Conscientiousness, Education, and Longevity of High-Ability Individuals

Working paper

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Abstract

In this paper, I investigate whether investments in higher education causally affect longevity. I also investigate the role of personality skills in producing longevity, taking into account their potential interaction with education. The causal status of higher education in affecting health and longevity is unclear in the literature, largely because of unknown confounding factors, reverse causality, and difficulty in finding instrumental variables that are both valid and sufficiently strong to reliably estimate the causal effect of higher education on longevity. I examine whether there are confounding factors among early cognitive and personality skills, and estimate the causal effect by controlling for latent confounding personality factors and for the reverse causality.

I use measures of personality skills that were shown to be close to the established Big Five taxonomy of personality, and find that a personal skill of Conscientiousness has strong effects on both education and longevity. I estimate a model that uses Conscientiousness and education as arguments of a production function for longevity. The model accounts for the endogeneity of education, measurement error in the proxies for Conscientiousness, and the interaction between education and Conscientiousness in producing longevity. I estimate the model using the 1922–1991 Terman life cycle data of children with high ability, a prospective study with unique life cycle information including early health variables, childhood personality and IQ measures, mortality observations, and detailed background characteristics.

My results show that while both Conscientiousness and education increase longevity for males, the effect of Conscientiousness on longevity is only strong at low levels of education, and the effect of education on longevity is especially strong at low levels of Conscientiousness. In addition, I show that a failure to account for Conscientiousness leads to an upward bias in the estimate of the effect of education on longevity. The bias from omitting Conscientiousness is comparable to the bias from omitting all other control variables in the model including parental education and occupation. For females, I find that the effects of education and Conscientiousness are not precisely determined. I argue that this lack of strong effects for females born around 1910 might not be generalizable to the contemporary female population.

Key words: longevity, higher education, cognitive skills, noncognitive skills, personality skills, Conscientiousness, factor analysis, measurement error, interaction, Terman life cycle data of children with high ability, gender difference

JEL codes: C33, C38, C41, D91, I12, J24
1 Introduction

It is well-documented in the literature that health and longevity are primarily produced through health behaviors such as not smoking tobacco, drinking alcohol in moderation, following a healthy diet, engaging in physical exercise, following doctor’s advice, and many others (e.g., Phelps, 2010). Health behaviors are formed as a result of a complex process of human development. This paper aims to identify major determinants of human development that increase longevity. The literature in economics of human development suggests that we should expect to find such determinants among cognitive and personality skills, as well as among investments in education (Almlund et al., 2011). I use personality skills that are close to the well-established Big Five taxonomy of personality, and estimate effects of these personality skills and investments in higher education on longevity. I emphasize the causal status of the estimated effect of education on longevity as well as the interaction between education and personality skills in longevity production.

In his influential model of the demand for health, Grossman (1972) uses education as an argument in the health production function. Although there is no doubt that education is strongly associated with health and longevity, the causal status of education is still controversial. Even based on seemingly convincing instrumental variables such as changes in compulsory schooling laws, different authors arrive at different conclusions. Lleras-Muney (2005) used U.S. Census data and changes in education laws from 1915 to 1939 to show a strong causal effect of compulsory education on mortality. Mazumder (2008) argues that results by Lleras-Muney (2005) are not robust to the inclusion of state-specific time trends, that the causal effect of education on health is, at best, much smaller than initially suggested, and that compulsory schooling laws are suspect instruments. Clark and Royer (2009) found no strong effect of compulsory education on mortality up to age 69 based on the British cohort data and changes in compulsory schooling in the years 1957 and 1972. These results are contrary to multiple results in favor of the causal
effect of compulsory education on health (see Grossman and Kaestner (1997) and Grossman (2004) for surveys). Given the controversy about the causal status of education and doubts about the quality of instrumental variables used, it seems especially beneficial to apply a method alternative to IV for establishing the causal status of education, which I do in this paper.

It is difficult to determine whether education has a causal effect on longevity primarily because of two econometric problems: reverse causality (expected longevity may affect education), and confounding variables (factors such as cognitive, personality, and health endowments may affect both education and longevity) (Becker, 2007; Conti et al., 2010; Farrell and Fuchs, 1982; Fuchs, 1982; Grossman, 2000). Establishing causality is especially difficult for higher education. While compulsory education can at least be instrumented by changes in compulsory schooling laws, as discussed above, it is hard to find valid and sufficiently strong instrumental variables that make it possible to reliably estimate the causal effect of schooling above typical compulsory levels. This paper aims to establish a causal link between higher education and longevity by accounting for cognition, personality, and health as potential confounding factors causing the ability bias and by controlling for reverse causality.

The search for confounding factors among personality skills is motivated by the emerging literature in economics of human development as well as the literature in personality psychology. Research in economics of human development has shown strong effects of personality skills (also called personality traits, soft skills, behavioral skills, and noncognitive skills) on essential life outcomes including health and education (Borghans et al., 2008; Conti et al., 2010; Heckman et al., 2011, 2006). Research in personality psychology has shown that personality, especially the trait of Conscientiousness, is associated with both longevity and education (Friedman, 2008; Friedman et al., 1994, 1995, 1993; Hampson and Friedman, 2008; Martin et al., 2007, 2002).

I address these two problems in Section 4.3.1.
To study the effect of cognitive and personality skills on education and longevity, I use the Terman life cycle data of children with high ability (Terman, 1986), which is the longest prospective longitudinal dataset ever collected (Friedman et al., 1995). The dataset covers years 1922–1991 and contains about 4,500 variables. The sample consists of 1,583 schoolchildren from California. On average, the subjects are born in 1910, and with the exceptions described in Section 2, have IQs above 140. Although the respondents are rather homogenous in IQ, they differ substantially in all other skills. The Terman dataset includes a large variety of information on each subject, including the respondent’s early health conditions, IQ, personality measures in both childhood and early adulthood, parental education, occupation, origin, and longevity, World War II experience, and dates of birth and death. By 1991, about 62% of the males and 52% of the females had died. Additionally, comprehensive education data for each subject were gathered both prospectively and retrospectively multiple times over the life cycle.

Using data from the Terman study, I identify the causal effect of investments in higher education on longevity by accounting for potentially confounding latent personality skills (see also Borghans et al. (2008); Carneiro et al. (2003); Heckman et al. (2011, 2006, 2001, 2003); Heckman and Vytlacil (2007)). I represent personality skills by skills that are theoretically and statistically similar to the established Big Five personality taxonomy, and find that the trait of Conscientiousness plays a major role in determining both longevity and education. In contrast, I find that the remaining near-Big Five personality traits—Openness, Extraversion, Agreeableness, and Neuroticism—do not contribute

\[\text{While years 1922–91 are covered prospectively, the survey actually covers an even longer period through questions asked in 1922 about conditions at birth (about 1910), conditions after birth, and family background.}\]

\[\text{In the literature it is suggested that, except for Openness, the Big Five psychological traits are generally uncorrelated with IQ (e.g., Ackerman and Heggestad (1997); Borghans et al. (2011); DeYoung et al. (2005)).}\]

\[\text{The Big Five Conscientiousness is defined as “individual differences in the propensity to follow socially prescribed norms for impulse control, to be task- and goal- directed, to be planful, to delay gratification, and to follow norms and rules” (John and Srivastava, 1999). Conscientiousness as measured in this paper was empirically shown to be related to the Big Five Conscientiousness with correlation coefficient 0.55 and p-value below 0.001 (Martin and Friedman, 2000).}\]
to explanatory power while consuming many degrees of freedom.\textsuperscript{5} I estimate a system of two models, both of which account for latent Conscientiousness: a discrete time proportional odds model of hazard of death, and a generalized ordered logit model of educational investment choice. I account for the endogeneity of education and the measurement error in proxies of skills (see Figure 1).

For males, both Conscientiousness and education increase longevity. In addition, Conscientiousness increases education, which leads to a bias in the estimated effect of education on longevity when Conscientiousness is omitted. Moreover, I find a previously unknown interaction between Conscientiousness and education in producing longevity. The effect of Conscientiousness on longevity decreases with educational attainment, while the effect of educational attainment decreases with Conscientiousness. I conjecture that this interaction occurs because education and Conscientiousness affect longevity through multiple common mediators, such as smoking and drinking habits, diet, mental health, physical exercise, and patient adherence to medical protocols. Once high Conscientiousness has resulted in beneficial levels of these mediators, little additional improvement can be produced by additional education (and vice versa).

For females, I find greater longevity than for males, but the effects of education and Conscientiousness on longevity are generally not statistically significant.\textsuperscript{6} However, given that many developments have occurred in women’s lifestyles and in the job and marriage markets for females (Chiappori et al., 2009), these results may be specific to women born at the beginning of the 20th century and may not apply to later generations.

The greater longevity of females compared to males is well established in the literature. Women are more biologically robust, less exposed to risky and unhealthy behav-

\textsuperscript{5}In this paper, Conscientiousness, Openness, and Extraversion are childhood skills measured in 1922. Since measures for the remaining two Big Five traits, Agreeableness and Neuroticism, are not available for 1922, I use those from 1940 as proxies. These results are in line with the results obtained by psychologists based on the same data who find that among a number of childhood skills, early Conscientiousness is the only strong and robust predictor of longevity (Martin et al., 2007). In addition, the authors find that adult Neuroticism, Agreeableness, and Extraversion are not predictive of longevity.

\textsuperscript{6}I was only able to find a statistically significant positive effect of Conscientiousness on longevity for females with incomplete college education.
iors, and use more preventative care (e.g., Read and Gorman (2010)). Healthier lifestyles of females may explain the lack of strong effects of education and Conscientiousness. Since women already practice healthy behaviors, education and Conscientiousness cannot produce much further improvement.7

My main contributions to health economics include the establishment of a strong causal effect of higher education on longevity for high-ability males, the establishment of Conscientiousness as a confounding factor in the effect of education on longevity, and the discovery of a strong education-Conscientiousness interaction that makes the causal effect of education on longevity dependent on the level of Conscientiousness. While it is impossible to control for all possible confounding factors, a large set of theoretically-relevant controls, including latent personality, makes it likely that estimates of this paper are close to the true effects. I also suggest that Conscientiousness is a potential policy variable that should be considered in health economics research.

The establishment of the causal effect of higher education on longevity supplements findings about the causal effects of compulsory education on health and longevity that were obtained using compulsory schooling laws as instrumental variables (Adams, 2002; Arendt, 2005, 2008; Lleras-Muney, 2005; Mazumder, 2008; Silles, 2009; Spasojevic, 2003). I also confirm and supplement Grossman’s finding that higher education benefits the health of men with above average cognitive ability (Grossman, 1975), and I caution against extrapolation of the findings by Auld and Sidhu (2005) outside the range of particular health outcomes and relatively young ages specific to their paper.8

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7Statistically insignificant association between Conscientiousness and longevity for females of the Terman sample was also found by Friedman et al. (1993) based on somewhat different methodology. Authors conjecture that the effects of Conscientiousness on health and longevity could be smaller for female Terman subjects because women have historically played a more restricted role in society than men, and thus had less opportunities to practice unhealthy behaviors. In their later work Friedman et al. (1995) essentially assume the same effect of Conscientiousness for males and females by pooling the sample and not allowing for different effect of Conscientiousness by gender in the model.

8Auld and Sidhu (2005) find that schooling has a large effect “only for individuals who obtain low levels of schooling, particularly low-ability individuals” and “years of schooling beyond high school contribute very little to health.” Authors obtain their results for two binary health limitations and a general health index measured at ages below 43. They use parental education to instrument the effect of education on health.
The establishment of Conscientiousness as a confounding factor in the effect of education on longevity supplements findings by Fuchs (1982) and Cutler and Lleras-Muney (2010). Fuchs (1982) studied the role of time preference as a potential confounding factor, but did not find any strong effect, and suggested that measurement error was behind the inconclusive evidence. In a recent paper, Cutler and Lleras-Muney (2010) dismiss the role of personality as a confounding factor, reporting that their personality controls do not account for any of the education gradient. However, the authors do not directly account for the trait of childhood Conscientiousness, and acknowledge that their use of noisy proxies may dismiss potentially important theories. In this paper I explicitly account for measurement error and I find that the bias from omitting Conscientiousness is comparable to the bias from omitting all other controls, which include parental education, occupation, origin, longevity, and many other essential variables (see Table 1 for a full set).

