A Dynamic Model of Health, Education and Wealth with Credit Constraints and Rational Addiction*

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Abstract

Positive correlations between health, education, and wealth are well documented in the literature. However, estimating causal effects of these three factors is difficult, due to existence of reverse causality and selection: What are the economic mechanisms through which health, education and wealth impact each other over lifecycle? How much of observed positive correlations among these three factors is due to selection? To address these questions, this paper develops and structurally estimates a dynamic lifecycle model of health, education and wealth that allows for credit constraints and rational addictive unhealthy behavior. Utilizing data from the National Longitudinal Survey of Youth 1997 (NLSY97), we estimate our model via a two-step estimation procedure that combines factor analysis and simulated method of moments. We quantify causal effects of education and wealth on health and unhealthy behavior over lifecycle, as well as the reverse causality of health on education and wealth. Using counterfactual simulations, we evaluate the effects of borrowing constraints and rational addiction, on health, education, wealth, and labor market outcomes; and also assess the economic importance of selection.

JEL Classification: I1, I2, J2

Keywords: Health, Education, Wealth, Human Capital, Rational Addiction

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1 Introduction

A large literature documents a positive correlation between health, education and other socioeconomic statuses such as wealth. It is often extremely difficulty to estimate the causal effect of education, health and wealth. The main difficulty arises from the inability to control for unobservables that individuals act upon to make joint decisions on health, education and wealth accumulation. Although many studies have tried various methods to evaluate the effect of education and wealth on health, their findings are in general inconclusive.

Two sets of questions remain unanswered in this literature: First, what are the determinants of health, education and wealth, and is there a causal effect of education and wealth on health while holding other determinants constant? Second, how much of the correlation between health, education and wealth is due to selection, and what are the sources of selection?

We address these two sets of questions within a framework of lifecycle human capital accumulation. The demand for health is modeled from the following four channels. First, as a form of human capital, it affects an individual's productivity in both the market sector and home sector. Second, it directly enters the utility function as a consumption good. Third, it impacts marginal utility of consumption, leisure and schooling. Last, current health also affects an individual's choice of other health inputs such as healthy behavior because health is self-productive.

Individuals are risk-averse and forward-looking. At the beginning of the model period, each individual is endowed with an initial level of health capital, cognitive ability and noncognitive ability. These endowment vectors are not observable to econometricians but are known to the agents. Health stock evolves stochastically with age and current health status, and can be increased (stochastically) by health investment. The direct inputs of health investment include healthy behavior, consumption and leisure.[1] The latter two inputs establish the link between an individual's level of health and the available financial resources that the individual possesses. Most importantly, the production function of health also depends on the level of education and cognitive and noncognitive abilities of the agent.[2]

[1]We do not explicitly model medical care, mainly because that we do not observe medical care expenditure in our data.

[2]Grossman (1972) also allows the level of education to affect the efficiency of the health production process.

Using the structurally estimated model, we evaluate the quantitative contribution of the determinants of education and health inequality. We investigate the channels through which education (and wealth) can impact health, and quantify the importance of each channel.

1.1 Literature Review and Relative Contributions

The viewpoint that health is a form of human capital can be dated back to 1960s (Mushkin (1962), Becker (1964) and Fuchs (1966)). Grossman (1972) models health as a durable capital stock that produces an output of healthy time, and shows that the shadow price of health falls with education if more educated people are more efficient producers of health.

A growing literature establishes a strong empirical relationship between education, health, and health-related behaviors(Conti, Heckman, and Urzua (2010a) and Cutler and Lleras-Muney (2006)). Extending a Roy Model by allowing sequential education choices, Heckman, Humphries, Urzua, and Veramendi (2010) show that education at most levels causally produces gains on health, and that early cognitive and socio-emotional abilities have important effects on schooling choices and adult health. Besides education, there is also large empirical evidence documenting the positive correlation between health and other socioeconomic statuses such as income, wealth and family background (see Deaton (2003) and Currie (2009) for a literature review). Case, Lubotsky, and Paxson (2002) show that not only is children's health positively related to household income, but the relationship between household income and children's health becomes more pronounced as children age due to accumulation of adverse health effects such as chronic conditions. Conti, Heckman, and Urzua (2010b) show that family background characteristics, and cognitive, noncognitive, and health endowments developed by age ten, are important determinants of labor market and health disparities at age 30. Carman (2013) studies the mechanisms behind a positive correlation between inheritances and health, and find that among men and those expecting to receive an inheritance, there is a causal relationship likely driven by the fact that bequests signal a stronger interest in one's child. Health risk, life expectancy and medical expenses are important factors in understanding the elderly's savings behavior (see De Nardi, French and Jones (2009, 2010)). Build upon previous studies, our paper explicitly considers the joint determination of education, income, wealth and health and investigates the dual pathways through which socioeconomic status (such as one's own education and wealth) and health affect each other.

Our paper also contributes to the literature on rational addiction. A large literature has dedicated itself to empirically test the model of rational addiction proposed in the seminal work of Becker and Murphy (1988). Consistent with the rational addiction model, Becker, Grossman, and Murphy (1991), and Becker, Grossman, and Murphy (1994) find that cross price effects for cigarette consumption are negative and that long-run responses exceed short-run responses. Chaloupka (1991) and Gruber and Köszegi (2001) provide evidence that cigarette smoking is an addictive behavior and smokers are forward-looking in their smoking decisions. Adda and Cornaglia (2006) apply the rational addiction model to study smoking intensity and show smokers compensate for tax hikes by extracting more nicotine per cigarette. Grossman, Chaloupka, and Sirtalan (1998) show that alcohol consumption is addictive and there is a positive and significant future consumption effect. Research also shows that the rational addiction model can be applied to empirically investigate individuals' demand for caffeine consumption (Olekalns and Bardsley (1996)) and cocaine consumption (Grossman and Chaloupka (1998)). Sundmacher (2012) finds that health shocks had a significant positive impact on the probability that smokers quit during the same year in which they experienced the health shock, providing evidence that smokers are aware of the risks associated with tobacco consumption, and are willing to quit for health-related reasons.

Our approach recognizes that individuals are forward-looking and make rational decisions on unhealthy behavior (e.g., smoking and drinking) by structurally estimating a dynamic lifecycle model. Furthermore, it explicitly allows the person's previously accumulated years of schooling, years of unhealthy behavior, years of working experience, wealth, current health, cognitive and noncognitive endowment, and family background to affect an individual's decisions on current unhealthy behavior and thus affect one's future health. Last, it recognizes that a person's current decisions on schooling and working may interact with his decisions on unhealthy behaviors.

Finally, our paper contributes to the literature on human capital investment and credit constraints (see Heckman and Mosso (2014) for an overview). The evidence on the existence of credit constraints and their effect on schooling decisions is mixed. Using NLSY79 data, Keane and Wolpin (2001), Carneiro and Heckman (2002), Cameron and Taber (2004) find little evidence of the importance of credit constraints on college education.[3] By linking the information between children and parents (CNLSY79 and NSLY79), Caucutt and Lochner (2012) find strong evidence of credit constraints among young and high skilled parents. More recent studies suggest that borrowing constraints may play a bigger role in individuals' college enrollment in NLSY97 cohorts (see Belley and Lochner (2007), Bailey and Dynarski (2011), and Lochner and Monge-Naranjo (2012)).[4] Methodologically our work is closer to that of Keane and Wolpin (2001) and Caucutt and Lochner (2012). We structurally estimate the lower bound on accessible asset levels within a dynamic lifecycle model that explicitly allows schooling and education decisions, and therefore provide a direct test on the sources and effects of credit constraints. Moreover, our study differs from previous studies in the following two aspects. First, our research question is more broadly defined. We not only study the effect of credit constraint and family background on education, but also on health and health related behaviors that are rational addictive. Our study also recognizes measurement errors of abilities. Second, we focused on the later cohort (NLSY97) compared to earlier studies such as Keane and Wolpin (2001) and Caucutt and Lochner (2012). We also directly utilized information on parents' wealth and transfers provided by NLSY97, which does not exist in NLSY79.

2 Data and Regression Analysis

We use data from National Longitudinal Survey of Youth 1997 (NLSY97). We restrict our sample to white males, so the estimation results on inequality is isolated from discrimination by race or gender. Our final sample contains 2,103 individuals, with 27,213 individual-year observations.

Table 1 provides some selected summary statistics of our sample. For detailed information on variable description and sample selection, please refer to Appendix A.

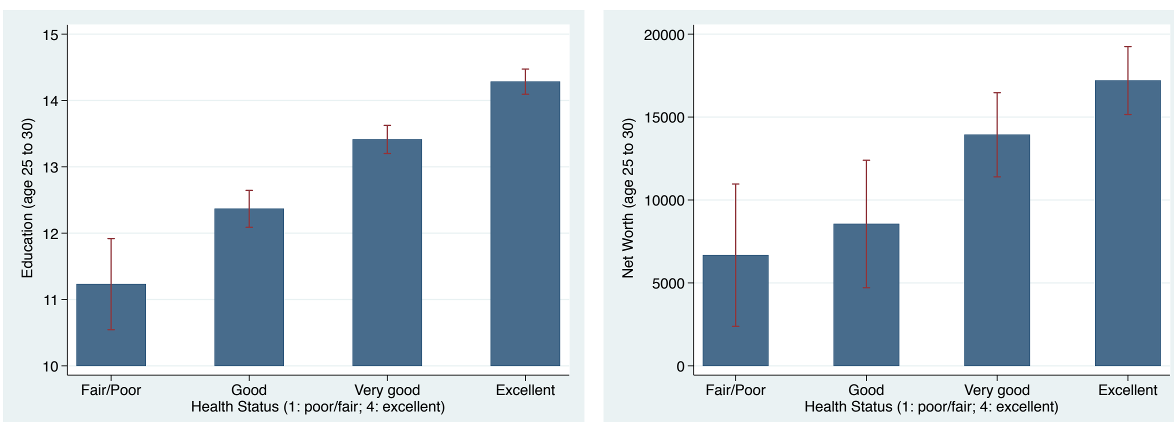
Figure 1 provides suggestive evidence that initial health can potentially impact the youth's adult outcomes. Specifically, Figure 1(a) shows that on average the highest grade completed of

[3] Keane and Wolpin (2001) find the presence of credit constraints, which are shown to be irrelevant for schooling decisions.

[4] The presence of credit constraints in these studies is captured by the estimated effects of quantities of family income on college attendance.

young men aged 25 to 30 is higher among those with better self-reported health status at age 17. Similarly, Figure 1(b) shows that the average net wealth of young men aged 25 to 30 increases with their initial health status at age 17.

Figure 2 suggests the potential role of parental wealth on the youth's adult education and health. The proportion of young men who report very good or excellent health status at age 25 to 30 is lower for those whose parents' net worth is below median (Figure 2(a)); The years of schooling is lower for those whose parents' net worth is below median (Figure 2(b)). Figure 3 documents a positive impact of parental education on young men's education and health. Figure 3(a) shows that the average highest grade completed by young men aged 25 to 30 increases with their parents' education level. Similarly, as seen in Figure 3(b), the proportion of young men who report very good or excellent health status increases with the education level of their parents.



(a) Education & Initial Health (b) Net Worth & Initial Health

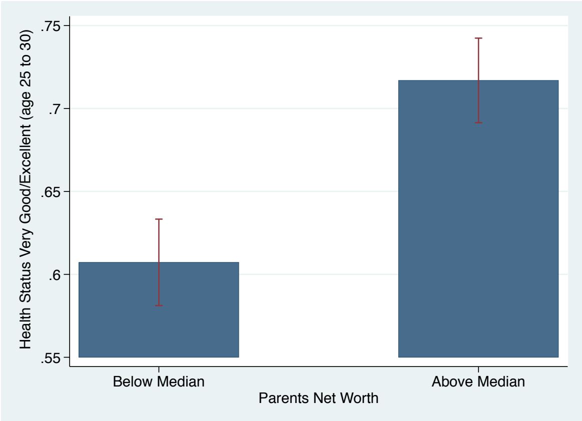
Figure 1: Correlation between Adult Outcomes and Initial Health

Data source: NLSY97 white males aged 17 to 31.

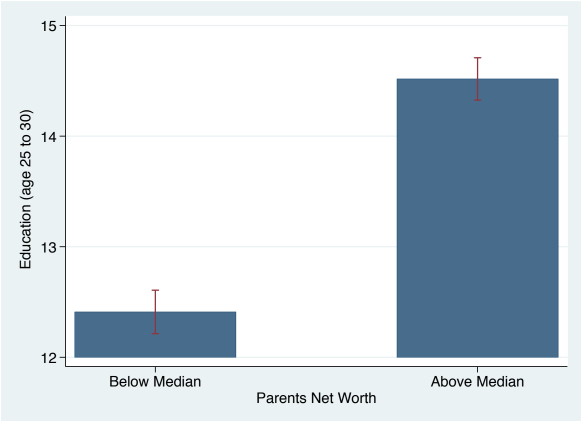
2.1 Regression Results

2.1.1 Adult Outcomes and Initial Conditions

Table 2 reports the OLS regression results of adult outcomes at age 25 to 30 as a function of individuals' initial conditions. As we can see, measured initial health level have a positive and



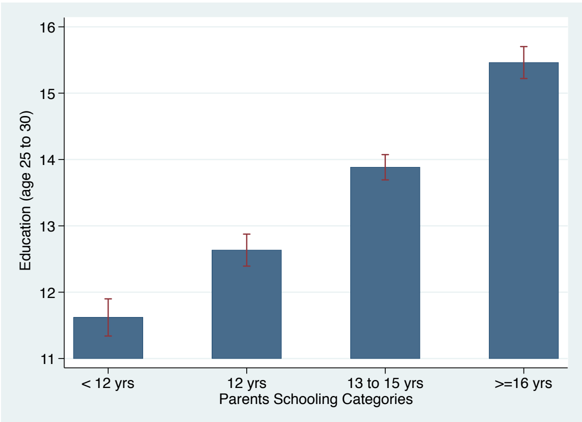
(a) Health & Parental Wealth



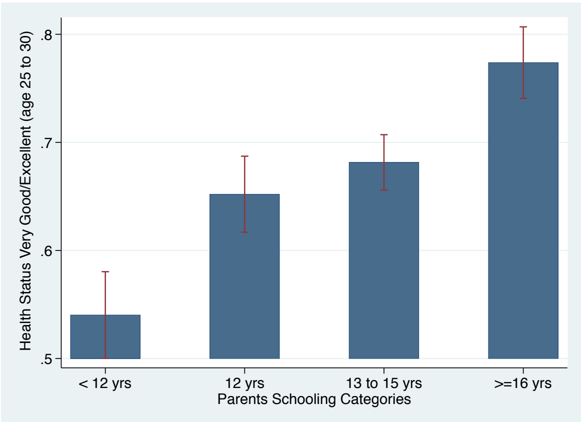
(b) Education & Parental Wealth

Figure 2: Correlation with between Adult Outcomes and Parental Wealth

Data source: NLSY97 white males aged 17 to 31.



