	0.131	0.272
	(0.22)	(1.30)	(1.72)
Observations	703	754	819

t statistics in parentheses. 'Income quartile 1 - 4' measures the difference in the college enrolment rate between children whose parental income is the first income quartile with respect to children whose parents' are in the highest income quartile.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 3.6: College Enrolment Gaps for Different AFQT-Scores, 1979 NLSY, 2- and 4-year colleges

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3
Income quartile 4 - 1	-0.0158	-0.228	-0.0942
	(-0.46)	(-4.54)	(-1.55)
Income quartile 4 - 2	0.0318	-0.137	-0.0978
	(0.94)	(-3.19)	(-2.10)
Income quartile 4 - 3	-0.00552	-0.182	-0.0693
	(-0.16)	(-4.40)	(-1.68)
highest grade comp., father	-0.000360	-0.00100	0.0196
	(-0.10)	(-0.14)	(2.16)
highest grade comp., mother	-0.00262	-0.00868	0.00521
	(-0.70)	(-1.03)	(0.50)
college, father	0.0999	0.203	0.0651
	(1.73)	(3.35)	(1.09)
college, mother	-0.0846	0.248	0.0626
	(-1.19)	(3.31)	(1.01)
Grew up in south	-0.0174	-0.0431	0.128
	(-0.73)	(-1.04)	(2.55)
intact family	0.0298	-0.0000900	0.0183
	(1.42)	(-0.00)	(0.40)
number of siblings(1979)	-0.00811	-0.00916	-0.0324
	(-2.02)	(-1.25)	(-3.69)
Constant	0.101	0.474	0.393
	(1.67)	(4.12)	(2.57)
Observations	703	754	819

t statistics in parentheses. 'Income quartile 1 - 4' measures the difference in the college enrolment rate between children whose parental income is the first income quartile with respect to children whose parents' are in the highest income quartile.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 3.7: College Enrolment Gaps for Different AFQT-Scores, 1979 NLSY, 4-year college

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3
Income quartile 4 - 1	0.0340	-0.0503	-0.123
	(1.12)	(-1.00)	(-1.82)
Income quartile 4 - 2	0.0516	0.0209	-0.0630
	(1.76)	(0.49)	(-1.20)
Income quartile 4 - 3	0.0228	-0.0756	-0.0627
	(0.77)	(-1.87)	(-1.36)
Income (1986) quartile 4 - 1	0.000337	-0.0867	0.0183
	(0.01)	(-1.95)	(0.36)
Income (1986) quartile 4 - 2	-0.0120	-0.121	-0.114
	(-0.47)	(-2.99)	(-2.23)
Income (1986) quartile 4 - 3	0.0150	-0.0789	-0.0732
	(0.59)	(-1.98)	(-1.57)
Highest grade compl., father	-0.00273	0.00539	0.0253
	(-0.90)	(0.76)	(2.43)
Highest grade compl., mother	0.00376	0.00453	0.00860
	(1.15)	(0.54)	(0.74)
College, father	0.131	0.0743	0.0134
	(2.63)	(1.27)	(0.20)
College, mother	-0.0844	0.151	0.100
	(-1.45)	(2.10)	(1.44)
Constant	-0.0102	0.129	0.202
	(-0.19)	(1.10)	(1.14)
Observations	525	614	695

t statistics in parentheses. I also control for south, intact family and number of siblings. 'Income quartile 1 - 4' measures the difference in the college enrolment rate between children whose parental income is the first income quartile with respect to children whose parents' are in the highest income quartile.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 3.8: College Enrolment Gaps for Different AFQT-Scores, 1979 NLSY, 2- and 4-year colleges

	AFQT Tercile 1	AFQT Tercile 2	AFQT Tercile 3
Income quartile 4 - 1	0.0117	-0.196	-0.0790
	(0.26)	(-3.43)	(-1.21)
Income quartile 4 - 2	0.0519	-0.0743	-0.0724
	(1.20)	(-1.54)	(-1.43)
Income quartile 4 - 3	0.00191	-0.160	-0.0740
	(0.04)	(-3.49)	(-1.67)
Income (1986) quartile 4 - 1	-0.0456	-0.139	0.0284
	(-1.24)	(-2.75)	(0.58)
Income (1986) quartile 4 - 2	-0.0552	-0.112	-0.0739
	(-1.47)	(-2.44)	(-1.50)
Income (1986) quartile 4 - 3	0.000224	-0.0993	-0.0733
	(0.01)	(-2.20)	(-1.63)
Highest grade compl., father	-0.00174	0.000938	0.0238
	(-0.39)	(0.12)	(2.37)
Highest grade compl., mother	-0.00356	-0.0103	0.00515
	(-0.74)	(-1.07)	(0.46)
College, father	0.0930	0.180	0.0382
	(1.28)	(2.73)	(0.59)
College, mother	-0.0640	0.276	0.0516
	(-0.75)	(3.39)	(0.77)
Constant	0.139	0.555	0.376
	(1.79)	(4.19)	(2.20)
Observations	525	614	695

t statistics in parentheses. I also control for south, intact family and number of siblings. 'Income quartile 1 - 4' measures the difference in the college enrolment rate between children whose parental income is the first income quartile with respect to children whose parents' are in the highest income quartile.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
European University Institute DOI: 10.2870/26812

Table 3.9: Family Income in 1986 and its Determinants,

	(1) Family Income 1986
college father	1391.3
	(1.83)
Income	0.348
	(18.81)
Father hs. dropout	-2674.4
	(-5.12)
Mother hs. dropout	-2172.5
	(-4.28)
Constant	14781.4
	(26.90)
Observations	7563

t statistics in parentheses. Only significant regressors are reported.

Winter, Christoph (2009), Altruism, Education and Inequality in the United States
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