Although the results of this paper are obtained for individuals with extraordinarily high IQs, they might also apply to a much broader population. Indeed, healthy behaviors, through which education and Conscientiousness produce health (Bogg and Roberts, 2004; Hampson and Friedman, 2008; Phelps, 2010), do not require extraordinary levels of cognitive ability.⁹ Hence, the results of this paper likely apply to individuals with high, but not necessarily extraordinarily high cognition, such as those successful in high school and college. Because such individuals tend to be the most productive part of the work force, the results of this paper may have strong implications for important aggregates such as demand for education, labor supply, private investments, and government revenues.

⁹In their meta-analysis of Conscientiousness-related skills and the leading behavioral contributors to mortality in the United States, Bogg and Roberts (2004) provide evidence that Conscientiousness is negatively related to health behaviors such as tobacco use, diet and activity patterns, excessive alcohol use, violence, risky sexual behavior, risky driving, suicide, and drug use.
2 Terman Data Description

The Terman dataset is one of the most widely known datasets among psychologists, but it is relatively unknown to economists. However, the recent spate of major developments in the new field of economics of personality (Almlund et al., 2011; Borghans et al., 2008) has elicited a renewed interest in the dataset due to its unique combination of detailed life-cycle measurements.

The Terman Life Cycle Study of Children with High Ability was started in 1921 and continued with follow-ups every 5–10 years through 1991. The sample consists of 856 males and 672 females. Selection of the gifted children was based on teacher’s nomination followed by an IQ test. Subjects were selected for having an IQ above 140, which corresponds to the 99.6th percentile of the intelligence distribution.

Terman’s selection procedure led to a sample of mostly middle-class, white schoolchildren. The subjects were born, on average, in 1910 with standard deviation 3.7. The study has an attrition rate below 10%, which is exceptionally low for a 70-year-long prospective study. Moreover, lost subjects are known not to differ systematically in terms of education, income, and demographic factors (Sears, 1984). There is also no evidence that members of the attrited group differ significantly from others on measures of personality (Friedman et al., 1993).

About 4,500 measurements collected in the period 1922–1991 describe detailed fam-

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10In the 1970s, economists published several papers based on the Terman data. The papers are concerned with marriage and divorce decisions, consumption and retirement, fertility and children’s schooling, and home investments in children (Becker et al., 1977; Hamermesh, 1984; Leibowitz, 1974; Michael, 1976; Tomes, 1981). A recent paper by Gensowski (2012) analyzes developmental determinants of lifecycle earnings.

11Teachers nominated from one to five children, usually four, from classes of 30–50 pupils. Teachers were asked to base nominations on intelligence, quickness of grasp, originality, ability to reason clearly about new and difficult problems, breadth and accuracy of information, command of language, common sense, and independence of judgment. They were also asked to take age into account and nominate younger children other things being equal. (Terman et al., 1925)

12To be more precise, 180 children had IQs in the range of 135–139, and an additional 7 had IQs in the range 126–135. Information about the type of IQ test is included later in this section.

13Terman et al. (1925) refers to the economic status of a majority of families as “fairly comfortable,” and indicates that only a few families were “truly in poverty.”

14Here I consider measurements based on the same question asked in different years as separate mea-
ily backgrounds, parental investments, personality skills, health statuses, and economic outcomes, among others (Burks et al., 1930; Terman et al., 1925; Terman and Oden, 1959; Terman et al., 1947; Terman and Sears, 2002a,b; Terman et al., 2002).

The key variables used in this paper include five binary education variables, the IQ variable, and personality measures. Education refers to the highest level of education achieved in life, up to 1986. The most prevalent education attainment for both genders is a bachelor’s degree. Doctorates are almost as common as bachelor’s degrees among males, but very uncommon for females. The second largest category among females is a master’s degree, which is almost as frequent as “some college.” The smallest education category for both genders is high school graduate (see Table 1 for more information about education variables). One important benefit of the longitudinal nature of the Terman study, with detailed education data collected multiple times prospectively and retrospectively, is that measurement error in education is bound to be negligible when using the education variable based on all available longitudinal information.

The average IQ is about 149 for males and 148 for females. Children who were already in high school, about 30% of the sample, took an intelligence test called the Terman Group Test (TGT) instead of the Stanford Binet Test. As a precaution, I check if the effect of IQ is different for the TGT takers, but observe no difference.

Literature in psychology that uses the Terman data personality skills (Friedman, 2000, 2008; Friedman et al., 1994, 1995, 1993; Hampson and Friedman, 2008; Martin et al., 2007, 2002) is based on averages of teachers’ and parents’ ratings, as explicitly stated in Martin et al. (2002). I also calculate the average of parents’ and teachers’ ratings of personality skills in 1922, when the children were, on average, 12 years of age. This averaging

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15 There are also several high school dropouts, whom I drop from the sample as outliers (see below in this section).
16 The Stanford-Binet test is the 1916 Stanford revision of the Binet-Simon Intelligence Test. In longevity and schooling models, I use what is called “the best measure of IQ” constructed by psychologists from all available tests in order to correct for various measurement issues (Terman and Sears, 2002a).
17 If both teachers’ and parents’ ratings are present, I average them. If one of them is absent, I use the only one that is available.
procedure allows me to increase the sample of non-missing personality measures, to account for additional information, and to obtain measures comparable to those used in the previous literature.\(^\text{18}\) Alternative estimations conducted using only teachers’ ratings and only parental ratings lead to similar results. Since childhood Agreeableness and Neuroticism are missing in the sample, I use measures of these two skills made in 1940 as proxies.\(^\text{19,20}\) I standardize all non-binary measures so that the mean for the estimation sample is zero and variance is one. See Table 2 for more information on measures of personality.

Background variables in this paper can be grouped into five categories: general intelligence, early health, parental longevity and background, World War II Experience,\(^\text{21}\) and cohort. See Table 1 for more information on the background variables.

I restrict the data based on a number of criteria determined prior to estimation. I exclude: (1) 155 people who were not born in the period 1904–1915;\(^\text{22}\) (2) 41 people who never participated, were lost, or dropped out before 1940;\(^\text{23}\) (3) 47 people who are missing both parents’ and teachers’ personality trait ratings;\(^\text{24}\) (4) 15 high school dropouts;\(^\text{25}\) (5) two men who died in service during World War II;\(^\text{26}\) (6) six people with

\(^{18}\)It would be best to derive a common factor through a hierarchical (higher order) factor model (e.g., Bollen (1989)), but this option is not available, because at least three sources of ratings (e.g., parents, teachers, and peers) are needed for the identification of such a model, while the Terman study only contains two. Thus, I perform a standard factor analysis on averaged items rather than the hierarchical factor analysis on items based on responses of different raters.

\(^{19}\)Measures of Positive Neuroticism (or Emotional Stability) are higher when a person is more emotionally stable.

\(^{20}\)Neither of those 1940 skills shows any effect on longevity in a five-factor model. Also, I test and do not reject the hypothesis that they jointly do not affect longevity.

\(^{21}\)World War II experience, which includes war and combat participation, was to a large extent determined by draft lottery and orders of the military, which can be considered as exogenous variation. Clearly, some of endogenous variation can not be ruled out (e.g., volunteering). I made a robustness check and found that results are robust to the exclusion World War II variables from the model.

\(^{22}\)This restriction makes the cohorts more comparable by excluding long tails of the year of birth distribution.

\(^{23}\)From now on I report observations dropped from the sub-sample that remained after all previous filtering, so that a summation of all observations dropped is equal to the total loss in the sample size.

\(^{24}\)These people have missing proxies for the key variables of this paper.

\(^{25}\)High school dropouts are a small group of outliers with a likely case of reverse causality between education and health (bad health leads to small education investment), which I wish to minimize.

\(^{26}\)These deaths are most likely exogenous, since they were reasonably beyond the person’s control.
serious diseases in their early life, such as chorea or Hodgkin’s disease;\(^7\) seven people who have missing education level information; (8) 24 people who died before age 31;\(^8\) and (9) 51 people for whom childhood Conscientiousness measures are missing. The final estimation sample contains 1,180 people; 661 males and 519 females. Criteria (1–3) are identical or similar to those used by psychologists (Martin et al., 2007).

3 Modeling Personality Skills

An emerging literature in economics of human development (e.g., Borghans et al. (2008); Cunha and Heckman (2009); Cunha et al. (2006); Heckman et al. (2011)) demonstrates the vital importance of personality skills for essential life outcomes including health and health behaviors. Although there are various different ways to define personality skills, the Big Five taxonomy of personality is, perhaps, the most established way to do so (John and Srivastava, 1999). The data on personality collected in 1922, 1940 and 1950, factors that are available do not correspond exactly to the Big Five personality skills, but are both theoretically and empirically close to the big five taxonomy (Martin and Friedman, 2000).\(^9\)

In this paper, I extract personality factors using exploratory factor analysis (EFA), which I perform on the psychological ratings from 1922. Exploratory factor analysis is a dimensionality-reducing statistical procedure widely used in psychometrics and other disciplines for finding a low-dimensional vector consisting of latent factors that

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\(^{27}\)These diseases likely serve as confounding factors by affecting personality, education, and longevity.

\(^{28}\)To condition on the same starting age for everybody, and to make education a past event to minimize possible reverse causality.

\(^{29}\)Four of five factors in this paper, childhood Conscientiousness and Extraversion, as well as adult Agreeableness and Neuroticism, were empirically shown to be correlated with the Big Five factors having the same names (Martin and Friedman, 2000). The Conscientiousness factor used in the final model of this paper is shown to be related to the Big Five Conscientiousness (with correlation 0.55, and \(p\)-value below 0.001). The authors also show a relationship of their Sociability with the Big Five Extraversion (with correlation 0.40, and \(p\)-value below 0.001). Extraversion in this paper is defined similar to the authors’ Sociability (see Table A-8 of the Web Appendix), and, hence, should also be related to the Big Five Extraversion. Openness, as defined in this paper was not compared with Big Five Openness by Martin and Friedman (2000), but it should be related to the Big Five Openness from theoretical considerations.
explain multiple variables. The procedure, which is documented in Web Appendix A, makes it possible to find blocks of measures such that variables are closely correlated within blocks, but are uncorrelated or weakly correlated between blocks. Each block corresponds to one latent factor proxied by the multiple measures contained within the block. As a result of the exploratory factor analysis, I obtain three reliable personality factors for year 1922: Conscientiousness, Openness, and Extraversion. According to John and Srivastava (1999), Openness describes the breadth, depth, originality, and complexity of individual’s mental and experimental life; Extraversion implies an energetic approach to the social and material world and includes skills such as sociability, activity, assertiveness, and positive emotionality; Neuroticism contrasts emotional stability and even-temperedness with negative emotionality, such as feeling anxious, nervous, sad, and tense. Finally, Agreeableness contrasts a prosocial and communal orientation towards others with antagonism and includes skills such as altruism, tender-mindedness, trust, and modesty. I define Conscientiousness in the following section.

**Understanding Conscientiousness** Conscientiousness is the only personality skill among the five near-Big Five personality skills that shows statistically significant effects on longevity in this paper. Moreover, Conscientiousness affects both education and longevity, not just one of them. John and Srivastava (1999) define Conscientiousness as “individual differences in the propensity to follow socially prescribed norms for impulse control, to be task- and goal-directed, to be planful, to delay gratification, and to follow norms and rules.” Alternatively, Conscientiousness can be described as the “propensity to be organized, controlled, industrious, responsible, and conventional” (Roberts et al.,

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30 As we know, it is up to the researcher to determine how to label factors obtained by exploratory factor analysis. Interpretation of factors is derived from the interpretation of their measures. See Table 1 for the list of factors and their measures.

31 The exploratory factor analysis including measures of Neuroticism and Agreeableness from 1940 to be documented in the next version of this working paper.

32 All other psychological skills are statistically insignificant based on both individual and joint tests. Omitting the other skills leads to virtually no change in estimated coefficients and to a large decline in consumed degrees of freedom.
A growing body of evidence shows that personality skills develop both during childhood and afterwards. Helson et al. (2002) and Roberts et al. (2005) provide a comprehensive overview of the debate surrounding personality trait development. Using a cross-sectional evaluation of Conscientiousness by age, Srivastava et al. (2003) show that Conscientiousness increases throughout early and middle adulthood at varying rates. Roberts et al. (2006) conducts a meta-analysis of longitudinal studies, showing continuous changes in personality throughout life. Conscientiousness increases the most when people are in their 20s and 30s.