(a) Highest Grade Completed and Parental Education



(b) Health Status and Parental Education

Figure 3: Correlation with between Adult Outcomes and Parental Education

significant coefficient on individuals' health, education and net worth at age 25 to 30. Both measured cognitive and noncognitive abilities are positively correlated with adult health and education. Parental education and wealth have a significant and positive correlation on individuals' health and education.

2.1.2 Health Production Function

We consider a Cobb-Douglas health production function:

$$\begin{aligned}\log h_{t+1} = &\beta_{h,h} \log h_t + \beta_{h,q} q_t + \beta_{h,1} d_{q,t} + \beta_{h,2} d_{e,t} + \beta_{h,3} d_{k,t} + \beta_{h,t} t \\ &+ \sum_{j=c,n} \alpha_{h,j} \theta_j + \beta_{h,e} e_t + \beta_{h,ee} \mathbf{1}(e_t \geq 16) + \beta_{h,0} + \epsilon_t^h, \end{aligned} \tag{1}$$

where h_t is age-t health, q_t is the accumulated years of unhealthy behavior, $d_{q,t}, d_{e,t}$ are indicator variables of unhealthy behavior and schooling respectively, $d_{k,t}$ describes the working decisions, θ_c and θ_n are cognitive and noncognitive abilities respectively, and e_t is the years of schooling. Furthermore, we assume $\epsilon_t^h \sim N(0, \sigma_{h,t}^2)$ and allow $\sigma_{h,t}$ to be a function of individuals' states, specifically:

$$\log \sigma_{h,t} = \beta_{\sigma,h} h_t + \beta_{\sigma,q} q_t + \beta_{\sigma,e} e_t + \alpha_{\sigma,c} \theta_c + \alpha_{\sigma,n} \theta_n + \beta_{\sigma,0}. \tag{2}$$

Tables 3 and 4 report the regression results using health measures of self-reported health status and body mass index (BMI) respectively.

2.1.3 Unhealthy Behavior

Table 5 reports the regression results of unhealthy behavior. This regression model is a myopic regression model, which does not consider the impact of future into the regressors. As we can see, the measured cognitive and noncognitive ability have a significant and negative impact on unhealthy behavior. Health is significantly and negatively correlated with the individuals' unhealthy behavior. This negative correlation does not necessarily imply a causal effect and may be due to reverse causality and selection. Without controlling for the accumulated years of previous unhealthy behavior, education is negatively correlated with unhealthy behavior and age is positively correlated with unhealthy behavior. Years of previous healthy behavior is positively correlated with current unhealthy behavior. Moreover, after controlling the years of unhealthy behavior, the coefficient of education becomes not significant and the coefficient in front of age in the regression becomes negative and significant. This suggests previous behavior is strongly correlated with education level as well.

3 Model

Now we present a lifecycle model where forward-looking agents maximize their expected discounted remaining lifetime utility by making decisions on schooling, working, unhealthy behavior, and savings, allowing individuals' choices to depend on their cognitive and noncognitive skills (unobserved to econometrician), parental education and wealth, in the presence of financial market frictions and rational addiction.

3.1 Setup

3.1.1 Choice Set and Preferences

At the beginning of age t_0, each individual is endowed with an initial level of health capital h_{t_0}, cognitive ability θ_c and non-cognitive ability θ_n. Denoted $\theta \equiv (\theta_c, \theta_n)$ to be an individual's endowment vector of abilities. These endowment vectors are not observable to econometricians but are known to the agents.

At each age $t = t_0, \dots T$, an individual makes decisions on schooling $d_{e,t} \in \{0,1\}$ and working $d_{k,t} \in \{0, 0.5, 1\}$, where $d_{k,t} = 0.5$ and $d_{k,t} = 1$ indicate working part-time and full-time respectively. An individual can not go to school and work full-time at the same time, i.e. $d_{e,t} + d_{k,t} < 2$. Furthermore, an individual also makes decisions on savings s_{t+1} and unhealthy behavior indicator $d_{q,t} \in \{0,1\}$ (such as heavy drinking, regular smoking or other unhealthy behaviors).

An individual has well-defined preferences over his health h_t, consumption c_t, schooling and working choices $(d_{e,t}, d_{k,t})$, and decisions on unhealthy behavior $d_{q,t}$:

$$\begin{aligned} U_t = {} & \phi_c(\theta, h_t)u(c_t) + \phi_h(h_t) + \phi_q(\theta, h_t, q_t, \epsilon_{q,t})d_{q,t} \\ & + \phi_e(\theta, h_t, e_t, d^e_{t-1}, \epsilon_{e,t})d_{e,t} + \sum_{j=1,2} \phi_{k,j}(\theta, h_t)\mathbf{1}(d_{k,t} = j/2) + \phi_{k,e} d_{e,t} d_{k,t} \end{aligned} \tag{3}$$

where q_t is the accumulated experience of unhealthy behavior at age t and $(\epsilon_{e,t}, \epsilon_{q,t})$ represent preference shocks to schooling and unhealthy behavior respectively. Note we allow the accumulated experience of engaging unhealthy behavior at period t, q_t, to directly enter the utility, thus affect the agent's current period choice, this allows our model to generate rational addiction behavior patterns. The subjective discount rate is given by $\rho(\theta, h_t) \in (0,1)$.

3.1.2 Human Capital Production

We normalize the health stock to be an unit interval: $h_t \in [0,1]$. Thus $h_t = 0$ is the worst health possible to stay alive and $h_t = 1$ is the best health status possible. The production function of next period's health depends on the individual's cognitive and noncognitive skills, current health stock, education level, schooling and working decisions, current unhealthy behavior, consumption, age and an idiosyncratic shock:

$$h_{t+1} = H(\theta, h_t, t, e_t, q_t, d_{q,t}, c_t, d_{e,t}, d_{k,t}, \epsilon_t^h). \tag{4}$$

Education level, measured by years of schooling, evolves as follows,

$$e_{t+1} = e_t + d_{e,t}. \tag{5}$$

Accumulation of work experience is given by:

$$k_{t+1} = k_t + d_{k,t}. \tag{6}$$

Accumulation of stock of unhealthy behavior, such as the years as a heavy smoker etc:

$$q_{t+1} = q_t + d_{q,t} \tag{7}$$

Thus our model can generate rational addiction behavior.

3.1.3 Labor Markets Outcomes

An individual's wages for part-time job $w_{1,t}$ and in the competitive labor market depends on an individual's abilities θ, health h_t, education e_t and the accumulated working experience at age t, k_t, and is subject to an idiosyncratic transitory productivity shock $\epsilon_{w,t}$:

$$w_{j,t} = r_j(e_t)\omega_t(\theta_t, h_t, e_t, k_t, \epsilon_{w,t}) \tag{8}$$

3.1.4 Budget Constraint and Financial Market Imperfection

The budget constraint of the individual is given by

$$c_t + \mathrm{tc}(e_t)d_{e,t} + p_q d_{q,t} + s_{t+1} = (1+r_l)s_t\mathbf{1}(s_t > 0) + (1+r_b)s_t\mathbf{1}(s_t < 0) + \sum_{j=1,2} w_{j,t}\mathbf{1}(d_{k,t} = j) + \mathrm{tr}_{p,t} + \mathrm{tr}_{g,t} \tag{9}$$

where $\mathrm{tc}(\cdot)$ is tuition cost, which depends on the individual's schooling level, p_q is the monetary cost of unhealthy behavior, r_l is the fixed lending rate and r_b is the fixed borrowing rate of interest, s_t is the individual's asset level at age t, w_t is the wage rate, $\mathrm{tr}_{p,t}$ is the monetary transfers the individual received from parents, , and $\mathrm{tr}_{g,t}$ is the government transfers.

To directly model the presence of financial market frictions and investigate its impact on agents' behavior, we not only allow the lending rate and borrowing rate to be different, but also explicitly introduce a borrowing limit. Furthermore, we allow the borrowing limit to evolve as a function of the individual's human capital level and age:

$$s_{t+1} \geq \underline{s}(\theta, h_t, e_t, t). \tag{10}$$

The level of parental transfer is assumed to be a deterministic non-negative function of their schooling e_p and assets s_p, the current school attendance status of the youth $d_{e,t}$ and working status $d_{k,t}$, namely[5]

$$\mathrm{tr}_{p,t} = \mathrm{tr}_p(e_p, s_p, d_{e,t}, d_{k,t}). \tag{11}$$

Following a number of studies,[6] we assume that the government transfer provides a minimum consumption floor, c_{min}:

$$\mathrm{tr}_{g,t} = \max\{0, c_{min} - [(1+r_l)s_t\mathbf{1}(s_t > 0) + (1+r_b)s_t\mathbf{1}(s_t < 0) + w_t d_{k,t} + \mathrm{tr}_{p,t} - \underline{s}(\theta, h_t, e_t, t)]\}. \tag{12}$$

The existence of c_{min} captures the social safety net programs provided by the government. Under Equation 12, government subsidizes an individual's consumption only after the individual exhausts all of his financial resources (i.e., reaches borrowing limit); also treating c_{min} as sustenance level, we require attending school ($d_{e,t}$) and saving ($s_{t+1} > 0$) are feasible only if $c_t \geq c_{min}$.

[5] This is an extension of the parental transfer function in Keane and Wolpin (2001).

[6] Examples include Hubbard, Skinner, and Zeldes (1995), Keane and Wolpin (2001) and French and Jones (2011).

3.2 Information Structure and Treatment Effect

Let Ω_t be the individual's information set:

$$\Omega_t \equiv (\theta_c, \theta_n, h_t, e_t, s_t, d_{e,t-1}, k_t, q_t, e_p, s_p, t, \epsilon_t) \tag{13}$$

where ϵ_t is a vector that summarizes idiosyncratic transitory shocks. Individuals have perfect knowledge of their heterogeneity θ.

We assume that education choice $d_{e,t} = 1$ is available only before age 30. Denote $\mathcal{O}_t$ as the choice set of individuals at age t; it contains all the combinations of alternatives available to the individual given the individual's information set at time t. The treatment effect of education at time t is the effect of leaving school at time t. The time of treatment is a choice of the agent.

3.3 Model Solution

An individual's value function $V_t(\cdot)$ for $t = 1, \ldots T-1$ is characterized by the following Bellman equation:

$$\begin{aligned} V_t(\Omega_t) = \max_{d_t \in \mathcal{O}_t, s_{t+1}} \Big\{ & U_t(\theta, h_t, c_t, d_{e,t}, d_{k,t}, d_{q,t}, q_t, \epsilon_{e,t}, \epsilon_{k,t}, \epsilon_{q,t}) \\ & + \rho(\theta, h_t) \mathbb{E}(V_{t+1}(\Omega_{t+1}) | \Omega_t, d_{e,t}, d_{k,t}, d_{q,t}, h_{t+1}, e_{t+1}, k_{t+1}, q_{t+1}, s_{t+1}) \Big\} \end{aligned} \tag{14}$$

subject to

$$c_t + \mathrm{tc}(e_t) d_{e,t} + p_q d_{q,t} + s_{t+1} = (1 + r(s_t)) s_t + \sum_{j=1,2} w_{j,t} \mathbf{1}(d_{k,t} = j/2) + \mathrm{tr}_{p,t} + \mathrm{tr}_{g,t} \tag{15}$$

$$w_{j,t} = r_j(e_t) \omega_t(\theta_t, h_t, e_t, k_t, \epsilon_{w,t}) \tag{16}$$

$$h_{t+1} = H(\theta, h_t, t, e_t, q_t, d_{q,t}, c_t, d_{e,t}, d_{k,t}, \epsilon_t^h) \tag{17}$$

$$e_{t+1} = e_t + d_{e,t} \tag{18}$$

$$k_{t+1} = k_t + d_{k,t} \tag{19}$$

$$q_{t+1} = q_t + d_{q,t} \tag{20}$$

$$s_{t+1} \geq \underline{s}(\theta, h_t, e_t, t) \tag{21}$$

$$d_{e,t} + d_{k,t} < 2 \tag{22}$$

where $r(s_t) = r_l \mathbf{1}(s_t > 0) + r_b \mathbf{1}(s_t < 0)$.

At age T, an individual's value function is given by the following

$$V_T(\Omega_T) = \max_{d_T \in D_T, s_{T+1}, d_{q,t}} \left[u(\theta, h_T, c_T, d_{e,T}, d_{k,T}, d_{q,T}, q_T, \epsilon_{e,T}, \epsilon_{k,T}, \epsilon_{q,T}) + \mathbb{E}_{h_{T+1}}(R(\theta, h_{T+1}, s_{T+1})) \right] \tag{23}$$

where $R(\cdot)$ is a terminal value function that depends on individuals' state variables at age $T+1$.

First-order conditions with respect to c_t and s_{t+1} are respectively:

$$\frac{\partial U_t}{\partial c_t} = \lambda_{1,t} \tag{24}$$

$$\rho(\theta, h_t)\mathbb{E}\left(\frac{\partial V_{t+1}}{\partial s_{t+1}}\right) + \lambda_{2,t} = \lambda_{1,t} \tag{25}$$

where $\lambda_{1,t}$ and $\lambda_{2,t}$ is the Lagrangian multiplier of the budget constraint and borrowing constraint respectively. Envelop condition implies

$$\frac{\partial \mathbb{E}(V_t)}{\partial s_t} = \lambda_{1,t}(1 + r(s_t)) \tag{26}$$

The Euler equation is given by

$$\frac{\partial U_t}{\partial c_t} = (1 + r(s_t))\rho(\theta, h_t)\mathbb{E}_t\left(\frac{\partial U_{t+1}}{\partial c_{t+1}}\right) + \lambda_{2,t} \tag{27}$$

where $\lambda_{2,t}$ is the Lagrangian multiplier of the borrowing constraint.

3.4 Dedicated Measurement System for Unobserved Abilities and Health

The model is completed by defining a set of measurement equations that relate the unobserved skill endowment and latent health level to a set of observables. In our model, we focus on the evolution of health factor, while holding the cognitive and noncognitive levels constant at their initial level (age 17). Specifically, we assume that at age 17 there exist two sets of dedicated measurement equations for (θ_c, θ_n) given by Equations 28 and 29 respectively; and there is a set of dedicated measurement equations for unobserved health level h_t at each time period t given by Equation 30 as follows:

$$Z^*_{c,j} = \mu_{z,c,j} + \alpha_{z,c,j}\theta_c + \epsilon_{z,c,j}, \qquad j = 1, \ldots, J_c \tag{28}$$

$$Z^*_{n,j} = \mu_{z,n,j} + \alpha_{z,n,j}\theta_n + \epsilon_{z,n,j}, \qquad j = 1, \ldots, J_n \tag{29}$$

$$Z^*_{h_t,j} = \mu_{z,h,j} + \alpha_{z,h,j}h_t + \epsilon_{z,h_t,j}, \qquad j = 1, \ldots, J_h. \tag{30}$$

The measurement errors $\epsilon_{z,c}, \epsilon_{z,n}, \epsilon_{z,h_t}$ are independent distributed. The unconditional distribution of θ_j is given by $\theta_j \sim N(\mu_j, \sigma_j^2)$ for $j \in \{c, n\}$. Moreover, to incorporate both continuous and binary measurements, we assume that the following relationship holds for each measurement at every point of time:[7]

$$Z_{k,j} = \begin{cases} Z^*_{k,j} & \text{if } Z_{k,j} \text{ is continuous} \\ \mathbf{1}(Z^*_{k,j} > 0) & \text{if } Z_{k,j} \text{ is binary} \end{cases}, \quad k \in \{c, n, h_t\} \tag{31}$$

4 Empirical Strategy

4.1 Initial Conditions

Individuals start to make decisions starting at age 17 ($t_0 = 17$). The deterministic components of age 17 information set, $\overline{\Omega}_{17}$ is given by

$$\overline{\Omega}_{17} \equiv (\theta_c, \theta_n, h_{17}, e_{17}, s_{17}, d_{e,16}, k_{17}, q_{17}, e_p, s_p, 17).$$

However because as econometrician we observed neither individuals' skill endowment nor health, instead we observe a set of measurement equations for $\theta_c, \theta_n, h_{17}$. Therefore, the observed initial condition at age 17 from the data is as follows,

$$\overline{\Omega}^{\text{observed}}_{17} \equiv (e_{17}, s_{17}, d_{e,16}, k_{17}, q_{17}, e_p, s_p, 17).$$

The joint distribution of the unobserved abilities at initial age 17 is given by the following:

$$\left. \begin{pmatrix} \theta_c \\ \theta_n \\ \log h_{17} \end{pmatrix} \right| X_{17} \sim \pi(\overline{\Omega}^{\text{observed}}_{17}) N(\mu_1, \Sigma) + (1 - \pi(\overline{\Omega}^{\text{observed}}_{17})) N(\mu_2, \Sigma)$$

The initial distribution of the youth's education, lagged school attendance, parental education and parental wealth ($e_{17}, d_{e,16}, e_p, s_p$) are directly obtained from data. We also set the accumulated years of working experience, years of unhealthy behavior, net worth to be zero ($k_{17} = 0$, $q_{17} = 0$, $s_{17} = 0$).

[7] Here I omit the time subscript t for health measurements for notation abbreviation.

4.2 Parameterization

4.2.1 Preferences

We use a semi-separable utility functional form as a benchmark for our simulation exercise here:

$$
\begin{aligned}
U_t = & \frac{1}{1-\gamma}\left(\frac{c_t}{\mathrm{es}_{t,e}}\right)^{1-\gamma} + \phi_h h_t + \phi_q(\theta, h_t, q_t, \epsilon_{q,t}) d_{q,t} \\
& + \phi_e(\theta, h_t, e_t, d^e_{t-1}, \epsilon_{e,t}) d_{e,t} + \sum_{j=1,2} \phi_{k,j}(\theta, h_t) \mathbf{1}(d_{k,t} = j/2) + \phi_{k,e} d_{e,t} d_{k,t}
\end{aligned} \tag{32}
$$

where $\mathrm{es}_{t,e}$ is the equivalence scales of family size,[8] ϕ_h is the direct flow utility per unit of health stock, $\phi_q(\cdot)$, $\phi_e(\cdot)$, and $\phi_k(\cdot)$ are the utility (or disutility if negative) associated with the individual's choices on healthy behavior, schooling, and working respectively:

$$
\begin{aligned}
\phi_q(\theta, h_t, q_t, \epsilon_{q,t}) &= \alpha_{q,c}\theta_c + \alpha_{q,n}\theta_n + \phi_{q,h} h_t + \phi_{q,1} q_t + \phi_{q,0} + \epsilon_{q,t} && (33) \\
\phi_e(\theta, h_t, e_t, d^e_{t-1}, \epsilon_{e,t}) &= \alpha_{e,c}\theta_c + \alpha_{e,n}\theta_n + \phi_{e,h} h_t + \phi_{e,e} e_t + \phi_{e,1} d^e_{t-1} + \phi_{e,0} + \epsilon_{e,t} && (34) \\
\phi_{k,j}(\theta, h_t) &= \alpha_{k,j,c}\theta_c + \alpha_{k,j,n}\theta_n + \phi_{k,j,h} h_t + \phi_{k,j,0}, \quad j = 1, 2. && (35)
\end{aligned}
$$

We allow the subjective discount rate $\rho(\theta, h_t)$ to depend on individuals' cognitive and noncognitive skills and their health,

$$
\rho(\theta, h_t) = \frac{\exp(\rho_0 + \rho_c\theta_c + \rho_n\theta_n + \rho_h h)}{1 + \exp(\rho_0 + \rho_c\theta_c + \rho_n\theta_n + \rho_h h)}. \tag{36}
$$

Therefore, implicitly we allow the impact of health on life-expectancy, which effectively impact an individual's decision horizon and thus discount rate.

The terminal value function at age $T+1$ is given by

$$
R(\theta, h_{T+1}, s_{T+1}) = \phi_h h_{T+1} + \phi_{T+1,s} s_{T+1} \tag{37}
$$

[8] Household equivalence scales measure the change in consumption expenditures needed to keep the welfare of a family constant when its size varies. Specifically, we first calculate the average family size for each education group at every age using CPS data 1997 to 2012, and then calculate the corresponding equivalence scales following Fernández-Villaverde and Krueger (2007). For example, this scale implies that a household of two needs 1.34 the consumption expenditure of a single household.

4.2.2 Health Production

The health production function takes the form of Cobb-Douglas function:

$$\log h_{t+1} = \beta_{h,h} \log h_t + \log I_t + \beta_{h,t} t + \sum_{j=c,n} \alpha_{h,j} \theta_j + \beta_{h,e} e_t + \beta_{h,ee} \mathbf{1}(e_t \geq 16) + \beta_{h,0} + \epsilon_t^h, \tag{38}$$

where I_t is the net health investment in efficient units:

$$\log I_t = \beta_{h,c} \log c_t + \beta_{h,q} q_t + \beta_{h,1} d_{q,t} + \beta_{h,2} d_{e,t} + \beta_{h,3} d_{k,t}. \tag{39}$$

Furthermore, we assume $\epsilon_t^h \sim N(0, \sigma_{h,t}^2)$ and allow $\sigma_{h,t}$ to be a function of individuals' states, specifically:

$$\log \sigma_{h,t} = \beta_{\sigma,h} h_t + \beta_{\sigma,q} q_t + \beta_{\sigma,e} e_t + \alpha_{\sigma,c} \theta_c + \alpha_{\sigma,n} \theta_n + \beta_{\sigma,0}. \tag{40}$$

Thus the treatment effect of education on health over the lifecycle is given by $\frac{\partial h_{t+1}}{\partial e_t}$.

4.2.3 Wage Equation

Wages equation: $\log w_{j,t} = \log r_j(e_t) + \log \omega_t(\theta_t, h_t, e_t, k_t, \epsilon_{w,t})$

$$\begin{aligned}
&\log r_j(e_t) = r_{j,0} + r_{j,1} \mathbf{1}(e_t \geq 16) \\
&\log \omega_t(\theta_t, h_t, e_t, k_t, \epsilon_{w,t}) = \sum_{j=c,n} \alpha_{w,j} \theta_j + \beta_{w,0} + \beta_{w,1} h_t + \beta_{w,2} e_t + \beta_{w,3} k_t + \beta_{w,4} k_t^2 + \epsilon_{w,t}
\end{aligned}$$

where $r_{j,1}$ capture the sheepskin effect of college graduation on wages rate, $\epsilon_{w,t}$ is idiosyncratic transitory productivity shock at age t. We normalize $\beta_{w,0} = 0$.

4.2.4 Budget Constraint

Individuals' borrowing limit is

$$\underline{s}(\theta, h_t, e_t, t) = \frac{\exp(\beta_{\underline{s},0} + \beta_{\underline{s},1} t + \beta_{\underline{s},2} e_t + \beta_{\underline{s},3} \mathbf{1}(e_t < 12) + \beta_{\underline{s},3} \mathbf{1}(e_t > 16))}{1 + \exp(\beta_{\underline{s},0} + \beta_{\underline{s},1} t + \beta_{\underline{s},2} e_t + \beta_{\underline{s},3} \mathbf{1}(e_t < 12) + \beta_{\underline{s},3} \mathbf{1}(e_t > 16))} \underline{S} \tag{41}$$

$$\tag{42}$$

where $\underline{S}$ is a very large negative number, such that if $\underline{s}(\theta, h_t, e_t, t) = \underline{S}$ the individual is not borrowing constrained

Parental transfers are determined as follows,

$$\mathrm{tr}_{p,t} = \begin{cases} \mathrm{tr}^*_{p,t} & \mathrm{tr}^*_{p,t} > 0 \\ 0 & \text{otherwise} \end{cases} \tag{43}$$

where

$$\begin{aligned} \mathrm{tr}^*_{p,t} =& \beta_{\mathrm{tr},p,1} e_p + \beta_{\mathrm{tr},p,2} s_p + \beta_{\mathrm{tr},p,3} d_{e,t} \mathbf{1}(d_{e,t} + e_t > 12) + \beta_{\mathrm{tr},p,4} \mathbf{1}(d_{k,t} = 0.5) + \beta_{\mathrm{tr},p,5} \mathbf{1}(d_{k,t} = 1) \\ & + \beta_{\mathrm{tr},p,0} + \epsilon_{p,t} \end{aligned} \tag{44}$$

and we assume that parents do not transfer financial resources to older children, i.e. $\mathrm{tr}_{p,t} = 0$ for $t \geq 30$.[9]

The average transfer from the spouse for an age-t individual with education level e is given:

$$\mathrm{tr}_{f,t} = \begin{cases} \beta_{\mathrm{tr},f,0} + \beta_{\mathrm{tr},f,1} e & t < 20 \\ \beta_{\mathrm{tr},f,2} + \beta_{\mathrm{tr},f,3} e & t \geq 20 \ \& \ t < 25 \\ \beta_{\mathrm{tr},f,4} + \beta_{\mathrm{tr},f,5} e & t \geq 25 \end{cases} \tag{45}$$

Government transfer is as follows,

$$\mathrm{tr}_{g,t} = \begin{cases} \bar{\mathrm{tr}}_{g,t} + \mathrm{tr}^*_{g,t} & \mathrm{tr}^*_{g,t} > 0 \\ \bar{\mathrm{tr}}_{g,t} & \text{otherwise} \end{cases} \tag{46}$$

where

$$\bar{\mathrm{tr}}_{g,t} = \max\{0, c_{min} - [(1+r_l)s_t \mathbf{1}(s_t > 0) + (1+r_b)s_t \mathbf{1}(s_t < 0) + w_t d_{k,t} + \mathrm{tr}_{p,t} - \underline{s}(\theta, h_t, e_t, t)]\}$$

$$\mathrm{tr}^*_{g,t} = \beta_{\mathrm{tr},g,0} + \beta_{\mathrm{tr},g,1} \mathbf{1}(d_k = 0 \ \& \ d_e = 0) + \beta_{\mathrm{tr},g,2} t + \epsilon_{g,t}$$

Tuition cost of higher education is given by

$$\mathrm{tc}(e_t) = \mathrm{tc}_0 \mathbf{1}(e_t \geq 12 \ \& \ e_t < 16) + \mathrm{tc}_1 \mathbf{1}(e_t \geq 16) \tag{47}$$

[9]We make this assumption mainly because in our current data we do not observe parental transfers beyond age 30. This assumption is appropriate as we focus on the role of parental transfer on young adults' college attainment and the majority of individuals obtain their college degree before age 30. For the same reason, here we only focus on non-negative parental transfers. Negative parental transfers may be important for older adults and their parents for a different purpose, but it is outside the scope of this paper.

4.2.5 Distribution assumption

$$\epsilon^j \overset{i.i.d}{\sim} N(0, \sigma_j^2) \tag{48}$$

4.3 Identification Strategy

4.3.1 Dynamic Model and Structure Parameters

Government transfer impacts an individual's decisions through its effect on the individual's budget constraint, thus provides exogenous variation for individuals' choices. Similarly, parents' wealth only impact an individual's decisions through its effect on parental transfer and thus budget constraint. Parental education impacts a youth's decisions either though its effects on parental transfer and thus budget constraint or though shifting the youth's preference towards schooling. Conditional on received parental transfer which is directly observed in the data, parental education provides exogenous preference shifter to schooling choices.

The flow utility of health ϕ_h can not be separately identified from the constant term of the flow utility of unhealthy behavior $\phi_{q,0}$. Thus we normalize $\phi_{q,0} = 0$. Under this normalization, ϕ_h can be identified by the average choice probability of unhealthy behavior. Note the interpretation of flow utility on health is subject to this normalization. The unconditional choice probability of schooling identifies constant term in the utility of schooling $\phi_{e,0}$.