While the biological view of psychology still contends that developments of personality in adulthood are predetermined by biologically based, psychological tendencies (e.g., McCrae et al., 2000.), this traditional view of personality as pre-determined, stable, and non-malleable has been challenged by recent literature. Roberts and Bogg (2004) provide evidence showing that Conscientiousness and socioenvironmental factors influence and affect each other. Conscientiousness may change as a result of marriage or employment. Roberts et al. (2003) show the relationship between work experience and personality changes, including self-control, harm avoidance, and traditionalism, which are closely related to Conscientiousness. Heckman, Malofeeva, Pinto, and Savelyev (2011) show experimental evidence that externalizing behavior, which is closely related to Conscientiousness, can be strongly improved at ages 3–4 through educational intervention, at least for disadvantaged children, with major consequences for later life outcomes.

If personality skills are malleable during and after childhood, policy interventions with regards to parenting and counseling may be able to foster the growth of Conscientiousness. Piedmont (2001) reports that the outpatient counseling in a drug rehabilitation program showed significant shifts of the Big Five dimensions during, and even after, the intervention. Milgram and Toubiana (1999) and Pychyl et al. (2002) suggest that parent-

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33 An externalizing behavior is an aggressive, anti-social, or rule-breaking behavior.
ing styles influence procrastination, which is strongly related to child Conscientiousness. Finally, Forgatch and DeGarmo (1999) suggest that effective parenting practices can improve a child’s adjustment at school, which may well affect a child’s Conscientiousness. There is thus a sizable body of evidence indicating that Conscientiousness is likely malleable in both childhood and adulthood.

**Conscientiousness and IQ** Current literature suggests that while IQ is related to Openness, IQ and Conscientiousness are unrelated and so a selection on IQ doesn’t lead to a selection on Conscientiousness. In line with this claim, Ackerman and Heggestad (1997) show that the correlation of General Intelligence with Conscientiousness is both low (0.02) and statistically insignificant, whereas the correlation with Openness is sizable (0.33) and statistically significant. Similarly, the study by DeYoung et al. (2005) reports that the correlations between measures of Intelligence and Conscientiousness are generally statistically insignificant, while measures of Openness and Intelligence show statistically significant correlation ($p < .01$). Some recent studies suggest that there is a negative association between IQ and Conscientiousness. The main rationale behind this claim is that people with low IQ have a higher need to develop Conscientiousness (Moutafi et al., 2004). This idea has motivated research of relationships among Conscientiousness, intelligence and academic or professional success, as in Farsides and Woodfield (2003). While these claims deserve attention, a direct relationship between Conscientiousness and IQ has neither been proven nor widely accepted. Conversely, various papers continue to suggest that the relationship between IQ and Conscientiousness is either weak or non-existent. For instance, a recent study by Borghans et al. (2011) confirms a strong relationship between IQ and Openness, but finds no relationships between IQ and Conscientiousness. For the Terman sample, I also find that IQ and Conscientiousness are uncorrelated (see Table B-12 of the Web Appendix).
4 Methodology

4.1 Economic Model

The econometric model used in this paper is motivated by a version of the discrete
time life cycle economic model with time horizon $T$ years and uncertain duration of life
(Becker, 2007). I incorporate Conscientiousness into Becker’s model as an exogenous pa-
rameter: individuals cannot choose their levels of Conscientiousness, but Conscientious-
ness can possibly be influenced by parents and educators.\footnote{See Section 3 for a dis-
cussion of the growing evidence that Conscientiousness is malleable. In this simple model, I also abstract from a hypothetical possibility in line with (Becker and Mulligan, 1997) that
individuals may rationally invest in their Conscientiousness $\theta$ with the aim of reducing the discount on
future utilities.}

Consider a time-separable
expected utility function

$$U = \sum_{t=0}^{T} B^t(\theta) \cdot S_t(D, \theta) \cdot u_t(x_t, l_t), \tag{1}$$

where $B$ is the discount rate, $S_t$ is the unconditional survival probability through age $t$
for $t = 1, ..., T$, $S_0 = 1$, and $u_t(x_t, l_t)$ is the utility function at age $t$ determined by con-
sumption $x_t$ and leisure $l_t$. Let the discount rate, $B$, depend on Conscientiousness $\theta$ (Daly
et al., 2009). Let survival $S_t$\footnote{The corresponding probability in the econometric model will be defined in formula (10).} depend on years of education $D$\footnote{The model can be changed to use discrete schooling $D$, as in the rest of the paper, at the expense of losing the option to differentiate with respect to education.} and Conscientiousness $\theta$.

Consider a two-period model, which demonstrates the main features of the economic
problem and is easily generalizable to a multiple-period case using utility specification
(1) with a multiple-period budget constraint similar to a two-period constraint (3). Let
capital and annuity markets be perfect and earnings not be taxed. An individual maxi-
mizes the expected utility

\[ U(x_0, x_1, l_0, l_1, D; \theta) = u_0(x_0, l_0) + B(\theta) \cdot S_1(D, \theta) \cdot u_1(x_1, l_1) \]  

(2)

with respect to consumption \( \{x_0, x_1\} \), leisure \( \{l_0, l_1\} \), and education \( D \), subject to the intertemporal budget constraint\(^{38}\)

\[ x_0 + f(D, \theta) + \frac{S_1(D, \theta) \cdot x_1}{(1 + r)} = w_0(\theta) \cdot (1 - l_0) + \frac{S_1(D, \theta) \cdot w_1(D, \theta) \cdot (1 - l_1)}{(1 + r)}, \]  

(3)

where \( w_0(\theta) \) and \( w_1(D, \theta) \) are wages in period 0 and 1, and where the cost of education investment, \( f(D, \theta) \), depends on years of education and Conscientiousness.

Assume that (a) \( \partial w_0 / \partial \theta > 0 \), (b) \( \partial w_1 / \partial \theta > 0 \), (c) \( \partial^2 w_1 / \partial D \partial \theta > 0 \), (d) \( \partial B / \partial \theta > 0 \), (e) \( \partial^2 f / \partial D \partial \theta < 0 \), (f) \( \partial S_1 / \partial \theta > 0 \), and (g) \( \partial^2 S_1 / \partial D \partial \theta < 0 \).\(^{39}\) From the first-order conditions it follows that

\[ \frac{\partial u_0 / \partial l_0}{\partial u_0 / \partial x_0} = w_0(\theta) \]  

(4)

\[ \frac{\partial u_1 / \partial l_1}{\partial u_1 / \partial x_1} = w_1(D, \theta) \]  

(5)

\[ \frac{\partial u_0 / \partial x_0}{\partial u_1 / \partial x_1} = (1 + r) \cdot B(\theta) \cdot \frac{\partial u_1 / \partial x_1}{\partial u_1 / \partial x_1} \]  

(6)

\[ \frac{1}{1 + r} \cdot S_1(D, \theta) \cdot \frac{\partial w_1(D, \theta)}{\partial D} \cdot (1 - l_1) + \frac{1}{1 + r} \cdot B(\theta) \cdot \frac{\partial S_1(D, \theta)}{\partial D} \cdot \frac{u_1}{\partial u_1 / \partial x_1} = \frac{\partial f(D, \theta)}{\partial D} + \frac{1}{1 + r} \cdot \frac{\partial S_1(D, \theta)}{\partial D} [x_1 - w_1(D, \theta) \cdot (1 - l_1)]. \]  

(7)

\(^{38}\)In the present simple model, investments in health operate indirectly through investments in education. In contrast, in Grossman’s (1972) model, individuals directly invest in health. I leave generalizations of the current theoretical and empirical analysis for future research based on data better suited for studying direct health investments.

\(^{39}\)Based on the same data, Gensowski (2012) shows that, at least for experienced workers, \( \partial (w \cdot (1 - l)) / \partial \theta > 0 \) and \( \partial^2 (w \cdot (1 - l)) / \partial D \partial \theta > 0 \), which motivates assumptions (a), (b), and (c). Assumption (d) is in line with Daly et al. (2009). Assumption (e) is motivated by an observation that since education is effort-intensive it is less costly for Conscientious people, who are organized, controlled, planful, and hard working. Finally, assumptions (f) and (g) are based on the idea that Conscientiousness is good for longevity and that Conscientiousness and education substitute for each other in longevity production. Later in this paper I empirically confirm hypotheses (f) and (g).
Equations (4) and (5) coupled with assumptions (a) and (b) imply that higher Conscientiousness leads to higher compensated (i.e. Hicksian, utility-constant) labor supply\textsuperscript{40} in all periods of life. Equation (6) and assumption (c) imply that higher Conscientiousness leads to higher saving (or lower borrowing) in the early period of life.

Finally, equation (7) decomposes marginal costs and marginal benefits of education into several terms, all of which depend on Conscientiousness. Generally it is not clear whether these terms increase or decrease with Conscientiousness. Below, I discuss the terms of equation (7) on the high-hand-side (r.h.s), and on the left-hand-side (l.h.s.).

The first term on the r.h.s. is the marginal cost of education, which decreases with Conscientiousness by assumption (d). The second term is the discounted increase in the expected individual’s budget deficit in the second period of life induced by greater survival probability. While the marginal survival declines with Conscientiousness by assumption (e), the sign of the term is still unclear since, as predicted by equation (5) and assumption (b), consumption $x_1$, labor supply $(1 - l_1)$, and wage $w_1$ all increase with Conscientiousness, making the sign of the expression in the square brackets indeterminate.

The first term on the l.h.s. represents the discounted higher wages obtained as a result of getting higher education. The second term represents the additional expected utility obtained as a result of higher survival rate. In the first term, the survival rate, the marginal wage, and the labor supply all positively depend on Conscientiousness, by assumptions (f), (c), and by analysis above. In the second term, the discount rate $B(\theta)$ increases with Conscientiousness by assumption (d), while the marginal survival rate decreases by assumption (g), making the change of this term indeterminate too.

In summary, the model shows that Conscientiousness increases equilibrium levels of labor supply, consumption, and saving. The trait also decreases the marginal cost

\textsuperscript{40}The majority of leading experts in labor supply believe that the uncompensated (i.e. Marshallian) wage elasticity is either zero or positive (Fuchs et al., 1998), implying that the uncompensated labor supply is also likely increasing with Conscientiousness.
of education and increases the marginal monetary benefit of education. In addition, Conscientiousness likely affects the equilibrium choice of education, but the sign of this effect is unclear from the theoretical model and can thus be considered an empirical question. I answer this empirical question later in the paper.

The model also demonstrates that knowing the properties of the survival function, such as derivatives and cross-derivatives of the function with respect to education and Conscientiousness, is essential for understanding intertemporal choices such as educational investments. In this paper, I estimate the survival $S_t(D, \theta)$ as a function of education $D$ and Conscientiousness $\theta$ and investigate its properties controlling for the endogeneity of education, $D^* = D^*(\theta)$. I also empirically confirm hypotheses (f) and (g), as well as the Grossman hypothesis ($\partial S_t(D, \theta)/\partial D > 0$)

### 4.2 Econometric Models

From this section on, let $D$ be a categorical choice of the highest education level obtained in life. $D$ takes values from 1 to 5: (1) high school graduate, (2) some college, (3) Bachelor’s degree, (4) Master’s degree, and (5) Doctorate. My analysis is conditional on background variables $X$. I omit $X$ in formulas for a more compact notation.

#### 4.2.1 Longevity Model

The discrete time hazard function $h_t$ is the conditional probability that a person’s death occurs at age $t$ (event $T = t$),\(^{41}\) given that a person has survived to that age (event $T \geq t$). Let the hazard function depend on schooling $D$ and latent personality vector $\theta$:\(^{42}\)

$$h_t = \mathbb{P}(T = t | T \geq t, D, \theta). \quad (8)$$

The discrete time proportional odds model relates the conditional log-odds of the

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\(^{41}\)A random age of death is denoted by $T$.

\(^{42}\)Vector $\theta$ includes Conscientiousness and, possibly, other latent personality skills.
hazard $h_t$ to covariates and a time-specific intercept $\delta_t$ (Cox, 1972). An advantage of this model over a continuous time proportional hazard model is that the proportionality assumption can be easily relaxed by allowing for age-varying regression coefficients (Muthen and Masyn, 2005; Singer and Willet, 1993). Consider the following specification for the proportional odds model with an age-varying coefficient for education:

$$\ln \left( \frac{h_t}{1 - h_t} \right) = \sum_{d \neq q} \alpha_{dt} \cdot 1(D = d) + \sum_d \beta_d \cdot 1(D = d) \cdot \theta + \delta_t,$$  \hspace{1cm} (9)

where $1(D = d)$ is a random indicator that a person is at education level $d$, and $\alpha_{dt}$ are time-dependent coefficients. Index $q \in \{1, 2, \ldots, 5\}$ denotes the chosen reference category of education. The unconditional survival probability through age $\tau$ is given by a product of conditional survival functions:

$$S_{\tau}|D, \theta = \prod_{t=1}^{\tau} (1 - h_t).$$  \hspace{1cm} (10)

### 4.2.2 Education Choice Model

I use a generalized ordered logit model for studying schooling choice, since more parsimonious ordered choice models proved to be poorly specified. The model specifies

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43 This discrete time hazard model uses full years of life as a measure of survival: once a person reaches his birthday, he survives to the next age of life.