The household size equivalent scale ($\text{es}_{t,e}$) provides an exogenously shifter of the marginal utility of consumption over age and by education groups. The risk coefficient parameter γ is mainly identified by the asset distribution, which reflects precautionary motives.[10] Intuitively, a consumption floor reduces savings incentives among the poor while risk aversion coefficients shape the asset distribution among the asset-rich individuals.

The average wealth level identifies the value of wealth at terminal decision period, $\phi_{T+1,s}$. The difference in wealth level by different age groups, for example wealth at age 20 and age 25, identifies the constant term of the subjective discount rate, ρ_0. The correlation between wealth and cognitive skills helps to identify the effect of cognitive skills on subjective discount rate ρ_c. Similarly, the correlation between wealth and noncognitive skills and the correlation between wealth and health identify ρ_n and ρ_h respectively.

[10] see French and Jones (2011) for the same identification argument.

4.3.2 Factor Model and Measurement System

The identification of factor models requires normalizations that set the location and scale of the factors (see Anderson and Rubin 1956). We normalize the mean and factor loadings of the first measurement equation for each unobservable: $\mu_{z,k,1} = 0, \alpha_{z,k,1} = 1$ for $k \in \{c, n, h_{17}\}$.

4.4 Estimation Method

We use a two-step estimation procedure to estimate model parameters. In the first step, we estimate the parameters on the measurement system and the joint distribution of health, and cognitive and noncognitive skills at age 17.

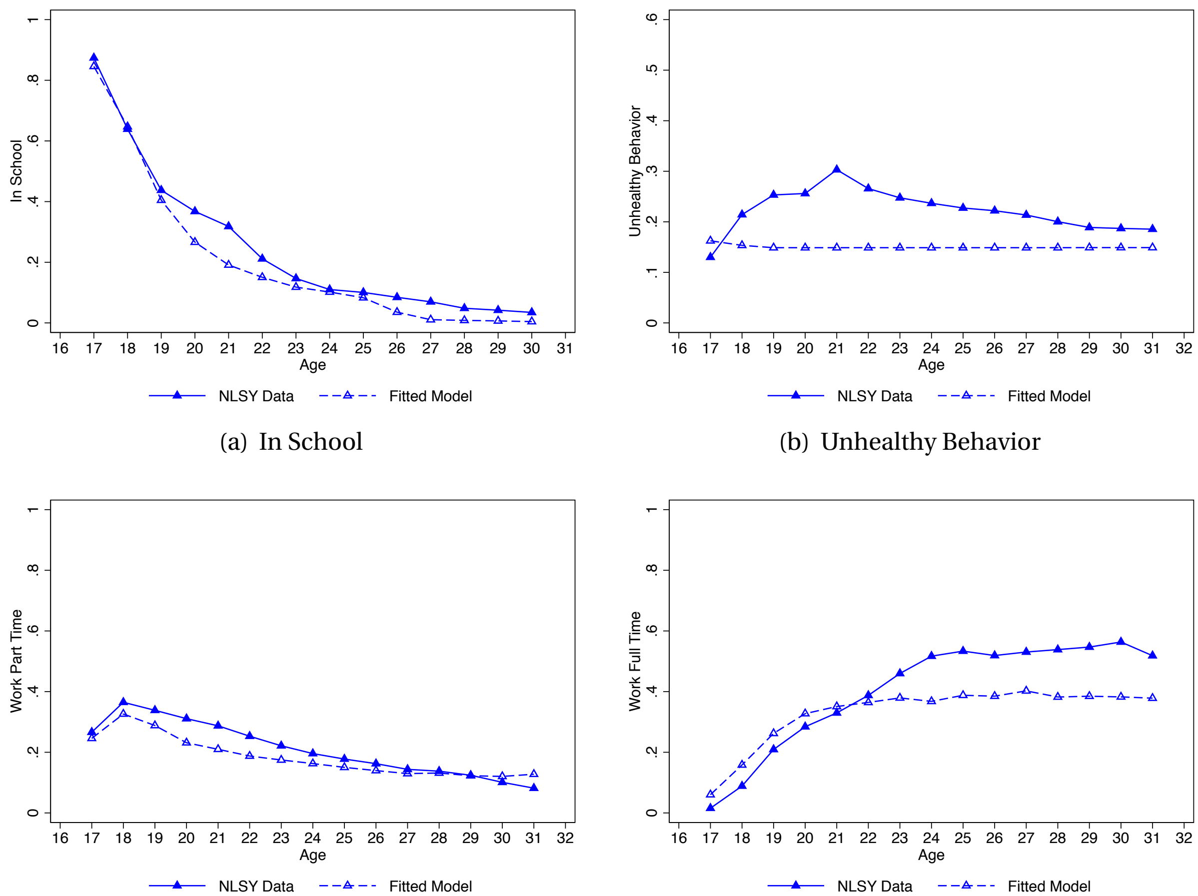
In the second step, we use method of simulated moments to estimate parameters on individuals' preferences, production function on health and labor market skills , budget constraint, and transfer function. The initial conditions for health, cognitive and noncognitive skills in the second step are obtained by simulation using the parameter estimates from the first step. The targeted moments condition is as follows:

The choice variables in the model include not only discrete controls such as schooling and working decisions but also continuous controls such as asset level. As a result, we use Simulated Method of Moments (SMM) to estimate the model.

5 Results

5.1 Parameter Estimates and Model Fit

Figure 4 plots the model fit on choice probability over age. Figure 5 shows the model fit on the evolution path of schooling, health, wealth, working experience, addiction stock over age. Figure 6 plots the model fits of health, wealth, unhealthy behavior, working decisions conditional on education groups.



(a) In School

(b) Unhealthy Behavior

(c) Work (Part-time)

(d) Work (Full-time)

Figure 4: Model Fit on Choice Probability Over Age

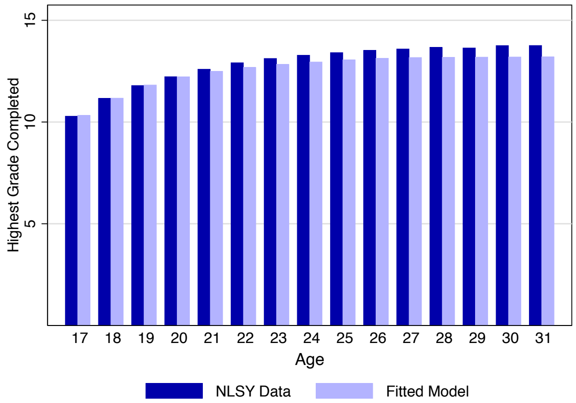
5.2 Economic Implications

5.2.1 Effects of Credit Constraints

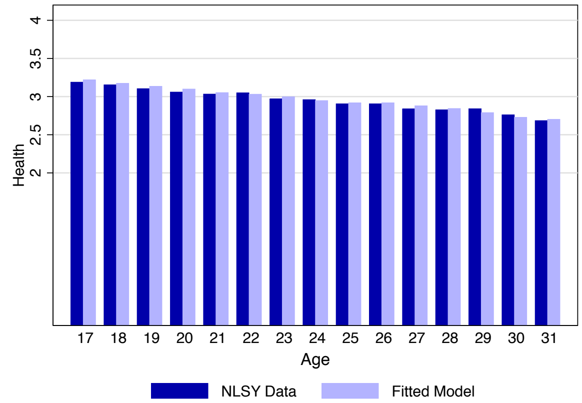
Figure 7 shows the effects of borrowing constraints on health, education, and wealth. Figure 8 documents the effects of borrowing constraints on individuals' decisions on unhealthy behavior and working.

5.2.2 Effects of Rational Addiction

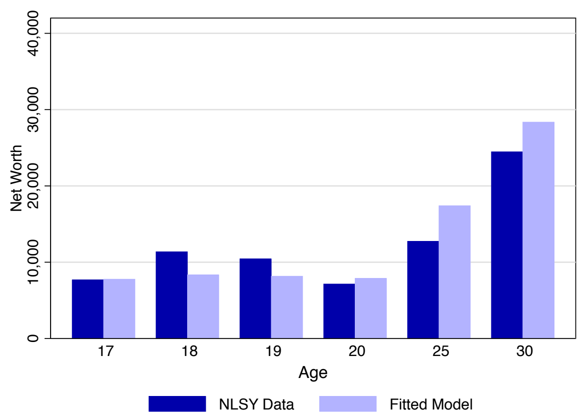
Figure 10 shows the effects of addiction of unhealthy behavior in utility on health, education, and wealth. Figure 9 documents the effects of addiction of unhealthy behavior in utility on individuals' decisions on unhealthy behavior and working.



(a) Education



(b) Health

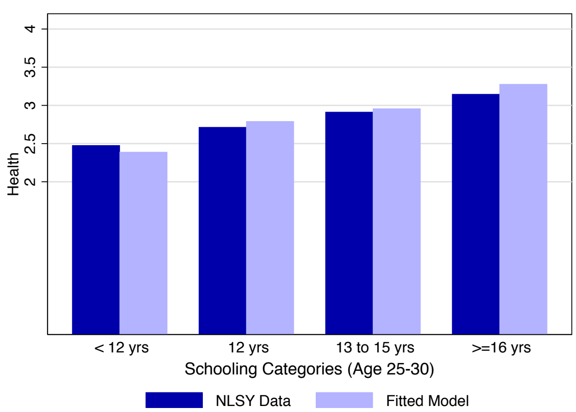


(c) Wealth

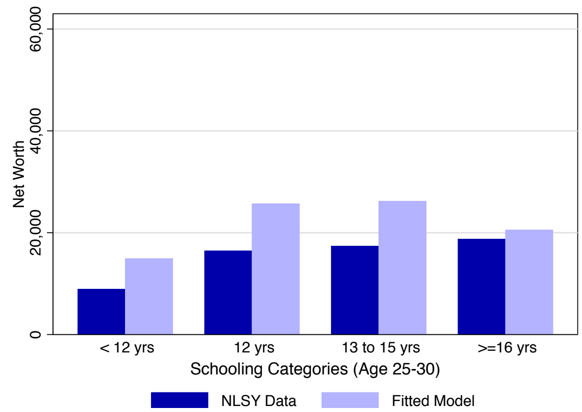
Figure 5: Model Fit on Stock Variables Over Age

5.2.3 Importance of Selection on Abilities

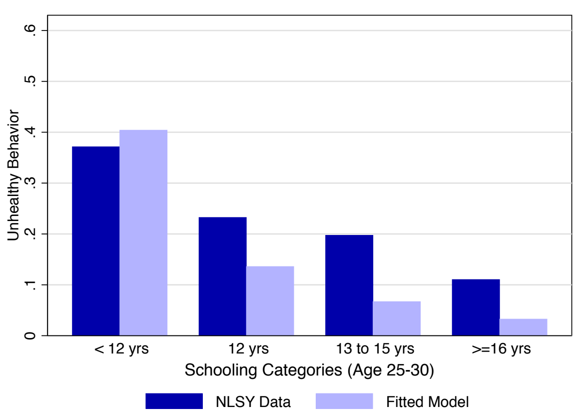
Figures 11 to 13 plot the importance of cognitive and noncognitive abilities on individuals' health, education and wealth at age 20 and age 30.



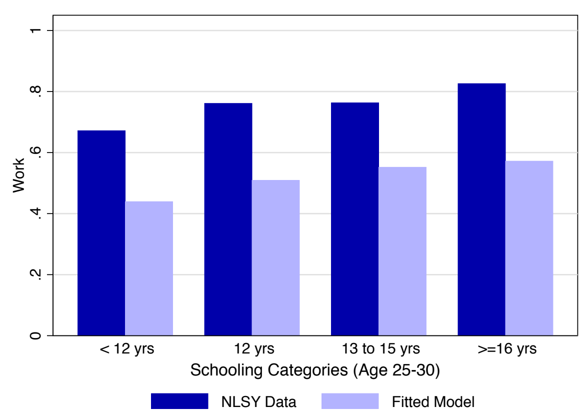
(a) Health



(b) Net Worth

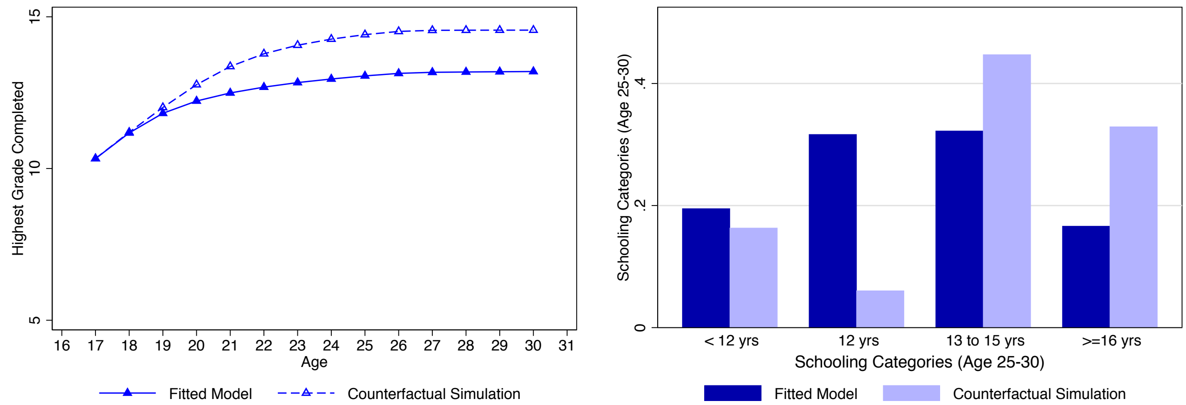


(c) Unhealthy Behavior

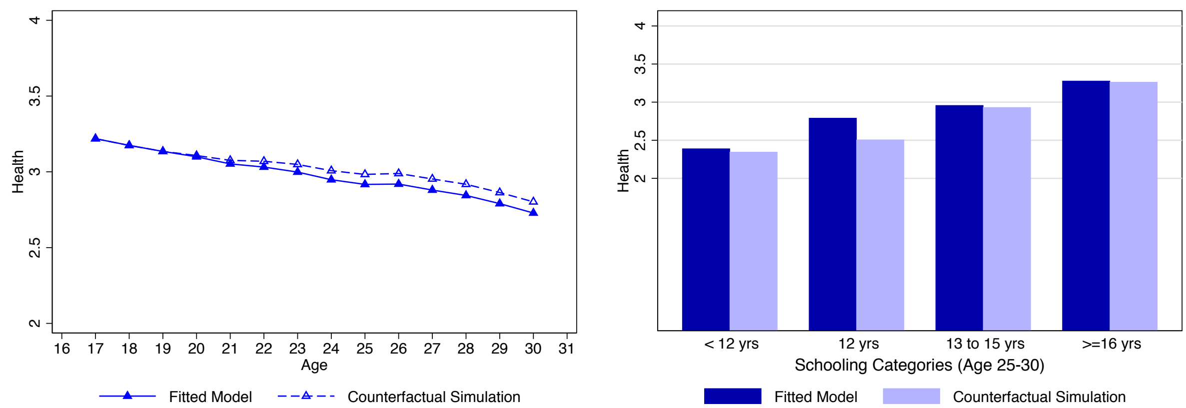


(d) Work (Full-time or Part-time)