44 In an exploratory analysis, the proportional hazard test is rejected with respect to education variables. The discrete model also allows for age-varying regressors.

45 In this model, $\alpha_{dt}$ depends on time $t$ only for $d = 1$ and $d = 5$ in order to relax the proportional odds assumption precisely for those variables for which the assumption is violated, as I found based on preliminary estimation.

46 The reference category of education is some college education ($q = 2$).

47 $S_{\tau}$ is traditionally called “unconditional survival probability.” This term might be confusing, since the probability is still conditional on being alive at starting point $t = 0$, which, in this paper, corresponds to being alive at one’s 31st birthday. Hence, $t = 1$ corresponds to survival through age 31, while $\tau$ corresponds to survival through age $\tau + 30$, which can also be phrased as survival to age $\tau + 31$. For instance, once a person has reached his 81st birthday, he has survived through age 80, and to age 81.

48 For the ordered logit model, the Brant test (Brant, 1990) of the parallel regression assumption is rejected. This is a test of equality of coefficients of a number of binary logit models (4 binary models in this paper with 5 education categories) implied by the the ordered logit model. I also find that for a multinomial logit, which is a potential alternative to the generalized ordered logit, the independence of irrelevant alternatives assumption is not satisfied. Therefore, I use a generalized ordered logit.
conditional probabilities of choosing each level of education as

\[ P(D > d | \theta) = g(a_d + b_d \theta) = \frac{\exp(a_d + b_d \theta)}{1 + \exp(a_d + b_d \theta)}, \]  

so that

\[ P(D = 1 | \theta) = 1 - g(a_1 + b_1 \theta) \]  

\[ P(D = d | \theta) = g(a_{d-1} + b_{d-1} \theta) - g(a_d + b_d \theta), d = 2, 3 \]  

\[ P(D = 4 | \theta) = g(a_4 + b_4 \theta). \]

4.2.3 Latent Factor Model

In order to account for personality variables as determinants of longevity and schooling choice it is natural to use a factor model (15) as an integral component of longevity model (8–9) and schooling models (11–14). Each of the factors \( \theta^i, i \in I = \{O, C, E, A, N\} \), depend on multiple measures \( M_{k_i} \), where \( k_i \in \{1, \ldots, K_i\} \), and \( K_i \) is the total number of measures of factor \( i \).

The model below accounts for different degrees of relation of measures \( M_{k_i} \) to factors \( \theta^i \) by allowing different coefficients \( \psi_{k_i} \) relating them. By estimating the factor model, I explicitly account for the measurement error in proxies, thus avoiding the attenuation bias:

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49 Factor models are designed for obtaining a small number of latent factors based on multiple noisy and correlated observable variables (e.g., Bollen, 1989).

50 “OCEAN” stands for Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism (See Section 3).

51 As shown by Cunha et al. (2010), it is theoretically possible to identify a general nonlinear factor model. However, given the relatively small sample size, a standard linear factor model is optimal for this project.
\[ M_i^1 = \psi_i^1 \theta_i^1 + \pi_1 A + \eta_i^1 \]
\[ M_i^2 = \psi_i^2 \theta_i^2 + \pi_2 A + \eta_i^2 \]
\[ \ldots \]
\[ M_i^{ij} = \psi_{K_i}^i \theta_i^j + \pi_{K_i} A + \eta_{K_i}^{ij} , \text{for all } i \in \mathcal{I}, \]

where \( \psi_i^1 \) is normalized to unity to achieve identification; \( \theta_i^j \perp \perp \eta_{K_i}^{ij} \) for all \( i \) and \( j \in \mathcal{I} \) and all \( k_i \in \{1, \ldots, K_i\} \); \( \eta_{K_i}^{ij} \perp \perp \eta_{K_i}^{ij} \), unless \( i = j \) and \( k_i = k_i \), but with no requirement of orthogonality between skills: \( \theta_i^j \not\perp \theta_i^j \) for \( i \neq j \). In addition, for all \( i \in \mathcal{I} \) and \( k_i \in \{1, \ldots, K_i\} \), \( \mathbb{E}(\eta_{K_i}^{ij}) = 0 \) and \( \mathbb{E}(\theta_i^j) = 0 \). \( A \) is age at the time of measurement to make latent factors \( \theta \) age-adjusted. Equations (15) have no intercepts, since all measures are standardized for the estimation sub-sample.\(^52\) A model with correlated factors and with at least three dedicated measures per factor is identified (e.g., Heckman, Malofeeva, Pinto, and Savelyev, 2011).

However, as mentioned above, I found that only Conscientiousness is predictive of longevity, while other skills consume many degrees of freedom without contributing to the model fit.\(^53\) Therefore, I use only one latent factor, Conscientiousness, in the final longevity model specification. As follows from Web Appendix A, Conscientiousness is well proxied by four measures, namely “prudence and forethought,” “conscientiousness,” “truthfulness,” and “freedom from vanity and egoism.” There are the same measures of Conscientiousness that psychologists found in earlier studies (Friedman et al., 1993).\(^54\)

\(^{52}\) A standardized measure \( M \) is obtained from a raw measure \( M' \) by a linear transformation: \( M = (M' - \bar{M}') / sd(M') \), where \( \bar{M}' \) and \( sd(M') \) denote a mean and a standard deviation of the raw measure. Such standardization is a standard technique in psychometrics (Allen and Yen, 2002).

\(^{53}\) Table B-10 of the Web Appendix confirms that a one-factor model controlling for Conscientiousness is preferable to a three-factor model by comparing AIC and BIC statistics, which are about twice as large for the three-factor model. For more information about Conscientiousness, see Table 2.

\(^{54}\) As already reported above, the Big Five Conscientiousness is briefly defined as “... the propensity to follow socially prescribed norms for impulse control, to be task- and goal- directed, to be planful, to delay gratification, and to follow norms and rules” (John and Srivastava, 1999). “Prudence” and “conscientiousness” are directly related to this definition. “Freedom from vanity and egoism” as well as “truthfulness” are related not only to to Conscientiousness (following socially accepted norms of behavior), but also, perhaps, to Agreeableness (Friedman et al., 1995). See Figure 12 for different shares of signal in measures.
### 4.2.4 Model Estimation

Following a standard approach (e.g., Muthen and Masyn, 2005), for a subject $i$, who is right-censored at age $t_i$, we only know that he was still alive at the time of censoring ($T_i = t_i - 1$). The ex-ante probability of such event is

$$P(T_i > t_i - 1) = \prod_{j=1}^{t_i-1} (1 - h_{ij}). \quad (16)$$

For the uncensored subjects, we know that $T_i = t_i$ with probability

$$P(T_i = t_i) = h_{it_i} \prod_{j=1}^{t_i-1} (1 - h_{ij}). \quad (17)$$

Hence, for a sample of $n$ subjects, we can form a likelihood function $L = \prod_{i=1}^{n} l_i$, such that

$$l_i = (h_{it_i})^{\xi_i} \prod_{j=1}^{t_i-1} (1 - h_{ij}), \quad (18)$$

where $\xi_i$ is 1 if the individual is uncensored, and 0 if he is right-censored. In order to account for latent factor $\theta$ as a determinant of the hazard function $h_i$ or educational attainment $D$ on the EM algorithm.

### 4.3 Treatment Effect Calculation

#### 4.3.1 Overcoming Endogeneity and Reverse Causality

As mentioned earlier, there are two major statistical problems that prevent us from interpreting correlation between education and longevity as causal effect (e.g., Gross-of Conscientiousness ranging from 20% (for “freedom from vanity”) to 77% (for “conscientiousness”).

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55 Right-censored subjects are those who either dropped out during the course of the study or were alive by the end of the study.

56 The uncensored subjects are those who died during the course of the study.
man, 2000): (1) a possible existence of confounding factors that affect both education and longevity, and (2) a possibility of reverse causality (expected longevity may affect education). In this paper, I address both problems in order to separate out the causal effect of education on longevity.

I employ a method alternative to IV that relies on the extraordinary richness of Terman data. I base the identification of the causal effects on the assumption that, conditional on background characteristics, all dependence across longevity outcomes given education and education choices comes from cognitive and personality skills. This is the same identification assumption as in Heckman, Stixrud, and Urzúa (2006). The background characteristics include early health, private tutoring, World War II experience, and detailed family background information including early deaths of mother and father (see Table 1). I account for the latent factor in a parametric factor model.

To address the reverse causality problem, I employ three techniques, which control for early health conditions that may allow subjects to anticipate short life and thus result in low educational investments. First, I drop all subjects who had severe medical conditions early in their life and so could expect early death. Second, I control for measures of early health, so that the effect of education is measured conditional on early health, which is a predictor of longevity. Finally, I restrict consideration to subjects who survived through age 30, which rules out people who died early and could potentially anticipate this. By construction, education is a past event for people in the estimation sample.

Even though it is generally impossible to fully account for confounding factors and reverse causality, I believe that using the methods described above makes adverse effects of confounding factors and reverse causality negligible given the extraordinary richness of Terman data.

57 Only 2.3% of respondents were still at school at age 30.
4.3.2 The Effect of Education

According to formula (10), the treatment effect of changing education from level \( d \) to level \( d' \) on the probability of survival through age \( \tau \) for a person with personality \( \lambda \) and will be\(^58\)

\[
\Delta_\tau(d, d', \lambda) = (S_\tau|D = d, \theta = \lambda) - (S_\tau|D = d', \theta = \lambda).
\] (19)

We can also obtain the unconditional average treatment effect by integrating (19) over the distribution of personality:

\[
\Delta_\tau(d, d') = \int \Delta_\tau(d, d', \lambda) d\theta(\lambda).
\] (20)

This effect based on the full model (model 1) can be compared with the effect calculated for a partial model (model 2) that does not account for Conscientiousness but accounts for background variables

\[
\tilde{\Delta}_\tau(d, d') = (\tilde{S}_\tau|D = d) - (\tilde{S}_\tau|D = d'),
\] (21)

and with the effect calculated for another partial model (model 3) that accounts neither for background variables nor for Conscientiousness

\[
\hat{\Delta}_\tau(d, d') = (\hat{S}_\tau|D = d) - (\hat{S}_\tau|D = d').
\] (22)

Here \( \tilde{S}_\tau \) and \( \hat{S}_\tau \) are analogous to \( S_\tau \) in formula (10), but are based on hazards \( \tilde{h}_t \) and \( \hat{h}_t \) calculated for partial models 2 and 3.

\(^58\)This model is based on the conditional independence assumption, which implies no selection effect after controlling for latent skills. Therefore, within this model, there is no difference among such parameters as the average treatment effect (ATE), the effect of treatment on the treated (TT), and the effect of treatment on the untreated (TUT) (Heckman and Vytlacil, 2007).
4.3.3 Direct, Indirect and Total Effects of Personality

For a random person from the Terman population, the expected survival probability as a function of personality can be written as

$$p_\tau(\lambda) = \sum_{d=1}^{5} P(D = d|\theta = \lambda)(S_\tau|D = d, \theta = \lambda).$$  \hspace{1cm} (23)

The total effect of some particular malleable trait $i$ can be decomposed into direct and indirect effects:

$$\frac{dp_\tau(\lambda)}{d\lambda^i} = \text{total effect} = \sum_{d=1}^{5} P(D = d|\theta = \lambda) \frac{\partial}{\partial \lambda^i}(S_\tau|D = d, \theta = \lambda) \text{direct effect}$$

$$+ \sum_{d=1}^{5} \frac{\partial}{\partial \lambda^i} P(D = d|\theta = \lambda)(S_\tau|D = d, \theta = \lambda) \text{indirect effect}$$  \hspace{1cm} (24)

The indirect effect represents enhanced survival probability induced by a higher level of education, which is, in turn, induced by higher Conscientiousness. The direct effect represents the part of the effect of Conscientiousness that is unrelated to enhanced education.
5 Empirical Results

5.1 Descriptive Results

Figure 2 shows nonparametric estimates of survival $S_r$ by education and gender. For males, higher levels of education correspond to increased longevity. For females, no substantial difference is observed between the survival curves. Although the survival curve for the sample of 27 females with doctoral degrees visually stays apart the other curves, the sample size is too small to make the statistical inference that this curve is below the others.\(^{59}\) Indeed, Figure 3 of the main paper and Figures D-2–D-7 of the Web Appendix show that we cannot statistically distinguish between survival curves for females with different education, while survival curves for males generally differ significantly, at least at older ages. Survival curves plotted for various levels of Conscientiousness, with higher Conscientiousness corresponding to higher longevity, also differ more for males than for females (see Figure 4).