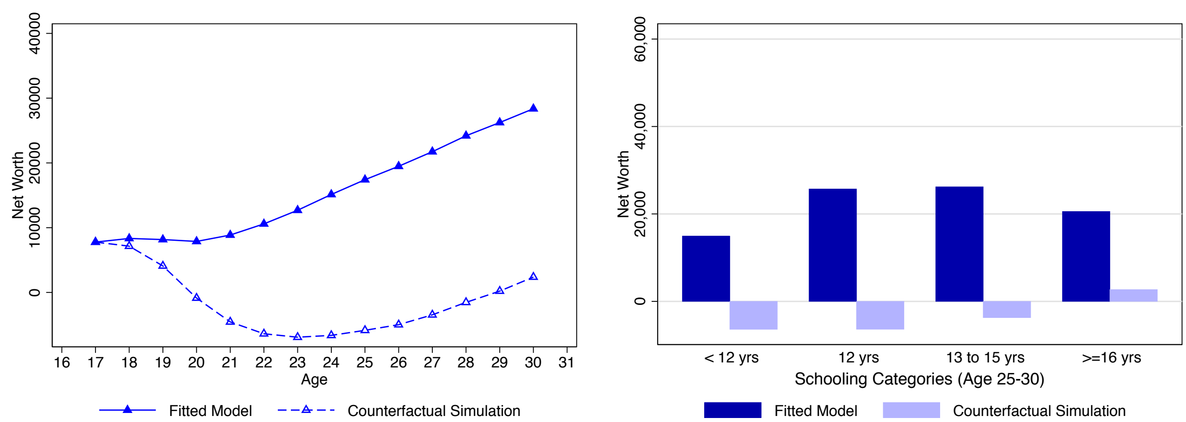
Figure 6: Conditional Model Fit By Education Groups (Age 25 to 30)



(a) Education

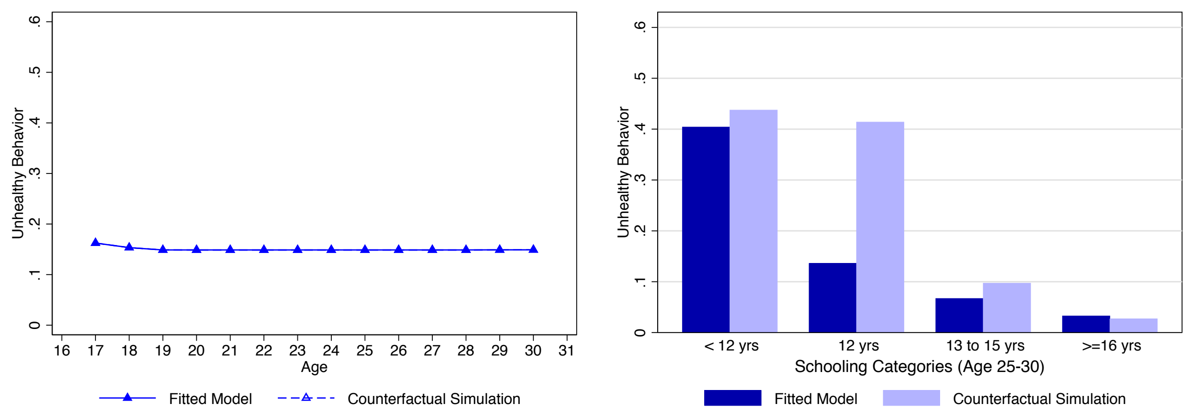


(b) Health

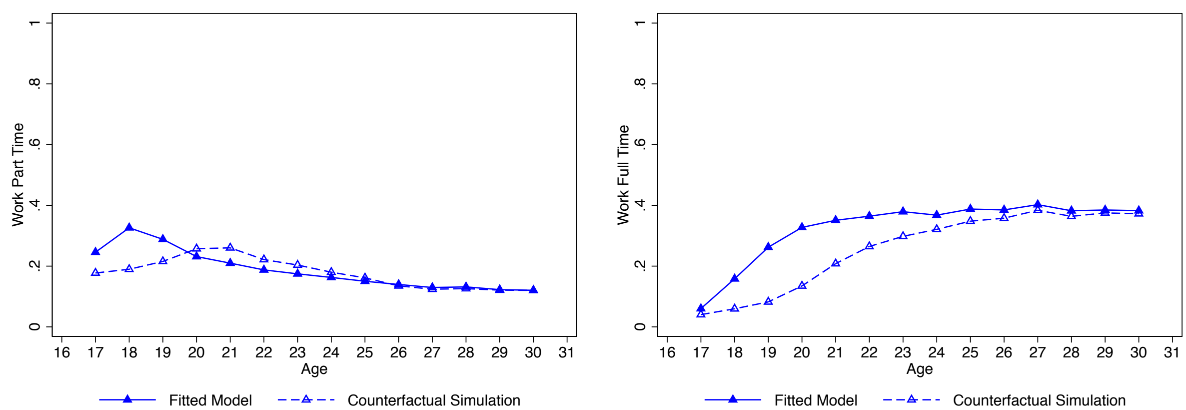


(c) Wealth

Figure 7: Counterfactual Simulation: No Credit Constraint on Health, Education and Wealth

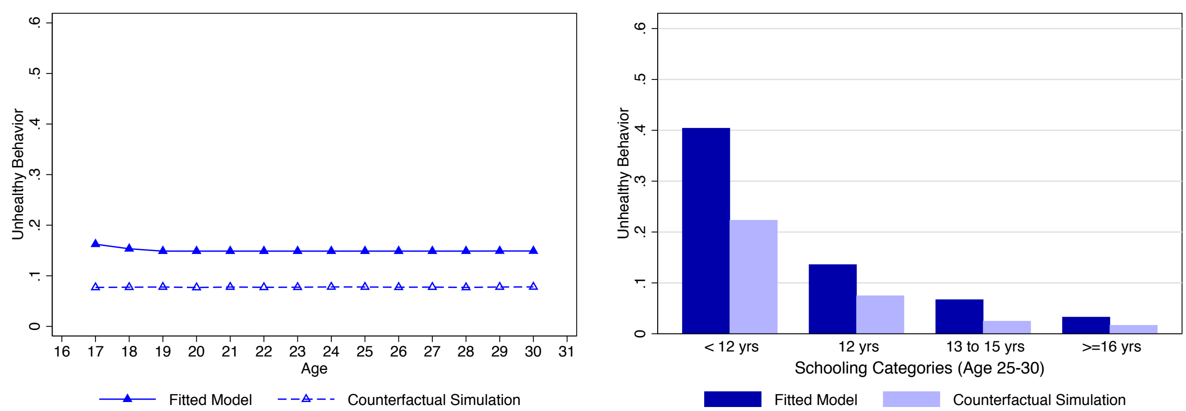


(a) Unhealthy Behavior

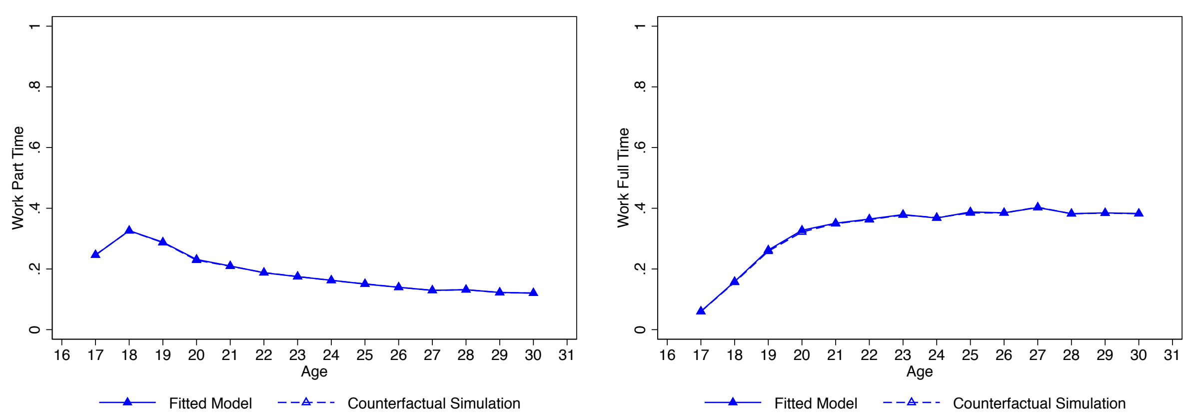


(b) Working Decisions

Figure 8: Counterfactual Simulation: No Credit Constraint on Unhealthy Behavior and Working Decisions

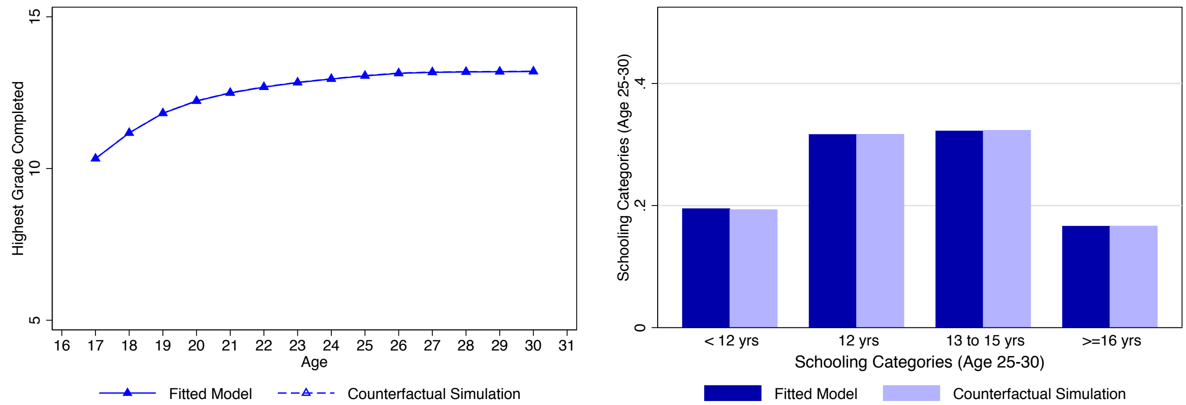


(a) Unhealthy Behavior

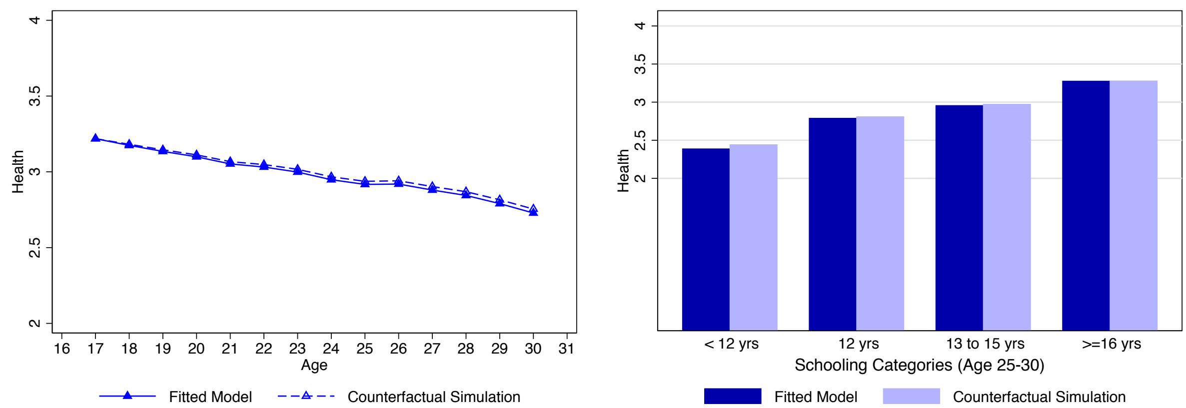


(b) Working Decisions

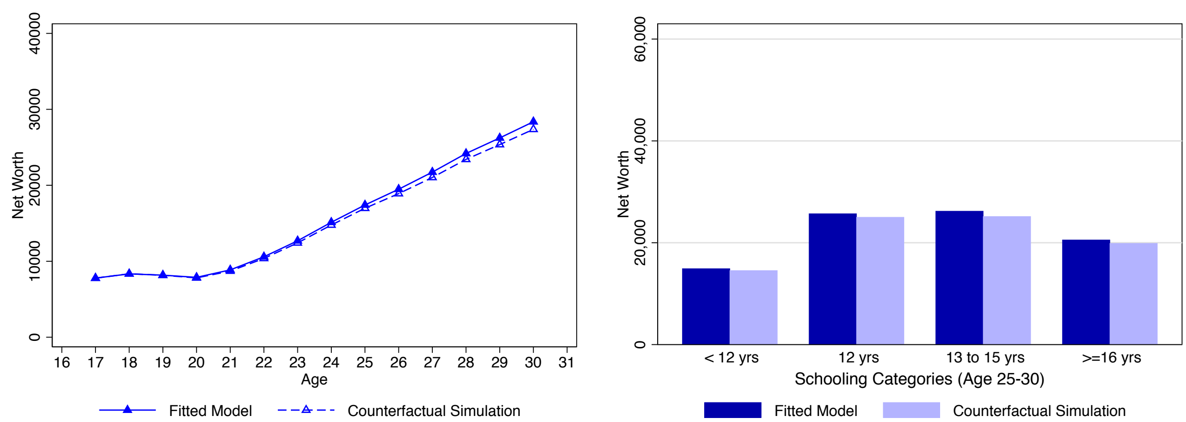
Figure 9: Counterfactual Simulation: No Borrowing Constraint on Unhealthy Behavior and Working Decisions



(a) Education

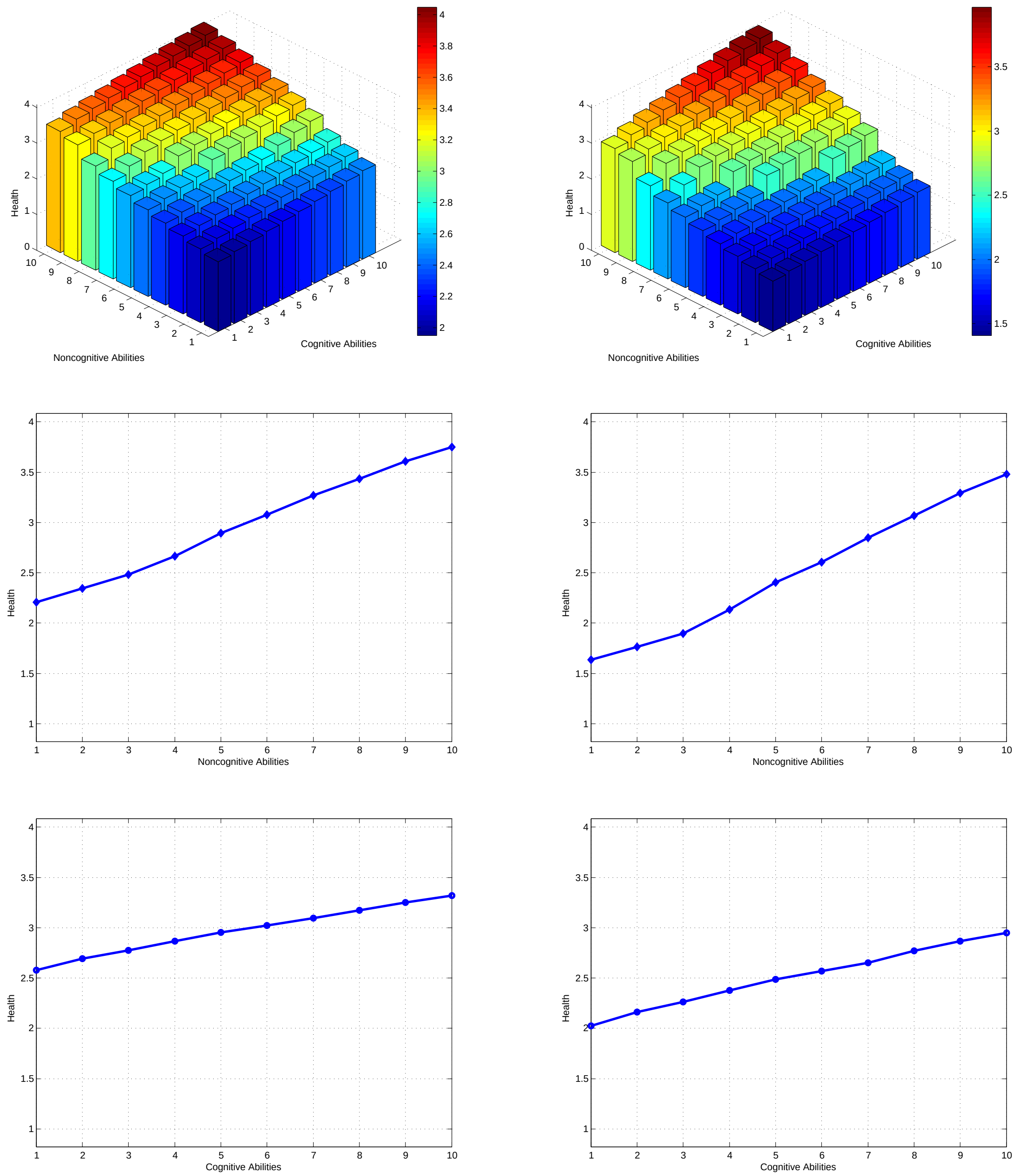


(b) Health



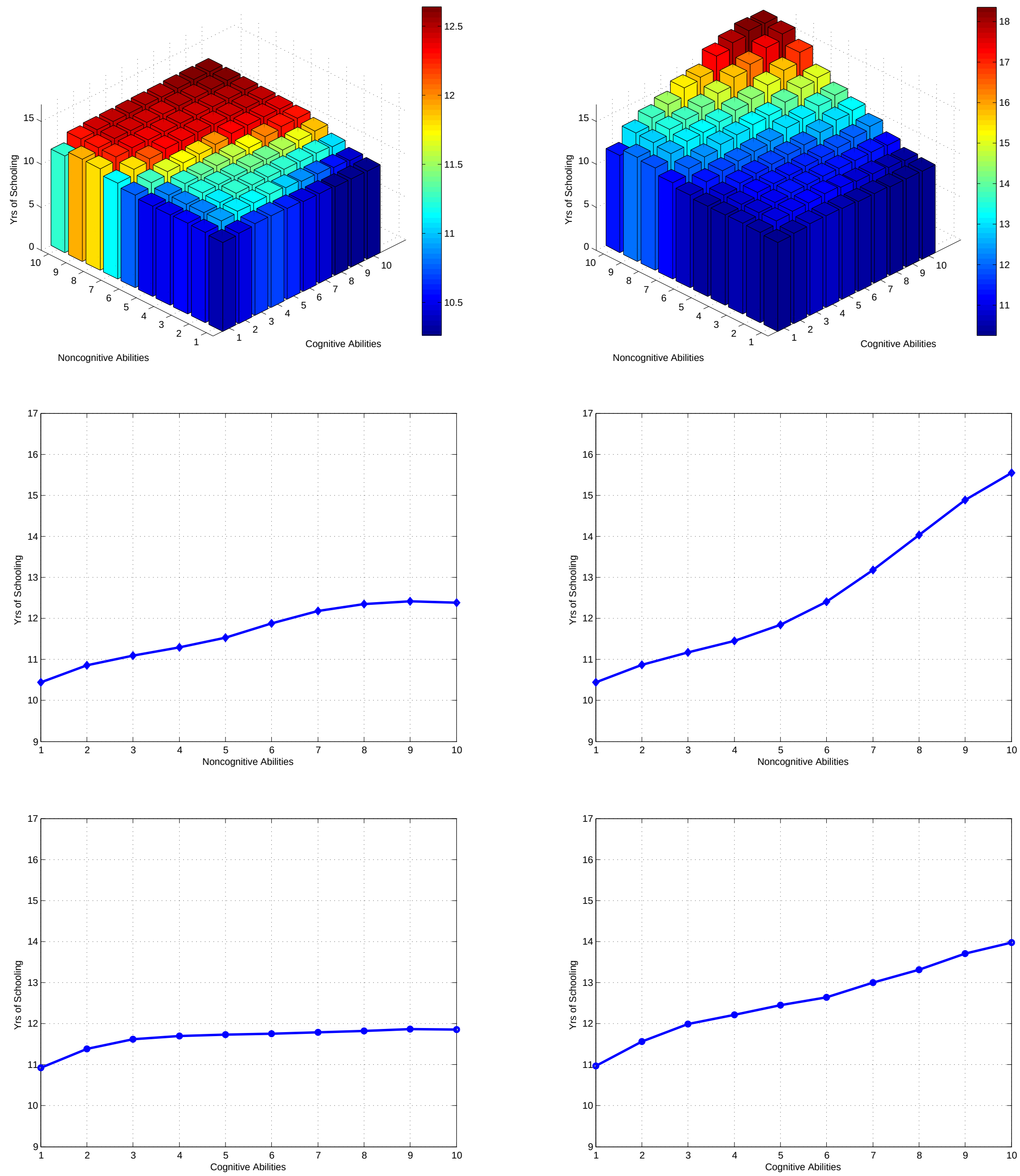
(c) Wealth

Figure 10: Counterfactual Simulation: No Addiction on Health, Education and Wealth



(a) Age 20 (b) Age 30

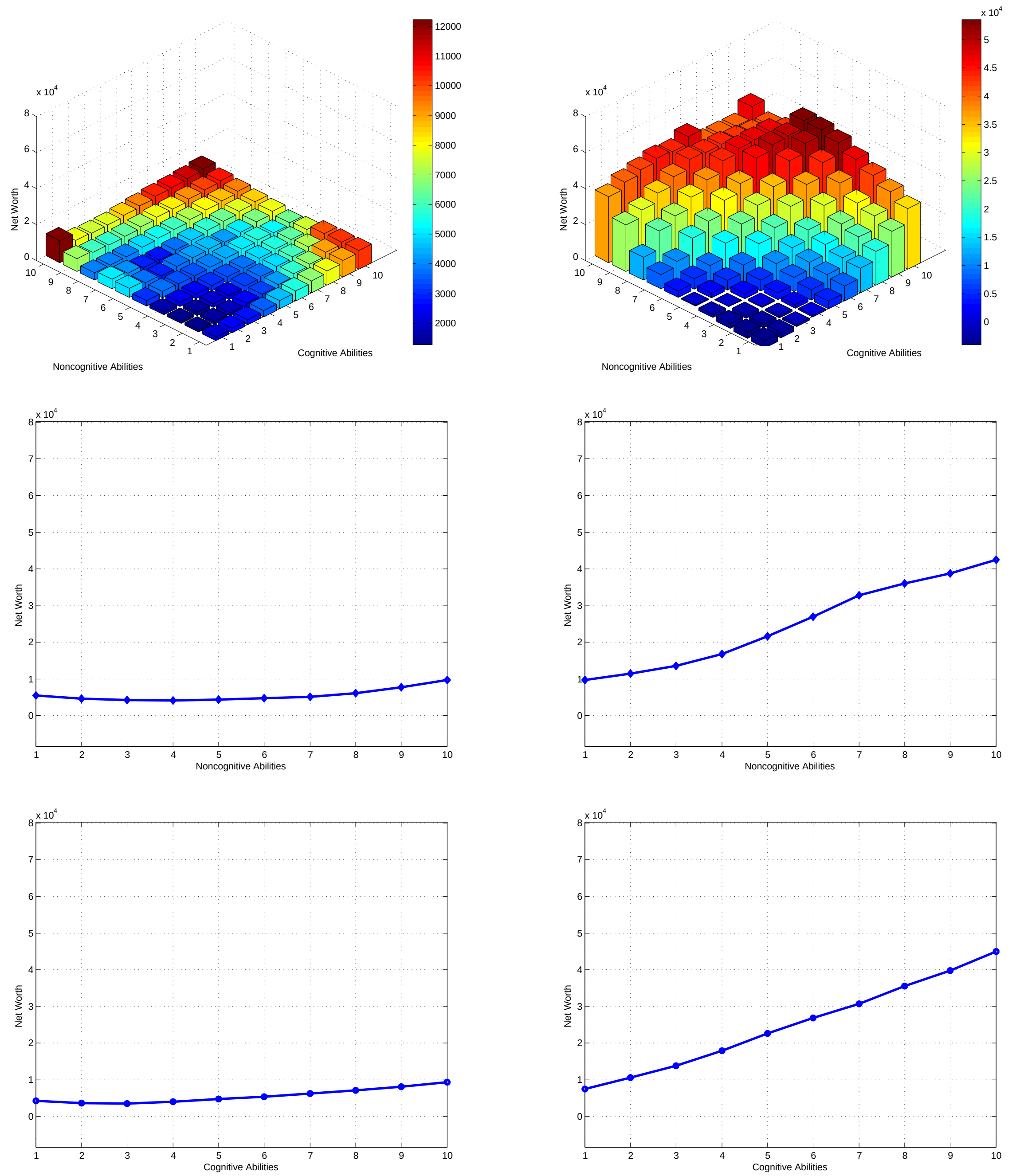
Figure 11: Health By Cognitive and Noncognitive Abilities: h_t