Figure 5 displays the association between Conscientiousness and education by showing kernel densities of factor scores by education.\(^{60}\) Generally, densities for higher levels of education are shifted to the right. An exception is Conscientiousness of males with some college, for whom the kernel density is, on average, much lower than that of high school graduates.\(^{61}\) Another exception is the Conscientiousness of females with a doctorate: the mean of their Conscientiousness is to the left of the corresponding means for both females with bachelor’s and master’s degrees.\(^{62}\) While distributions of skills by

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\(^{59}\)Obtaining a doctorate for this generation of females was an unusual path. Indeed, while about 25% of males in this sample obtained a doctorate, only 5% of females did so as well even though they were no different in terms of their intelligence.

\(^{60}\)See also Figures D-10 and D-10 of the Web Appendix for similar displays for IQ, Openness, and Extraversion.

\(^{61}\)Males with some college education went to college but did not get a bachelor’s degree despite their exceptional IQ. Low Conscientiousness may partly explain this outcome. This result is similar to that by Heckman and co-authors (Heckman et al., 2011a,b), who showed that high school drop-outs, even those with GED certificates, have low non-cognitive skills. Thus, there is a similarity between high-IQ college drop-outs and high school drop-outs from the general population.

\(^{62}\)This curve is for a very small and unusual group of 27 females. These women chose to obtain a doctor-
education demonstrate gender-specific features, there are no sizable gender differences in overall distributions of skills by gender (see Figure D-9 of the Web Appendix).

5.2 Results of Longevity, Education, and Measurement Models

I first discuss results on the scale of estimation, namely estimated model coefficients. Afterwards, I proceed with results on the scale of interest, such as the probability of survival through age 70 and its dependence on education and Conscientiousness. The results on the scale of estimation are clearly linked to the econometric model but might be hard to interpret, especially for nonlinear models. In contrast, results on the scale of interest are less clearly linked to the model, but directly address the question of interest.

The econometric model in this paper estimates the technology of human survival graphically displayed in Figure 1. In this model, latent Conscientiousness affects the hazard of death both directly and indirectly. The indirect channel operates through the change in education induced by a change in Conscientiousness. The direct channel summarizes all causal links from Conscientiousness to survival, excluding the education channel.

Model Estimates \textbf{Estimates} for the proportional odds model of mortality hazards (see equations (8), (9), and (15)) are presented in Tables 3 and 4.\textsuperscript{63} Negative coefficients in the tables imply a lower hazard of death and, thus, greater longevity. The tables include estimates for the full model (model 1), as well as for three partial models that are misspecified by omitting various right-hand-side variables (models 2–4). Tables 3 and 4 also show the proportional odds test $p$-values for model 1. The $p$-values of the test are large, implying that we cannot reject the current parsimonious model specification.\textsuperscript{64}

\textsuperscript{63}Tables 3 and 4 show estimates for the key variables only. Estimates for background controls and for the measurement system are presented and described in the Web Appendix (see Tables B-1–B-3).

\textsuperscript{64}The proportional odds test is a likelihood ratio test. The current (restricted) model with a constant regression coefficient over time is compared with an unrestricted model, where the regression coefficient is allowed to change freely over time. High $p$-values indicate that the specification of the current parsimo-
The “model 1” panel of Table 3 shows that both education and Conscientiousness decrease the odds ratio of the hazard of death for males. All else being equal, the estimates suggest that there is a negative and statistically significant effect of exogenously varied education on the hazard-of-death odds ratio. We also see that Conscientiousness negatively affects the odds of the hazard of death, although that effect is only statistically significant at lower levels of education (high school diploma, some college, and bachelor’s degree).

Misspecified models 2–4 in Table 3 are presented for comparison with model 1. For education levels above some college, the estimated effects of education are generally stronger in absolute value for models 2–4 than for model 1. Clearly, model 1 eliminates the upward omission bias by accounting for a set of control variables, some of which are correlated with both education and health. Coefficients for the high school diploma variable show opposite trends when comparing model 1 with models 2 and 3, for which Conscientiousness is omitted. This inverse sign of the omission bias is expected because of the inverse relationship between Conscientiousness and the choice of some college education over a high school diploma for males (see Figure 5, panel (a)).

Estimates for females are statistically insignificant with a few exceptions (see Table 4). As with males, Conscientiousness decreases the odds of the hazard of death for females with some college. However, the effects of Conscientiousness for women with a high school diploma or a bachelor’s degree are not precisely determined, unlike those for males.

Gender differences are consistent with results by Conti and Heckman (2010),
who show that both education and personality skills affect health and health behaviors more for males than for females. There are large positive estimates of coefficients for having a doctorate at ages 30–59 and 60–69, with the estimate for ages 60–69 being statistically significant. This implies that females with a doctoral degree who were born at the beginning of the 20th century have higher odds ratio of the death hazard than females with only some college, at least at ages 60–69.68

The effects of Conscientiousness and Cognition on the probabilities of schooling choices are shown in Table 5. For both males and females, educational attainment is increasing in Conscientiousness. Higher Conscientiousness of males leads to higher probabilities of obtaining education above some college, above Bachelor’s degree, and above Master’s degree compared to corresponding alternatives: some college and below, Bachelor’s degree and below, Master’s degree and below. At the same time, there is no effect of Conscientiousness on the probability of getting education higher than high school graduate.69 For females, Conscientiousness leads to higher probabilities of obtaining education above high school, some college, and a Bachelor’s degree, but not above a Master’s degree.70 IQ increases the probability of obtaining education above high school and above some college, but these effects are only statistically significant for males. All mentioned results are true for models with and without conditioning on

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68 In Appendix C, I show that having a doctoral degree for females born, on average, in 1910, is associated with lower family life satisfaction, lower general happiness, and fewer children. Some of these factors, along with relatively low Conscientiousness of females with a doctorate (see Figure 5), could be behind this unusual pattern of longevity. At the same time, I found no evidence that females with a doctorate degree were less likely to be married or more likely to be divorced than other females. Moreover, the Terman data suggest that being single is associated with higher mortality for males but not for females (see Figure D-8 of the Web Appendix).

69 No effect of Conscientiousness on the probability of obtaining education above high school graduate level can be explained by two opposite effects of Conscientiousness, which cancel each other: (1) a person is more likely to be a high school graduate than a college drop-out if Conscientiousness is higher (see Figure 5(a)), and (2) a person is more likely to hold a bachelor’s degree or above than a high school diploma if Conscientiousness is higher.

70 No effect on obtaining a doctorate is in line with unusually low Conscientiousness of females with doctorates born approximately around 1910 (see Figure 5(b)).
background variables.\textsuperscript{71}

**Treatment Effect of Education** In Figure 6, I show the causal effects of additional education of males on the probability of survival through ages varying from $\tau = 40$ to 80, calculated based on formula (20).\textsuperscript{72} All effects are relative to baseline education (high school)\textsuperscript{73} and conditional on survival through age 30.\textsuperscript{74}

The treatment effects of education on longevity of males are generally large and statistically significant. The effects represent the increase in survival probability through a particular age. The effects increase up to age 70 and decline afterwards. The maximum at age 70 is generated by two competing mechanisms. When people are young too little time has passed to observe large differences in survival. When people are old too many people have died, including those educated, to observe large education gradients. As a limiting case, expect no difference in survival to age 130 by education, since survival is zero no matter the education. Thus at least for the Terman population, age 70 is the age to observe the greatest education gradients in survival. At age 70, the effect of education varies from a 20 to a 30 percentage points increase in the probability of survival, depending on the final education level (compare panels (a)–(d) of Figure 6).

**Survival Conditional on Education and Conscientiousness** Consider survival thorough age 70 as a function of education and Conscientiousness. The estimate of the survival function, represented by formula (10), is shown in Figure 7. Each line in the figure corresponds to a particular level of education. The slope of each line represents the effect

\textsuperscript{71}Coefficients associated with background variables are presented in Tables B-8 and B-9 of the Web Appendix.

\textsuperscript{72}Corresponding estimates for females are statistically insignificant. See Figure D-12 of the Web Appendix.

\textsuperscript{73}The effects of additional education on longevity for people with baseline education higher than a high school diploma are generally statistically insignificant (see Figures D-20 and D-21 of the Web Appendix).

\textsuperscript{74}As discussed above, conditioning on survival through age 30 is motivated by a completion of education by that age by almost all subjects, which makes education a past event. In Tables B-4–B-7 of the Web Appendix I show that results of the model are robust to the choice of such age: regression coefficients and $p$-values for models with other reasonable initial ages such as 25 and 35 are similar.
of Conscientiousness on survival. Numbers corresponding to each line show $p$-values for the effect of Conscientiousness. These $p$-values imply that Conscientiousness has statistically significant effect on longevity for people with high school, some college, and Bachelor’s degree, but not for those with Master’s degree or Doctorate. While slopes represent the effect of Conscientiousness given education, vertical gaps between lines represent the causal effect of education given Conscientiousness.

Figure 7 allows us to derive some policy implications. First, education is effective for increasing longevity when Conscientiousness is low. Arrow AB represents the effect of inducing a high school graduate with low Conscientiousness to obtain at least some college education below a Bachelor’s degree. The effect of this policy is an increase in the probability of survival through age 70 from 30 to 55%. Second, provided that Conscientiousness is indeed malleable, as discussed in Section 3, an increase in Conscientiousness represented by arrow AC leads to improvement of survival from 30 to 40%. Finally, induced Conscientiousness can, in turn, induce higher educational attainment as represented by arrow AC inducing arrows CD, CE, and CF. Later in this section I show that the induced indirect effect of Conscientiousness on survival is much smaller than the direct effect.

**Treatment Effect of Education Conditional on Conscientiousness** This section presents the effects of education relative to baseline high school level on survival of males through age 70 by deciles of Conscientiousness. In Figure 8, the bold solid curves represent the effects, while the thin dashed curves represent the 90% and the 95% bootstrap confidence intervals. The estimates are downward-sloping with Conscientiousness, implying that Conscientiousness is a substitute for education in producing longevity. Effects tend to be strong (25–50 percentage points) and statistically significant at low levels of Con-

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75 $P$-values are taken from Table 3.

76 The effects of additional education for males with higher baseline levels of education and for females with any such levels are generally statistically insignificant (see Figures D-13–D-19 in the Web Appendix).
scientiousness. However, at high levels of Conscientiousness, estimates decline to 17–22 percentage points, and are no longer statistically significant. The loss of significance usually occurs above the eighth decile of Conscientiousness (see panels (b)-(d) of Figure 8). The effect on longevity of obtaining some college education by a high school graduate (see panel (a) of Figure 8) is much smaller than the effects of obtaining the higher levels of education discussed above, since some college education is close to a high school education. This effect is only statistically significant at the 95% level only for deciles 3–5 and at the 90% level for deciles 1–7. Note, that “some college” is not a precisely determined level of education, ranging from one college course to almost a full set of courses needed to obtain a Bachelor’s degree, which may contribute to less precise estimates of the effect shown in panel (a).

**Direct, Indirect, and Total Effects of Conscientiousness** Figure 9 shows direct, indirect, and total effects of Conscientiousness on survival through age 70 calculated based on formula (24) for a random person from the Terman sample. The indirect effect of Conscientiousness is a change in longevity caused by a change in the educational attainment induced by a change in Conscientiousness. The direct effect of Conscientiousness is the causal effect of Conscientiousness through all channels excluding the indirect channel. Finally, the total effect is the sum of the direct and the indirect effects (see Figure 1 for a scheme of the effects).