(a) Age 20

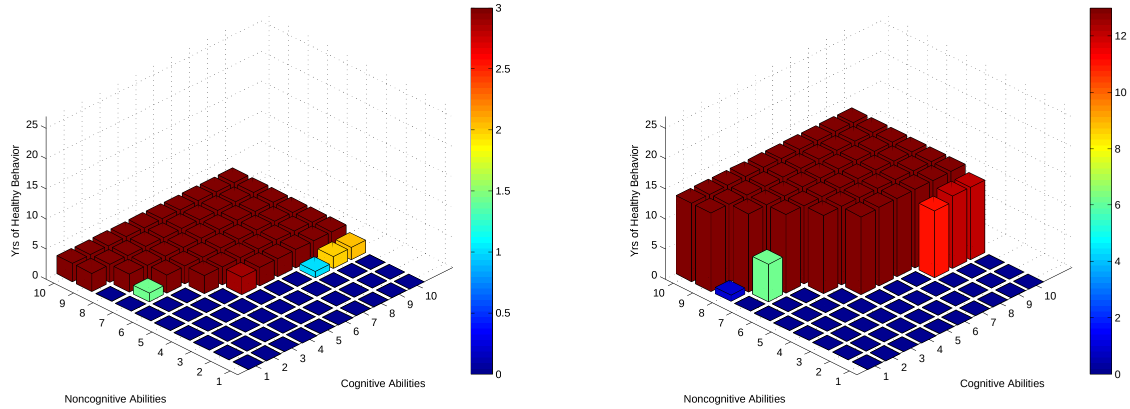
(b) Age 30

Figure 12: Education By Cognitive and Noncognitive Abilities: e_t



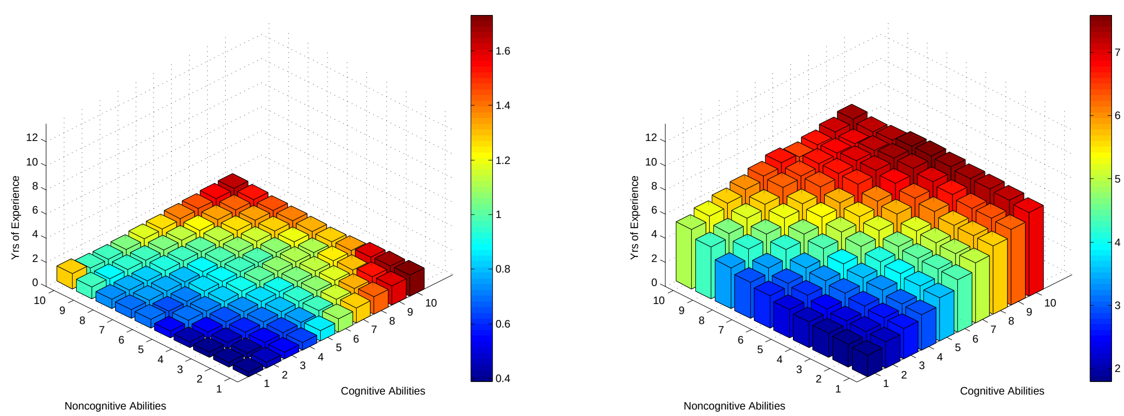
(a) Age 20 (b) Age 30

Figure 13: Wealth By Cognitive and Noncognitive Abilities: s_t



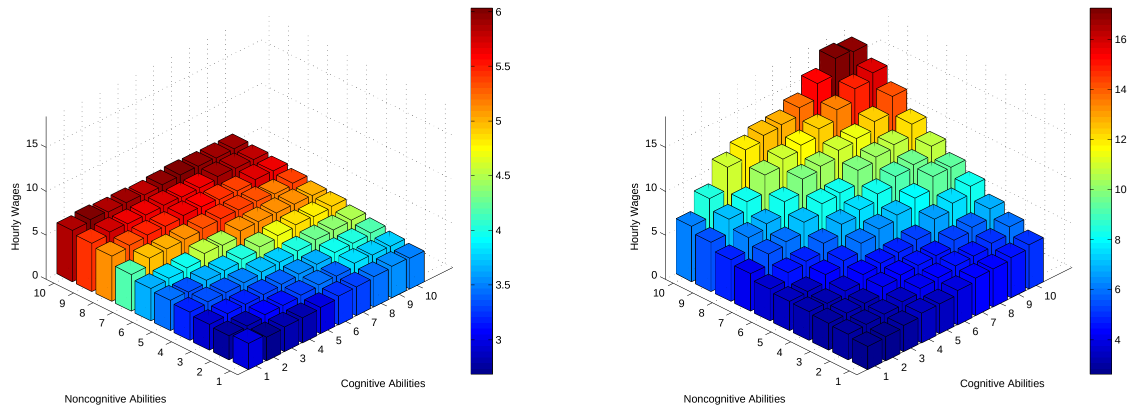
(a) Age 20 (b) Age 30

Figure 14: Years of Healthy Behavior By Cognitive and Noncognitive Abilities: $t - q_t = \sum_t (1 - d_{q,t})$



(a) Age 20 (b) Age 30

Figure 15: Years of Working Experience By Cognitive and Noncognitive Abilities: k_t



(a) Age 20 (b) Age 30

Figure 16: Accepted Hourly Wages By Individual Cognitive and Noncognitive Abilities: w_t

6 Conclusion

We develop and structurally estimate a lifecycle model with endogenous health capital production, rational addictive unhealthy behavior, schooling, working, and wealth accumulation, in the presence of financial market frictions. Using this estimated model, we evaluate the economic mechanisms through which health, education and wealth impact each other over time and assess the economic importance of selection based on cognitive and noncognitive skills. Using counterfactual model simulation, we also quantify the effects of borrowing constraints and rational addiction, on health, education, and labor market outcomes. We also use the model to quantify the contribution of selection to the observed correlation among health, education and wealth.

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Table 1: Descriptive Statistics of NLSY97 Sample

	mean	sd	min	max	N
Age	23.05	3.85	17.00	31.00	27,213
Education	12.63	2.35	0.00	20.00	24,552
Work Full Time	0.38	0.49	0.00	1.00	26,806
Work Part Time	0.23	0.42	0.00	1.00	26,806
Working Experience	2.49	2.69	0.00	13.50	25,405
Full-Time Hourly Wage	7.57	4.56	1.00	58.79	7,220
Part-Time Hourly Wage	5.72	4.44	1.00	68.63	4,271
Net Worth	10705.20	25435.50	-463300.56	257625.41	9,224
Unhealthy Behavior	0.23	0.42	0.00	1.00	23,921
Yrs of Unhealthy Behavior	1.17	2.02	0.00	14.00	20,959
Parents' Educ	13.38	2.35	5.00	20.00	26,339
Parents' Net Worth	85911.81	99424.17	-195171.34	373831.78	20,854
Total Parental Transfers	477.78	4180.98	0.00	563236.00	24,884
Total Government Transfers	189.98	826.27	0.00	14178.93	26,663
Health Status (1: poor/fair; 4: excellent)	2.99	0.89	1.00	4.00	23,962
Height (Inches)	70.96	3.05	53.00	88.00	23,567
BMI	25.75	5.11	7.39	61.02	23,481
Obese	0.17	0.38	0.00	1.00	23,481
Has Asthma	0.11	0.31	0.00	1.00	21,083
ASVAB Percentile (Normalized)	-0.00	1.00	-1.97	1.54	23,006
ASVAB: Arithmetic Reasoning	-0.06	0.95	-3.14	2.37	23,069
ASVAB: Mathematics Knowledge	0.10	0.99	-2.80	2.68	23,006
ASVAB: Paragraph Comprehension	-0.13	0.93	-2.36	1.83	23,041
ASVAB: Word Knowledge	-0.24	0.89	-3.15	2.35	23,055
Noncognitive (Normalized)	-0.00	1.00	-1.88	1.03	27,157
Noncognitive: Violent Behavior in 1997	0.23	0.42	0.00	1.00	27,157
Noncognitive: Smoked Cigarettes bef. Age 17	0.46	0.50	0.00	1.00	27,213
Noncognitive: Drank Alcohol bef. Age 17	0.50	0.50	0.00	1.00	27,213
Noncognitive: Smoked Marijuana bef. Age 17	0.23	0.42	0.00	1.00	27,213

Table 2: OLS Regression of Adult Outcomes (Age 25 to 30)

	(1)	(2)	(3)
	Health Status (1: poor/fair; 4: excellent)	Education	Net Worth/100,000
Health Status at Age 17	0.282**	0.392**	0.033**
	(0.014)	(0.032)	(0.011)
Highest Grade Completed at Age 17	0.040**	0.786**	0.014
	(0.015)	(0.035)	(0.012)
Net Worth at Age 17	-0.007	0.395**	0.022
	(0.054)	(0.130)	(0.043)
ASVAB	0.059**	0.832**	-0.011
	(0.014)	(0.032)	(0.010)
Noncognitive	0.068**	0.376**	-0.008
	(0.012)	(0.028)	(0.009)
Parents' Educ	0.021**	0.208**	0.002
	(0.006)	(0.013)	(0.005)
Parental Net Worth/100,000	0.047**	0.317**	0.043**
	(0.013)	(0.030)	(0.010)
Constant	1.224**	1.209**	-0.179
	(0.167)	(0.393)	(0.130)
Observations	5444	5292	1718

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

Table 3: Production Function of Log Health Status

	(1)		(2)	
	Log Health Status (Next Period)		Log Health Status (Next Period)	
Log Health Status	0.517**	(0.007)	0.564**	(0.008)
Yrs of Unhealthy Behavior	-0.002	(0.002)	-0.004**	(0.002)
Unhealthy Behavior	-0.031**	(0.006)	-0.031**	(0.006)
In School	0.038**	(0.006)	0.032**	(0.006)
Work	0.033**	(0.007)	0.023**	(0.006)
Age	-0.008**	(0.001)	-0.005**	(0.001)
ASVAB	0.015**	(0.003)	0.015**	(0.003)
Noncognitive	0.009**	(0.003)	0.011**	(0.002)
Education	0.013**	(0.001)	0.010**	(0.001)
Constant	0.487**	(0.022)	0.418**	(0.021)
$\log \sigma_h$				
Log Health Status			-0.545**	(0.017)
Yrs of Unhealthy Behavior			0.022**	(0.003)
Education			-0.031**	(0.003)
ASVAB			-0.068**	(0.006)
Noncognitive			-0.030**	(0.006)
Constant	-1.237**	(0.006)	-0.339**	(0.041)
Observations	15457		15457	
AIC	5634.010		3674.249	
BIC	5718.114		3796.582	
Log lik.	-2806.005		-1821.124	

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

Table 4: Production Function of Log(BMI)

	(1)		(2)	
	Log(BMI)	(Next Period)	Log(BMI)	(Next Period)
Log(BMI)	-0.279**	(0.015)	-0.276**	(0.015)
Yrs of Unhealthy Behavior	-0.005**	(0.002)	-0.007**	(0.002)
Unhealthy Behavior	-0.059**	(0.007)	-0.058**	(0.008)
In School	0.074**	(0.007)	0.067**	(0.007)
Work	0.076**	(0.008)	0.065**	(0.007)
Age	-0.012**	(0.001)	-0.011**	(0.001)
ASVAB	0.029**	(0.003)	0.027**	(0.003)
Noncognitive	0.021**	(0.003)	0.022**	(0.003)
Education	0.025**	(0.002)	0.023**	(0.002)
Constant	1.854**	(0.051)	1.860**	(0.051)
$\log \sigma_h$				
Log(BMI)			0.242**	(0.030)
Yrs of Unhealthy Behavior			0.025**	(0.003)
Education			-0.028**	(0.003)
ASVAB			-0.073**	(0.007)
Noncognitive			-0.031**	(0.006)
Constant	-1.102**	(0.006)	-1.560**	(0.099)
Observations	15180		15180	
AIC	9637.051		8997.678	
BIC	9720.956		9119.722	
Log lik.	-4807.526		-4482.839	

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

Table 5: Unhealthy Behavior

	(1)	(2)	(3)	(4)
	OLS	OLS	Probit	Probit
main				
ASVAB	-0.015**	-0.015**	-0.056**	-0.071**
	(0.003)	(0.003)	(0.012)	(0.014)
Noncognitive	-0.066**	-0.031**	-0.220**	-0.125**
	(0.003)	(0.003)	(0.010)	(0.012)
Health	-0.218**	-0.168**	-0.749**	-0.663**
	(0.020)	(0.020)	(0.069)	(0.081)
Education	-0.016**	0.000	-0.059**	-0.002
	(0.002)	(0.002)	(0.006)	(0.007)
Age	0.001*	-0.022**	0.004	-0.108**
	(0.001)	(0.001)	(0.003)	(0.005)
Yrs of Unhealthy Behavior		0.093**		0.332**
		(0.002)		(0.007)
Constant	0.539**	0.713**	0.347**	1.579**
	(0.024)	(0.024)	(0.089)	(0.109)
Observations	20043	17390	20043	17390
AIC	20212.797	14315.873	19839.721	14523.408
BIC	20260.230	14370.218	19887.155	14577.753
Log lik.	-1.01e+04	-7150.936	-9913.861	-7254.704

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

Table 6: OLS regression: Log Hourly Wage

	(1)	(2)	(3)
ASVAB	0.0585**	-0.00232	0.00218
	(0.006)	(0.006)	(0.006)
Noncognitive	-0.0266**	-0.0414**	-0.0403**
	(0.006)	(0.006)	(0.006)
Health Status (1: poor/fair; 4: excellent)	0.0336**	0.0482**	0.0459**
	(0.007)	(0.007)	(0.007)
Education		0.0298**	0.0354**
		(0.006)	(0.006)
Working Experience		0.156**	0.139**
		(0.007)	(0.007)
Working Experience Squared		-0.00736**	-0.00626**
		(0.001)	(0.001)
Education ≥ 12		0.130**	0.143**
		(0.021)	(0.025)
Education ≥ 16		0.261**	0.245**
		(0.025)	(0.026)
Part-Time Job			-0.0491*
			(0.028)
Part-Time Job $\times$ Education ≥ 12			-0.0681**
			(0.030)
Part-Time Job $\times$ Education ≥ 16			-0.0604*
			(0.032)
Constant	1.649**	0.679**	0.685**
	(0.023)	(0.062)	(0.063)
Observations	9570	8993	8993

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

Table 7: Parameter Estimates on Preferences Over Health, Leisure, Working and Schooling

Flow Utility		
Health	ϕ_h	0.117
Working Part-Time	$\phi_{k,1,0}$	-0.019
Working Part-Time × Cognitive Abilities	$\alpha_{k,1,c}$	0.002
Working Part-Time × Noncognitive Abilities	$\alpha_{k,1,n}$	0.000
Working Part-Time × Health	$\phi_{k,1,h}$	0.000
Working Full-Time	$\phi_{k,2,0}$	-0.015
Working Full-Time × Cognitive Abilities	$\alpha_{k,2,c}$	0.003
Working Full-Time × Noncognitive Abilities	$\alpha_{k,2,n}$	0.000
Working Full-Time × Health	$\phi_{k,2,h}$	0.000
Schooling	$\phi_{e,0}$	-0.102
Schooling × Cognitive Abilities	$\alpha_{e,c}$	0.009
Schooling × Noncognitive Abilities	$\alpha_{e,n}$	0.005
Schooling × Health	$\phi_{e,h}$	0.014
Schooling × Yrs of Schooling	$\phi_{e,e}$	-0.001
Schooling × In School Previous Period	$\phi_{e,1}$	0.496
Schooling × Parents High School	$\phi_{e,pr,1}$	0.014
Schooling × Parents Some College	$\phi_{e,pr,2}$	0.040
Schooling × Parents 4-Year College	$\phi_{e,pr,3}$	0.043
Unhealthy Behaviors	$\phi_{q,0}$	0.000
Unhealthy Behaviors × Cognitive Abilities	$\alpha_{q,c}$	-0.299
Unhealthy Behaviors × Noncognitive Abilities	$\alpha_{q,n}$	-0.487
Unhealthy Behaviors × Health	$\phi_{q,h}$	0.000
Unhealthy Behaviors × Yrs of Unhealthy Behaviors	$\phi_{q,1}$	0.155
Terminal Value of Wealth/10,000	$\phi_{T+1,s}$	0.001
Sd of Shocks to Schooling	σ_e	0.036
Sd of Shocks to Unhealthy Behaviors	σ_q	0.015