The effect is the change in survival probability, in percentage points, per one standard deviation change in Conscientiousness. From the first to the ninth decile of Conscientiousness, the estimates of the effects of Conscientiousness decline from 7.8 to 2.8 for the total effect, 6.5 to 3.3 for the direct effect, and 1.2 to −0.4 for the indirect effect. The declining estimate of the indirect effect estimates can be explained by generally declining estimates of the effect of education that were previously discussed (see Figure 8 of the main paper and Figures D-13–D-15 of the Web Appendix). The direct effect appears

\[^{77} We cannot make any strong conclusions about the effect itself because of high standard errors.\]
to be declining, too. The total effect estimate is also declining, since it is a sum of declining direct and indirect effect estimates. Education is just one of many channels through which Conscientiousness affects longevity. Estimates suggest that the education channel might be sizable, although it is certainly not the only major channel through which Conscientiousness affects longevity.

Figure 10 presents each of the three curves from Figure 9, but with the 90% and the 95% bootstrap confidence intervals shown. The total effect of Conscientiousness (see panel (a)) is statistically significant at the 95% level for deciles 1–4 and at the 90% level for deciles 1–6. The direct effect in panel (b) is not significantly different from zero at the 95% significance level, but is statistically significant for deciles 1–6 at the 90% significance level. The indirect effect shown in panel (c) is not precisely determined.

### Bias from Omitting Conscientiousness

Figure 11 compares the estimated effect on survival through age 70 based on the full model (“model 1,” see formula (20)) with the effects based on the partial models (“model 2” and “model 3,” see formulas (21) and (22)). Model 2 does not account for Conscientiousness (see the “omitted $\theta$” bar of Figure 11), and model 3 accounts for neither Conscientiousness nor background variables (see “omitted $\theta$ and $X$” bar).

Figure 11 also compares the bias from omitting Conscientiousness with the bias from omitting both Conscientiousness and background variables. The figure shows that a bias from omitting Conscientiousness only is about a half of the bias from omitting both Conscientiousness and background variables (15% bias), even though background variables include many essential controls such as parental education and occupation (see Table 1 for a full list of background variables).

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78 Even though the affect is called “direct,” it likely works through multiple channels such as doing physical exercise, healthy diet, stable marriage, and the like. If effects of these channels decline with conscientiousness, like it happens with education, this may explain the declining direct effect of conscientiousness.

79 Corresponding decompositions for females are based on a smaller sample and are not precisely determined.
6 Discussion

In this work, I establish the causal effect of education on the longevity of high-ability males. This is a contribution to the literature, as the causal status of higher education in health and longevity production has been controversial (e.g., Clark and Royer (2009); Mazumder (2008)). In addition, I establish the role of a personality trait, Conscientiousness, that affects both education and longevity and interacts with education in producing longevity. In the introduction, I mention how my findings are related to results in the literature. Below, I discuss this relationship in more detail.

There is no such thing as a single “causal effect of education on health” because the effect of education on health generally depends on type of health outcome, level of education, level of cognitive and personality skills, age, and gender. Every dataset has natural restrictions on what effects can be estimated and which methods can be used for causal effect identification. Thus, we can only achieve a comprehensive understanding of education’s causal status through efforts of multiple researchers estimating this effect using a large variety of data and methodologies. This paper contributes to these efforts by filling in the gaps in our knowledge about the effects of higher education on longevity of high-ability individuals.

Results in the literature concerned with the influence of cognitive ability and higher education on health could be verified using results of this paper. For instance, my results imply that generalizations of the main results of Auld and Sidhu (2005) should be made with caution. Auld and Sidhu (2005) use three health measures from the National Longitudinal Survey of Youth data: two health limitations indicators, and a general health index for the relatively healthy years below age 43. The authors use parental education and, in some specifications, occupation as instrumental variables and arrive at

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80 I consider longevity as one of possible measures of health, since death can be considered as an indicator of extremely poor health, at least in the moment before death. A good property of this measure is that it is an objective measure unlike self-evaluated health.

81 The two binary health limitations indicators are (1) health limits the type of employment; (2) health limits the amount of employment. The general health index is SF12.
a key conclusion that schooling beyond high school contributes very little to health. They also conclude that both schooling and cognitive ability are strongly related to health at their low levels, but are less related or unrelated at high levels. In contrast, my work shows that, even conditional on the top 0.4% of cognitive ability, education beyond high school strongly affects health at least for males, implying that even the highest IQs cannot fully substitute for education in producing health. On a separate note, Auld and Sidhu (2005) use the AFQT achievement test, not IQ. This suggests that the effect they observe may be partly due to Conscientiousness, since achievement tests are known to be largely dependent on personality (Borghans et al., 2011).

This paper supplements results in the literature that investigate causal effects of education on health and longevity by using compulsory schooling laws as instruments (Adams, 2002; Arendt, 2005, 2008; Lleras-Muney, 2005; Silles, 2009; Spasojevic, 2003). All of these papers identify the effect of education on health at relatively low levels of education, below high school diploma. The paper by Lleras-Muney (2005) and the reanalysis by Mazumder (2008) are based on cohort assumption and identify the causal effect of changes in compulsory education on longevity. My paper supplement findings of the authors by identifying the effect of higher education on longevity. Furthermore, I do not need to rely on the synthetic cohort assumption, since the Terman dataset follows the same cohort for 70 years.

My results also confirm and supplement findings by Grossman (1975), who finds that post-high school education has strong effects on the health of middle-aged, white males from the top 50% of the cognitive ability distribution, even after controlling for a number of background, economic, and early health variables. I confirm Grossman’s findings by showing that even after eliminating the ability bias through controlling for

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82 Changes in compulsory education occurred in the range of 0–10 years of schooling.
83 Higher education corresponds to about 13–20 years of schooling.
84 The men were volunteers, accepted as candidates to the Aviation Cadet status in 1943. The minimum passing score in the qualifying examination could be achieved by about one half of high school graduates (Grossman, 1975).
latent psychological factors, I still obtain strong and statistically significant effect of education on longevity. I also supplement Grossman’s findings by discovering an interaction of education with Conscientiousness in affecting longevity.

Some of the results of this paper, such as the declining effects of education with Conscientiousness and gender differences, can be partly explained by recent results by Conti, Heckman, and Urzúa (2010); Conti, Heckman, and Urzua (2010) on the effect of education on health behaviors. These authors study the effects of latent cognitive and nocognitive factors on education, health, and health behaviors based on the British cohort data. They show that the effects of higher education on health behaviors and health indicators vary with levels of early cognitive and personality skills even at ages as young as 30. They find that the effects of higher education tend to be stronger when the level of a personality trait is low. Smoking is an example of health behavior with such an outcome. Moreover, for some health behaviors and health outcomes such as the use of cannabis, depression, and general health, the authors find strong effects for males, but not for females, when a personality trait is low.

Relation of this Paper to Work by Friedman and Co-Authors Psychologist Howard Friedman and his co-authors have extensively studied the associations between personality and health-related outcomes such as health behaviors, health, and longevity. They also investigated possible mechanisms behind these associations. Friedman and Martin (2011) provide a comprehensive summary of findings from papers by Friedman and co-authors related to health and longevity and based on Terman data. My results are based on the same data but on a more elaborate methodology, and supplement findings by these authors.

I add to results by Friedman et al. by establishing the causal effect of higher education on longevity and the interaction between education and Conscientiousness in

85 The personality scale of self-regulation that the authors use includes Locus of Control, Perseverance, Cooperativeness, Completeness, Attentiveness, and Persistence (Conti, Heckman, and Urzúa, 2010). Most of these measures should be related to Conscientiousness.
affecting longevity. In addition, I elaborate on earlier works by Friedman et al. by using a less restrictive statistical model, by exploring gender differences in the effects of education and Conscientiousness on longevity, and by establishing a well-specified model supported by multiple tests of specification and robustness.

Friedman and co-authors use two models that rely on proportional hazard assumption: the Cox proportional hazard model and the Gompertz model (Friedman et al., 1995, 1993). I use a model that preserves the semiparametric feature of the Cox model (no parametric assumption about age dependence), while allowing for the relaxation of the proportionality assumption for all variables for which it doesn’t hold. In addition, I use binary variables for each education level thus relaxing the strong assumption of proportionality of effect of education to years of schooling relied on by Friedman et al. (1995; 1993). I also account for latent factors and the measurement error in measures by using a one-step maximum likelihood estimation procedure. In contrast, Friedman and co-authors use equally-weighted indexes of psychological measures as regressors (Friedman et al., 1993). Thus, they fail to account for measurement errors in the proxies of skills. Yet, I find that measurement error is not equal for different measures of Conscientiousness.86 As I show in Figure 12, measurement error in measures of Conscientiousness ranges from 24% (for a measure called “Conscientiousness”) to 80% (for a measure called “Freedom from vanity”).

Based on new exploratory factor analysis, I confirm the Conscientiousness measures used by Friedman and co-authors. I also complement results of the previous literature by finding that we can reliably control for Openness using 1922 measures, but I do not find any effect of childhood Openness on longevity. This result may not hold for other populations, since Terman sample was selected on IQ, which correlates with openness.

Throughout this paper, I use a number of findings by Friedman and co-authors when interpreting my results. Friedman et al. argue that Conscientiousness leads to better

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86In this paper I use the same four measures of childhood Conscientiousness as Friedman with co-authors.
health habits (less smoking, drinking, and substance abuse), better social environments, and more stable marriages (Friedman and Martin, 2011; Goodwin and Friedman, 2006). They argue that there is a negative association between Conscientiousness and a large array of severe medical conditions including serious depressions, diabetes, tuberculosis, and stroke.

A meta-analysis by Kern and Friedman (2008) based on 20 different samples shows that the link between Conscientiousness and longevity is not specific to Terman subjects. Furthermore, Martin and Friedman (2000) calculate correlations between the Big Five skills and skills based on the Terman questionnaires and show a strong relationship between them. These results allow me to relate my findings to the established Big Five taxonomy of personality skills and argue about possible generalizations of my results.

Conscientiousness and Education as Substitutes in Longevity Production In this paper, I show empirically that Conscientiousness and education are substitutes in the production of longevity. As shown in Tables 3 and 4, the effects of Conscientiousness on longevity are only strong and statistically significant at low levels of education (high school, some college, and bachelor’s degree for males; some college for females). At the same time, the effect of education on longevity has a tendency to decline with Conscientiousness, which is especially evident for the effect of obtaining a master’s degree or a doctorate (see panels (c) and (d) in Figure 8). This strong negative interaction between Conscientiousness and education in producing longevity was previously unknown and needs explanation.

I conjecture that this interaction occurs because Conscientiousness and education affect health and longevity through many common mediators including smoking, alcohol consumption, mental health, physical activity, patient adherence to medical protocols, and obesity. Given these overlapping mediators, it is possible that Conscientiousness

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87 The effect is relative to the baseline category: high school graduate.
88 Researchers find effects of education on the following mediators of longevity: smoking, obesity, de-
and education crowd each other out in the production of health. High levels of Conscientiousness improve outcomes for these health mediators, thus lessening the effect of additional educational attainment (and vice versa). This intuition is in line with results from Conti et al. (2010, 2010) who show a negative interaction between education and self-control, a trait closely related to Conscientiousness, in affecting smoking (for males and females), depression (for males), and obesity (for males).

**Gender Differences** It has been firmly established in the literature that women live longer than men, even though they have higher morbidity and lower socio-economic statuses. Women are more biologically robust, less exposed to risky and unhealthy behaviors, and use more preventative care, and these differences positively affect their longevity (see, for example, Read and Gorman (2010) for a survey of findings on gender differences in health and longevity).

In this paper, I find strong effects of education and Conscientiousness on the longevity of males, whereas the effects for females are not precisely determined. These gender differences have two sources, each documented in the literature: (1) differential effects of education on health behaviors, and (2) differential effects of health behaviors on health. Conti et al. (2010) find that the causal effects of education on obesity, exercise, and employment are stronger for males than for females, thus contributing to the first source of gender differences. The second source of gender differences is the greater biological robustness of females that was mentioned above: longevity of females is less affected by external factors.

expression, diet, alcohol consumption, physical activity, regular exercise, regular health checkups, and patient adherence to medical protocols (Conti et al., 2010; Droomers et al., 1998, 1999; Hegazi et al., 2010; Park and Kang, 2008; Ross and Mirowsky, 1998, 1999; Thrane, 2006). It has also been demonstrated that Conscientiousness affects at least the following mediators: smoking, alcohol consumption, mental health, patient adherence to medical regimens for renal dialysis, vigorous physical activity, physical activity, drug use, unhealthy eating, risky driving, risky sex, suicide, and violence (Bogg and Roberts, 2004; Christensen and Smith, 1995; de Brujin et al., 2009; Friedman et al., 1995; Martin et al., 2007, 1995; Roberts and Walton, 2004).
**Data Limitations and External Validity** The effects of education and Conscientiousness on the longevity of males at the top 0.4% of the cognitive distribution and born at the beginning of the 20th century are likely generalizable to males from later cohorts and with lower intelligence. Moreover, effects for later cohorts might be even stronger.

Not much has changed in the social role of males since the beginning of the 20th century. Later generations have increased longevity, but there is no reason to believe that the effects of education and Conscientiousness, which are primarily mediated through healthy lifestyles (Bogg and Roberts, 2004), would disappear. Moreover, contemporary cohorts have better knowledge regarding the determinants of health, especially about hazardous effects of smoking and unhealthy diet. This likely makes the effect of Conscientiousness even stronger than for Terman subjects, since conscientious people are better at resisting temptation. For instance, the Terman data shows that both child and adult Conscientiousness are inversely correlated with smoking and heavy drinking.

Furthermore, the results can likely be generalized to populations with somewhat lower IQs. As already mentioned, both Conscientiousness and education are known to affect health through healthy lifestyles (Bogg and Roberts, 2004; Hampson and Friedman, 2008). Unlike cognitively loaded activities such as professional chess playing, practicing a healthy lifestyle does not require an extraordinarily high cognitive ability. In line with this theoretical consideration, I find no effect of IQ on longevity and no interactions (a) between IQ and Conscientiousness and (b) between IQ and education. Hence, it is likely that the estimated effects of both education and Conscientiousness on longevity are also valid also for people with somewhat lower IQs. Grossman’s results, which were discussed above, suggest that IQ levels as low as the median of a cognitive score distribution of high school graduates might still have similar moderating capabilities (Grossman, 1975).

In contrast to the results for males, little can be said or generalized about females. Model estimates of the effects of education and Conscientiousness on longevity for fe-
males are, generally, not precisely determined. It is possible that the descriptive results for females, such as those in Figures 2–5, D-5-D-9, D-11 and in Tables 2–1, might be generalizable to somewhat lower IQs for the same cohort. However, the results may not be generalizable to later cohorts, since the role of females in the society, specifically in the marriage and job markets, as well as their freedom to choose a lifestyle changed dramatically during the course of the 20th century.

7 Conclusions

In line with the emerging literature in economics of human development, this paper explicitly accounts for psychological skills in order to investigate relationships between education, psychological skills, and longevity. To obtain my results, I use concepts and methods from psychometrics, a discipline at the forefront of measuring both cognitive and personality skills.

I apply these tools to a widely recognized, but still largely unsolved problem in health economics: the problem of unknown confounding factors that may affect both education and health, leading to spurious correlation and false causality claims. I find a confounding factor, Conscientiousness, which has proven to be firmly linked to its well-established Big Five counterpart (Martin and Friedman, 2000), and which strongly affects both education and longevity. In addition, Conscientiousness strongly interacts with education in affecting longevity.

I find a strong causal effect of both higher education and Conscientiousness on longevity for males, and I further determine that education and Conscientiousness are substitutes for each other. The effect of Conscientiousness on longevity is only strong at low levels of education, and the effect of education on longevity is especially strong at low levels of Conscientiousness.

The causality of education on health and longevity has standard implications for pos-
itive education subsidies in cases where education investments are at sub-optimal levels. The causality of Conscientiousness, however, suggests a new dimension for economic thought and public policy: encouraging the development of child Conscientiousness at home and at school may contribute to the production of both education and longevity. Thus, the question of the malleability of Conscientiousness deserves increased research efforts.
Figure 1: A Scheme of the Production Function for Longevity

Note: This scheme is a simplified visualization of the statistical model estimated in this paper and defined by equations (8), (9), and (11)–(15). In the scheme, I use notation \( a_t(\theta) \), \( b(D) \), and \( c \), which is a separate notation from that in the formulas.

Latent childhood personality skills \( \theta \) causally affect education \( D \). Education causally affects the hazard of death, with the effect \( a_t(\theta) \) depending on the level of personality skills and varying by age \( t \). In turn, the effect \( b(D) \) of personality skills on the hazard of death depends on the level of education \( D \). By allowing for interaction between education and personality skills I account for the fact that both education and personality skills affect longevity through the same health behaviors not shown on the scheme.

The three major variables of interest—personality skills, education, and the hazard of death—are not only related among themselves, but are also related to other variables. Background variables \( X \) affect all of them. Hazard of death depends on age-specific effect \( \delta_t \). Finally, personality skills affect their measures. Each measure is also affected by a measurement error, \( \eta \) and background variables \( X \).
Figure 2: Survival Function, $S_T$, by Education

(a) Males

(b) Females

Notes: Probability of survival is conditional on survival through age 30. Sample sizes are shown in parentheses. Education groups are mutually exclusive and refer to the highest level of education obtained in life. Calculations are based on the Terman data.
Figure 3: Survival Function, $S_\tau$, by Selected Education Categories

(a) High School vs. Bachelor, Males

(b) High School vs. Bachelor, Females

(c) High School vs. Doctorate, Males

(d) High School vs. Doctorate, Females

Notes: Probability of survival is conditional on survival through age 30. Sample sizes are shown in parentheses. Education groups are mutually exclusive and refer to the highest level of education obtained in life. One standard error curve is shown above and below each survival curve. Calculations are based on the Terman data. Survival curves for all other pairs of education categories are presented in Web Appendix C.
Figure 4: Survival Function, $S_T$, by Conscientiousness

Notes: Survival estimates are conditional on survival to age 30. One standard error curve is shown above and below each survival curve. Calculations are based on the Terman data. Survival curves are plotted for three intervals of Conscientiousness:

1. Lower than one standard deviation below the mean
2. From one standard deviation below the mean to one standard deviation above the mean
3. Higher than one standard deviation above the mean
Figure 5: Conscientiousness by Education

Notes: Kernel densities of Conscientiousness factor scores are shown. Normal kernel is used with bandwidth 0.8. Calculations are based on the Terman data. See Figures D-10 and D-11 of the Web Appendix for similar charts regarding other psychological traits.
Figure 6: Increase in Survival of Males Caused by Additional Education over Baseline Survival of High School Graduates

Notes: Treatment effects are effects on the probability of survival through a given age conditional on survival through age 30. The effects are calculated for various ages \( \tau \) using formula (20). Dashed lines denote 95% bootstrap confidence intervals. Calculations are based on the Terman data. For corresponding graphs for females, which show no statistically significant effect, see Web Appendix D, Figure D-12.
Figure 7: Probability of Survival through Age 70 by Conscientiousness and Education

Notes: The figure represents a model estimate of the probability of survival conditional of Conscientiousness and education as represented by formula (10). Slopes of lines represent the effect of Conscientiousness on survival conditional on education, with $p$-values for the effects shown next to each line. Horizontal gaps between lines represent the causal effect of education conditional on Conscientiousness. Arrows represent possible policies discussed in Section 5.2. Policy AB enhances longevity through inducing a person to obtain some college education, while policy AC does so through enhancing the childhood Conscientiousness. Beneficial effects on longevity such as CD, CE and CF are induced by policy AC of enhancing Conscientiousness of a person who would otherwise choose high school education, but with his enhanced level of Conscientiousness may now choose a higher level of education.
Figure 8: Increase in Survival of Males through Age 70 Caused by Additional Education over Baseline Survival of High School Graduates Conditional on Conscientiousness

Notes: The survival through age 70 is conditional on survival through age 30. Lines on these plots are calculated based on formula (19). Dashed lines represent the 95% bootstrap confidence intervals; dash-dot lines represent the 90% bootstrap confidence intervals. Calculations are based on the Terman data. For corresponding graphs for females, which show no statistically significant results, see Appendix D, Figure D-16.
Figure 9: Direct, Indirect, and Total Effects of Conscientiousness on Survival through Age 70, Males

Notes:
The effect is the change in the probability of survival in response to a small change in Conscientiousness. The scale of the effect corresponds to one standard deviation change in Conscientiousness. Survival through age 70 is conditional on survival through age 30. The decomposition is calculated based on formula (24).
Figure 10: Direct, Indirect, and Total Effects of Conscientiousness on Survival through Age 70, Males

Notes: The effect is the change in the probability of survival in response to a small change in Conscientiousness. The scale of the effect corresponds to one standard deviation change in Conscientiousness. Survival through age 70 is conditional on survival through age 30. Dashed lines denote the 95% bootstrap confidence intervals; dash-dot lines denote the 90% bootstrap confidence intervals. Calculations are based on the Terman data. The total, direct, and indirect effects are calculated based on formula (24).
Figure 11: Bias from Omitting Conscientiousness

Notes: Treatment effects estimated are effects on the probability of survival through age 70 conditional on survival through age 30 induced by obtaining Master’s degree. “Full model” is model 1 as in formula (9). The “model with omitted $\theta$” is model 2 accounting for background variables but not for Conscientiousness. The “model with omitted $\theta$ and $X$” is model 3, which accounts neither for Conscientiousness nor for background variables. The effects are calculated using formula (20) for model 1, formula (21) for model 2, and formula (22) for model 3. Calculations are based on the Terman data. See Figure D-24 for similar calculations for different ages $\tau$ and different levels of education.
Figure 12: Share of Signal in Measures of Conscientiousness

Notes: “Signal” is the share of explained variance in the total variance of measure $M^C_k$, $k^C \in \{1, \ldots, 4\}$, calculated by formula $100\% \cdot (\psi^C_k)^2 \cdot \frac{\text{var}(\theta^i)}{\text{var}(M^C_k)}$ using notation from formula (15) of the main paper.
## Table 1: Education and Background Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Year of measurement</th>
<th>Males</th>
<th>Standard Error</th>
<th>Females</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest Education Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School Graduate</td>
<td>1922-1968</td>
<td>.100 (.012)</td>
<td>.114 (.014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some College</td>
<td>1922-1968</td>
<td>.165 (.014)</td>
<td>.198 (.018)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bachelor’s Degree (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922-1968</td>
<td>.303 (.018)</td>
<td>.416 (.022)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Master’s Degree or equivalent (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922-1968</td>
<td>.186 (.015)</td>
<td>.220 (.018)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doctorate (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922-1968</td>
<td>.247 (.017)</td>
<td>.052 (.010)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General Intelligence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IQ (&lt;i&gt;^e&lt;/i&gt;)</td>
<td>1922</td>
<td>149.142 (.409)</td>
<td>148.293 (.430)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early Health</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal birth of no birth problems mentioned (&lt;i&gt;^f&lt;/i&gt;)</td>
<td>1922</td>
<td>.576 (.019)</td>
<td>.632 (.021)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No breastfeeding (&lt;i&gt;^g&lt;/i&gt;)</td>
<td>1922</td>
<td>.091 (.011)</td>
<td>.085 (.012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health rating in 1922 (&lt;i&gt;^f&lt;/i&gt;)</td>
<td>1922</td>
<td>8.518 (.076)</td>
<td>9.013 (.083)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical energy rating in 1922 (&lt;i&gt;^f&lt;/i&gt;)</td>
<td>1922</td>
<td>8.218 (.073)</td>
<td>8.805 (.078)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor mother’s health during pregnancy (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.169 (.015)</td>
<td>.177 (.017)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low birthweight (below 2.5 kg) (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.020 (.006)</td>
<td>.046 (.010)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persistent mouth breathing in 1922 (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.025 (.007)</td>
<td>.020 (.007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequent or very frequent colds in 1922 (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.165 (.015)</td>
<td>.112 (.014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headaches mentioned in 1922 (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.167 (.015)</td>
<td>.178 (.018)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headaches frequent or severe in 1922 (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.007 (.003)</td>
<td>.010 (.005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition poor or fair in 1922 (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.091 (.012)</td>
<td>.071 (.012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental Longevity and Background</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother is deceased in 1922</td>
<td>1922</td>
<td>.027 (.006)</td>
<td>.033 (.008)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father is deceased in 1922</td>
<td>1922</td>
<td>.080 (.011)</td>
<td>.075 (.012)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father’s age of death below 50 (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922-1950</td>
<td>.011 (.004)</td>
<td>.015 (.005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother’s age of death below 45 (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922-1950</td>
<td>.027 (.006)</td>
<td>.040 (.009)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parents are divorced before 1922</td>
<td>1922</td>
<td>.051 (.009)</td>
<td>.046 (.009)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father has at least a bachelor’s degree</td>
<td>1922</td>
<td>.287 (.018)</td>
<td>.254 (.019)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother is employed</td>
<td>1922</td>
<td>.127 (.013)</td>
<td>.131 (.015)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father is a professional</td>
<td>1922</td>
<td>.239 (.017)</td>
<td>.272 (.020)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Either parent from outside the US</td>
<td>1922</td>
<td>.301 (.018)</td>
<td>.266 (.019)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Either parent from Europe</td>
<td>1922</td>
<td>.219 (.016)</td>
<td>.206 (.018)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental finances limited or very limited (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.464 (.022)</td>
<td>.434 (.024)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental social position below average (&lt;i&gt;^a&lt;/i&gt;)</td>
<td>1922</td>
<td>.124 (.015)</td>
<td>.109 (.015)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>World War II Experience</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WWII Participation</td>
<td>1945</td>
<td>.413 (.019)</td>
<td>.027 (.007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WWII Combat Experience</td>
<td>1945</td>
<td>.094 (.011)</td>
<td>.004 (.003)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohort</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohort: 1904 - 1907</td>
<td>1922</td>
<td>.225 (.016)</td>
<td>.168 (.016)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohort: 1912 - 1915</td>
<td>1922</td>
<td>.300 (.018)</td>
<td>.362 (.021)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estimation Sample</td>
<td></td>
<td>661</td>
<td>519</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- (<i>a</i>) Includes those with a Bachelor’s degree who took some graduate courses but did not obtain any graduate degree.
- (<i>b</i>) Includes all completed graduate-level degrees below entry-level doctorate.
- (<i>c</i>) Includes both entry level and research level doctoral degrees such as M.D., LL.B., LL.M, and Ph.D. (<i>d</i>) The best estimate of IQ in 1922 is provided by survey organizers and is based on all available test scores including Stanford Binet and Terman Group Tests. (<i>e</i>) Indicators of conditions at birth and early health investments (breastfeeding) are reported retrospectively by parents in 1922. (<i>f</i>) An average over non-missing values of teachers’ and parents’ ratings is used, which leads to greater sample size and the use all available information (even though teachers are generally superior raters, they might still be unaware of some specific health issues of the student that are known to parents). Teachers and parents evaluated health and physical energy of the student by placing a sign on a line interval. This graphical rating was converted by the Terman group to numbers ranging from 1 to 13. (<i>g</i>) Variables marked with “(g)” are not controlled for in the final model, but robustness checks (available upon request) show that controlling for them does not change model results in any significant way, while generally reducing the estimation sample size below the numbers shown in the bottom of the table.
### Table 2: Measures of Intelligence and Personality