Table 8: Parameter Estimates on Discount Factor and Risk Aversion

Subjective Discount Factor	$\frac{\exp(\rho_0+\rho_c\theta_c+\rho_n\theta_n+\rho_h h)}{1+\exp(\rho_0+\rho_c\theta_c+\rho_n\theta_n+\rho_h h)}$	
Constant	ρ_0	2.850
Cognitive Abilities	ρ_c	0.001
Noncognitive Abilities	ρ_n	0.001
Health	ρ_h	0.001
Risk Aversion Coefficient	γ	1.898

Table 9: Parameter Estimates on Budget Constraints

Borrowing Limit		
Age	$\beta_{\underline{s},1}$	0.176
Yrs of Schooling	$\beta_{\underline{s},2}$	0.107
Yrs of Schooling < 12	$\beta_{\underline{s},3}$	-0.006
Yrs of Schooling > 16	$\beta_{\underline{s},4}$	0.008
Constant	$\beta_{\underline{s},0}$	-6.507
Parental Transfer Function		
Parents' Yrs of Schooling	$\beta_{tr,p,1}$	273.833
Parents' Wealth/1000	$\beta_{tr,p,2}$	4.411
Current Period In College	$\beta_{tr,p,3}$	2365.537
Work Part-Time	$\beta_{tr,p,4}$	-463.133
Work Full-Time	$\beta_{tr,p,5}$	-1145.092
Constant	$\beta_{tr,p,0}$	-5796.736
Sd of Shocks to Parantal Transfers	$\sigma_{tr,p}$	3446.465
Government Transfer		
Minimum Consumption Floor	$c_{\min}$	1069.244
Age	$\beta_{tr,g,2}$	205.147
Constant	$\beta_{tr,g,1}$	862.721
Sd of Shocks to Government Transfers	$\sigma_{tr,g}$	2976.824

Table 10: Parameter Estimates on Health Production Function

	Logarithm of Next Period Health	
Logarithm of Current Health	$\beta_{h,h}$	0.564
Age	$\beta_{h,a}$	-0.007
Cognitive Abilities	$\alpha_{h,c}$	0.015
Noncognitive Abilities	$\alpha_{h,n}$	0.011
Yrs of Schooling	$\beta_{h,e}$	0.010
Constant	$\beta_{h,0}$	0.409
Health Investment		
Yrs of Unhealthy Behavior	$\beta_{h,1}$	-0.004
Current Period Unhealthy Behaviors	$\beta_{h,2}$	-0.031
Log of Current Period Consumption	$\beta_{h,3}$	0.001
Current Period In School	$\beta_{h,4}$	0.012
Current Period Working	$\beta_{h,5}$	0.013
Log of the sd of Health Shocks		
Current Period Health	$\beta_{\sigma,h}$	-0.009
Yrs of Unhealthy Behavior	$\beta_{\sigma,q}$	0.001
Yrs of Schooling	$\beta_{\sigma,e}$	-0.002
Cognitive Abilities	$\alpha_{\sigma,c}$	-0.005
Noncognitive Abilities	$\alpha_{\sigma,n}$	-0.002
Constant	$\beta_{\sigma,0}$	-1.102

Table 11: Parameter Estimates on Labor Market Skill Production

Cognitive Abilities	$\alpha_{w,c}$	0.009
Noncognitive Abilities	$\alpha_{w,n}$	0.018
Health	$\beta_{w,1}$	0.046
Yrs of Schooling	$\beta_{w,2}$	0.035
Yrs of Experience	$\beta_{w,3}$	0.139
Yrs of Experience Squared	$\beta_{w,4}$	-0.005
Part-Time Job	$\beta_{w,5}$	0.413
Yrs of Schooling $>11, < 16$	$\beta_{w,6}$	0.143
Yrs of Schooling ≥ 16	$\beta_{w,7}$	0.245
Part-Time Job $\times$ Schooling $>11, < 16$	$\beta_{w,8}$	0.075
Full-Time Job $\times$ Schooling ≥ 16	$\beta_{w,9}$	0.185
Constant	$\beta_{w,0}$	0.513
Sd of Skill Shocks	σ_w	0.500

Online Appendix Not for Publication

Appendix A NLSY97 Data

A.1 Measurement System

A.1.1 Health

We use three sets of measures on health for each individual every year. First measure is self-reported health status, where the respondent is asked "in general, how is your health," on a holistic 1 to 5 scale, from "excellent" to "poor". The second set of measures is height, weight and related variables. We calculate Body Mass Index (BMI) from the respondent's height (in inches) and weight (in pounds)[11] and construct a dummy variable for obesity if the BMI is over 30. The third set of measures we use is on asthma. Asthma is a prevalent disease that many young people are suffering from and does not goes away once affected. We construct an indicator variable on whether an respondent has asthma in each reference year using information on the first age the individual is diagnosed with asthma.[12]

A.1.2 Cognitive Abilities

We use a subset of test scores on CAT-ASVAB to measure the respondent's cognitive ability.[13] Specifically, we consider the scores from Mathematical Knowledge (MK), Arithmetic Reasoning (AR), Word Knowledge (WK), and Paragraph Comprehension (PC). These four scores have been used by NLSY staff to create a summary percentile score (ASVAB/AFQT), which has been used commonly in the literature as a measure of IQ or cognitive abilities.

A.1.3 Noncognitive Abilities

Our measure for noncognitive abilities includes four variables that indicate respondents' adverse behavior before the model decision age 17. Specifically, we consider: had violent behavior in 1979 (ever attack anyone with the intention of hurting or fight), smoked cigarette before age 17, drank alcohol before age 17, and tried marijuana

[11] $\text{BMI} = 703 \cdot \text{Weight}/\text{Height}^2$.

[12] In 2002, 2007, 2008, 2009, The NLSY97 asks respondent about four types of health conditions: chronic conditions, sensory conditions, bodily deformities, and mental/emotional/eating disorders. We only focuses on the chronic diseases that are prevalent and can not be easily cured so that we can construct the whole panel from 1997 to 2009 using information asked only in 2002, 2007, 2008, 2009.

[13] The CAT-ASVAB is an automated computerized test developed by the United States Military which measures overall aptitude. The test is composed of 12 subsections and has been well researched for its ability to accurately capture a test-takers aptitude.

before age 17. We construct a summary score of the noncogntive abilities in our regression analysis (Section 2) by summing up these four indexes.

A.2 Key Variables

A.2.1 Unhealthy Behavior

The NLSY97 collects information on the youth's smoking and drinking behaviors every year. We create a dummy variable for heavy drinking based on commonly used measures, including the Center for Disease Control and Prevention (CDC) which defines heavy drinking as more than 2 drinks per day for men, and 1 drink per day for women. We modified this to be an average of over 3 drinks per day, or 90 drinks per month.[14]. We calculate this using two NLSY questions: "during the last 30 days, on how many days did you have one or more drinks of an alcoholic beverage," and "during the past 30 days, on the days you drank alcohol, about how many drinks did you usually have?". We calculated the dummy variable by multiplying the first question, number of days drank with the second, the average number of drinks per day when the respondent drank.

We similarly create a dummy variable for heavy smoking. based on the World Health Organization's definition of 1 pack - 20 cigarettes - a day or more, which we interpreted as a total of 600 or more per month.[15] We calculated this using two NLSY questions: "during the past 30 days, on how many days did you smoke a cigarette," and "when you smoked a cigarette during the past 30 days, how many cigarettes did you usually smoke per day." We calculated the dummy variable by multiplying the first question, number of days smoked with the second, the average number of cigarettes per day when the respondent smoked.

We use these dummy variables to construct a variable for unhealthy behavior, which indicates whether the respondent chooses a healthy lifestyle. Specifically, the dummy variable of unhealthy behavior equals to one if either heavy drinking or heavy smoking.

A.2.2 Schooling and Education

We use three main variables for education: highest grade completed, highest degree received, and enrollment status. Our primary variable is highest grade completed (HGC), which we use to back out enrollment and cross-check highest degree received. HGC is available every year during 1979-1993 and every other year during 1994-2010. Some manual recoding was necessary in order to correct for data coding errors, missing data, GEDs.[16]

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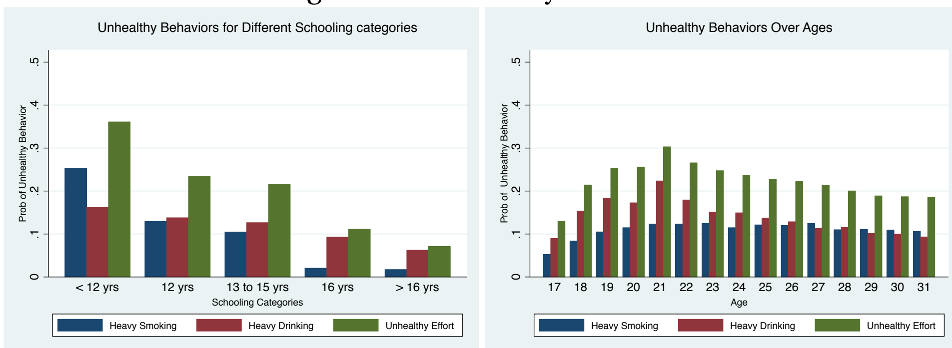
[14]Centers for Disease Control and Prevention, "Alcohol and Public Health." Accessed September 19, 2013. http://www.cdc.gov/alcohol/faqs.htm

[15]World Health Organization, "Tobacco Free Initiative." Accessed September 19, 2013. http://www.who.int/tobacco/en/.

[16] While the NLSY-created variable codes a GED and a high school diploma as the same - 12th grade - we recoded the data so that HGC only reflects the highest grade of school actually completed. That is, two participants who dropped out after completing 9th grade, one with a GED and one without, would be coded the same - 9th grade.

Figure 17: Unhealthy Behavior

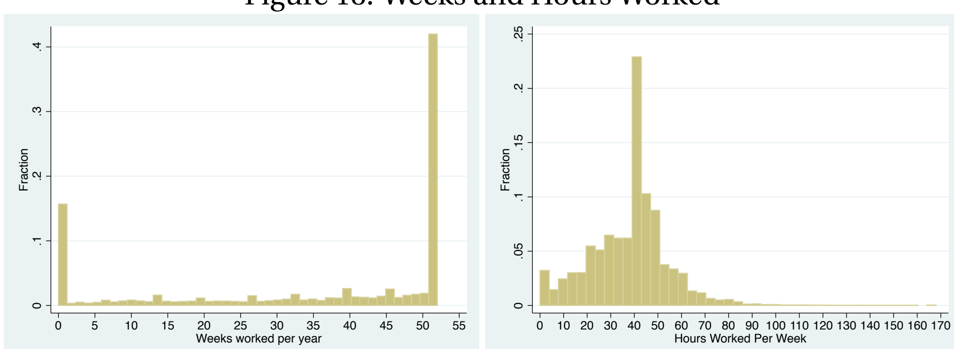


Source: NLSY97 white males.

While we used the NLSY monthly enrollment variables to cross-check HGC, after manually recoding HGC, we use it to back out a more accurate measure of enrollment: If HGC in year x was higher than in year $x-1$, then the respondent is considered enrolled in year $x-1$.

A.2.3 Employment and Wages

Figure 18: Weeks and Hours Worked



Source: NLSY97 white males.

A.2.4 Parental Transfers

Table 12 reports the Tobit model regression results of parental transfer as a function of parents' education and wealth, an individuals age, education, and decisions on schooling and working.

These recodings were made when it was clear from HGC and enrollment that the interviewee received a GED. We use the NLSY month-by-month enrollment variables, compiled into a total number of months enrolled per year variable to cross-check this.

Table 12: Tobit Regression of Parental Transfer Function

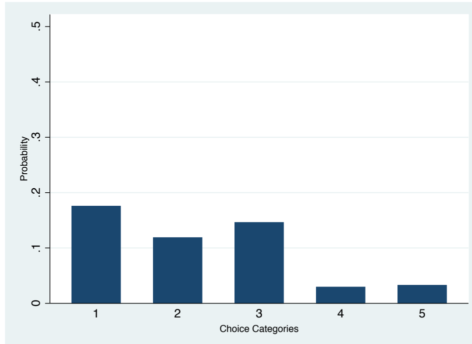
	(1)	(2)	(3)	(4)	(5)
model					
Parents' Educ	255.152**	253.083**	273.833**	252.792**	243.540**
	(16.510)	(16.606)	(16.684)	(16.543)	(17.213)
Parental Net Worth/1000	4.356**	4.332**	4.411**	4.278**	4.210**
	(0.370)	(0.371)	(0.370)	(0.371)	(0.375)
In College	2621.567**	2639.524**	2365.537**	2370.025**	2599.570**
	(92.142)	(93.507)	(93.559)	(113.489)	(92.552)
Work Part Time	-510.249**	-515.361**	-463.133**	-482.804**	-537.078**
	(84.497)	(84.619)	(84.469)	(84.929)	(85.275)
Work Full Time	-1611.958**	-1599.752**	-1145.092**	-1463.439**	-1661.200**
	(90.244)	(90.857)	(92.803)	(98.580)	(92.739)
In Graduate School		241.630	610.031**		
		(211.083)	(211.586)		
$\geq$ Age 25			-1848.901**		
			(93.931)		
In School				396.420**	
				(105.663)	
Education					41.275**
					(17.439)
Constant	-5857.505**	-5839.874**	-5796.736**	-5970.964**	-6181.502**
	(227.832)	(228.304)	(228.595)	(230.575)	(266.605)
sigma					
Constant	3478.340**	3478.173**	3446.465**	3481.271**	3478.326**
	(36.118)	(36.115)	(35.679)	(36.171)	(36.117)
Observations	16422	16422	16422	16422	16422
AIC	1.07e+05	1.07e+05	1.07e+05	1.07e+05	1.07e+05
BIC	1.07e+05	1.07e+05	1.07e+05	1.07e+05	1.07e+05
Log lik.	-5.37e+04	-5.37e+04	-5.35e+04	-5.37e+04	-5.37e+04

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$

A.2.5 Government Transfers

Figure 19: Prob of Receiving Government Transfers



Source: NLSY97 white males. Choice 1: Not Schooling, Not Working; choice 2: Not Schooling, Part-time Working; choice 3: Not Schooling, Full-time Working; choice 4: Schooling, Not Working; choice 5: Schooling, Part-time Working.