<table>
<thead>
<tr>
<th>Measures of personality skills (a)</th>
<th>Year of measurement</th>
<th>Cronbach’s alpha (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>males</td>
<td>females</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prudence and forethought</td>
<td>1922</td>
<td>0.783</td>
</tr>
<tr>
<td>Freedom from vanity</td>
<td>1922</td>
<td>0.771</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>1922</td>
<td></td>
</tr>
<tr>
<td>Truthfulness</td>
<td>1922</td>
<td></td>
</tr>
<tr>
<td>Openness</td>
<td>1922</td>
<td>0.768</td>
</tr>
<tr>
<td>Desire to know</td>
<td>1922</td>
<td>0.718</td>
</tr>
<tr>
<td>Originality</td>
<td>1922</td>
<td></td>
</tr>
<tr>
<td>Intelligence</td>
<td>1922</td>
<td></td>
</tr>
<tr>
<td>Extraversion</td>
<td>1922</td>
<td>0.732</td>
</tr>
<tr>
<td>Fondness for large group</td>
<td>1922</td>
<td>0.678</td>
</tr>
<tr>
<td>Leadership</td>
<td>1922</td>
<td></td>
</tr>
<tr>
<td>Popularity</td>
<td>1922</td>
<td></td>
</tr>
<tr>
<td>Agreeableness</td>
<td>1940</td>
<td>0.626</td>
</tr>
<tr>
<td>Easy to get along with</td>
<td>1940</td>
<td>0.600</td>
</tr>
<tr>
<td>Tries to avoid arguments (c)</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Critical of others (c)</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Avoids saying things that might hurt feelings of others (c)</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Ignores feelings of others (c)</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Neuroticism</td>
<td>1940</td>
<td>0.742</td>
</tr>
<tr>
<td>Moodiness</td>
<td>1940</td>
<td>0.675</td>
</tr>
<tr>
<td>Sensitive feelings</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Affected by praise or blame of others (c)</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Worries over humiliating experiences (c)</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Easily feels hurt (c)</td>
<td>1940</td>
<td></td>
</tr>
<tr>
<td>Frequently burdened by remorse or regret (c)</td>
<td>1940</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
(a) Grouping is based on the exploratory factor analysis (available upon request). I use teachers’ ratings for year 1922 and self-ratings for year 1940.
(b) Cronbach’s alpha (see Cronbach, 1951) is a statistic that captures how well a set of measures proxies a latent skill. Cronbach’s alpha is the lower bound of the internal consistency reliability of measures that are proxies for a skill. The internal consistency reliability is defined as the square of the correlation between the measured scale defined as the sum of the measures and the underlying skill $\theta$ (Allen and Yen, 2002). The Cronbach’s alphas can also be interpreted as a correlation between the observed scale and a hypothetical alternative scale measuring the same skill and based on the same number of hypothetical alternative items (Nunnally and Bernstein, 1994).
(c) All measures marked with “(c)” are binary. All other measures are continuous obtained by asking raters to place a sign onto a line interval. These graphical continuous ratings were converted by the Terman group to numbers ranging from 1 to 13.
Table 3: Proportional Odds Model of Mortality Hazard, Main Variables, Males

<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coef. p-value</td>
<td>coef. p-value</td>
<td>coef. p-value</td>
<td>coef. p-value</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High School × 30-59</td>
<td>.558 (.067)</td>
<td>.488 (.104)</td>
<td>.483 (.102)</td>
<td>.558 (.063)</td>
</tr>
<tr>
<td>High School × 60-69</td>
<td>.795 (.008)</td>
<td>.684 (.027)</td>
<td>.667 (.031)</td>
<td>.774 (.011)</td>
</tr>
<tr>
<td>High School × 70-up</td>
<td>-.026 (.942)</td>
<td>-.174 (.635)</td>
<td>-.243 (.513)</td>
<td>-.124 (.737)</td>
</tr>
<tr>
<td>Some College</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>-.306 (.056)</td>
<td>-.383 (.023)</td>
<td>-.416 (.013)</td>
<td>-.332 (.032)</td>
</tr>
<tr>
<td>Master’s Degree</td>
<td>-.302 (.089)</td>
<td>-.448 (.015)</td>
<td>-.481 (.009)</td>
<td>-.345 (.042)</td>
</tr>
<tr>
<td>Doctorate × 30-59</td>
<td>-.160 (.568)</td>
<td>-.235 (.392)</td>
<td>-.344 (.197)</td>
<td>-.281 (.302)</td>
</tr>
<tr>
<td>Doctorate × 60-69</td>
<td>-.738 (.024)</td>
<td>-.810 (.013)</td>
<td>-.900 (.005)</td>
<td>-.840 (.009)</td>
</tr>
<tr>
<td><strong>Conscientiousness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscientiousness × High School</td>
<td>-.482 (.032)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Some College</td>
<td>-.441 (.058)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Bachelor’s Degree</td>
<td>-.394 (.031)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Master’s Degree</td>
<td>-.282 (.210)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Doctorate</td>
<td>.219 (.222)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Background Variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log-likelihood</td>
<td>-5246.04</td>
<td>-1928.90</td>
<td>-1945.04</td>
<td>-5261.71</td>
</tr>
<tr>
<td>Degrees of freedom</td>
<td>100</td>
<td>87</td>
<td>69</td>
<td>82</td>
</tr>
<tr>
<td>Sample</td>
<td>661</td>
<td>661</td>
<td>661</td>
<td>661</td>
</tr>
</tbody>
</table>

Notes: (a) The table shows estimates for model described by equations (8), (9), and (15). $p$-Values below 0.1 are in bold. “–” refers to an omitted variable. Estimates for background variables can be found in the Web Appendix, Table B-1. Calculations are based on the Terman data.
Table 4: Proportional Odds Model of Mortality Hazard, Main Variables, Females

<table>
<thead>
<tr>
<th>Education</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Proportional odds test for model 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coef.</td>
<td>p -value</td>
<td>coef.</td>
<td>p -value</td>
<td>coef.</td>
</tr>
<tr>
<td>High School × age 30-59</td>
<td>-.091</td>
<td>(.857)</td>
<td>-.084</td>
<td>(.868)</td>
<td>-.138</td>
</tr>
<tr>
<td>High School × age 60-69</td>
<td>.847</td>
<td>(.030)</td>
<td>.860</td>
<td>(.024)</td>
<td>.804</td>
</tr>
<tr>
<td>High School × age 70-up</td>
<td>-.880</td>
<td>(.104)</td>
<td>-.867</td>
<td>(.117)</td>
<td>-.898</td>
</tr>
<tr>
<td>Some College</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Bachelor’s Degree</td>
<td>.009</td>
<td>(.965)</td>
<td>-.046</td>
<td>(.835)</td>
<td>-.053</td>
</tr>
<tr>
<td>Master’s Degree</td>
<td>-.067</td>
<td>(.789)</td>
<td>-.088</td>
<td>(.732)</td>
<td>-.073</td>
</tr>
<tr>
<td>Doctorate × age 30-59</td>
<td>.530</td>
<td>(.356)</td>
<td>.481</td>
<td>(.389)</td>
<td>.461</td>
</tr>
<tr>
<td>Doctorate × age 60-69</td>
<td>.952</td>
<td>(.070)</td>
<td>.921</td>
<td>(.102)</td>
<td>.883</td>
</tr>
<tr>
<td>Doctorate × age 70-up</td>
<td>-.117</td>
<td>(.831)</td>
<td>-.143</td>
<td>(.798)</td>
<td>-.159</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × High School</td>
<td>-.264</td>
<td>(.500)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Some College</td>
<td>-.510</td>
<td>(.034)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Bachelor’s Degree</td>
<td>.007</td>
<td>(.975)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Master’s Degree</td>
<td>.209</td>
<td>(.595)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Conscientiousness × Doctorate</td>
<td>.103</td>
<td>(.838)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Background Variables</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>–</td>
</tr>
<tr>
<td>Log-likelihood</td>
<td>-3841.17</td>
<td>–</td>
<td>-1216.13</td>
<td>–</td>
<td>-1224.05</td>
</tr>
<tr>
<td>Degrees of freedom</td>
<td>99</td>
<td>86</td>
<td>69</td>
<td>82</td>
<td>–</td>
</tr>
<tr>
<td>Sample</td>
<td>519</td>
<td>519</td>
<td>519</td>
<td>519</td>
<td>–</td>
</tr>
</tbody>
</table>

Notes: (a) The table shows estimates for model described by equations (8), (9), and (15). p-Values below 0.1 are in bold. “–” refers to an omitted variable. Estimates for background variables can be found in the Web Appendix, Table B-2. Calculations are based on the Terman data.
Table 5: Generalized Ordered Logit Model of Schooling Choice, Main Variables

<table>
<thead>
<tr>
<th>Models</th>
<th>Choice 1 (a)</th>
<th>Choice 2</th>
<th>Choice 3</th>
<th>Choice 4</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Background Controls (b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>-.103 (.642)</td>
<td>.400 (.013)</td>
<td>.586 (.000)</td>
<td>.511 (.002)</td>
<td>661</td>
</tr>
<tr>
<td>IQ</td>
<td>.530 (.004)</td>
<td>.292 (.010)</td>
<td>.105 (.220)</td>
<td>.018 (.868)</td>
<td></td>
</tr>
<tr>
<td>Without Background Controls (c)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>.056 (.789)</td>
<td>.537 (.000)</td>
<td>.635 (.000)</td>
<td>.494 (.002)</td>
<td>661</td>
</tr>
<tr>
<td>IQ</td>
<td>.414 (.002)</td>
<td>.236 (.011)</td>
<td>.138 (.081)</td>
<td>-.009 (.927)</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Background Controls (b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>.527 (.060)</td>
<td>.438 (.027)</td>
<td>.423 (.021)</td>
<td>.057 (.889)</td>
<td>519</td>
</tr>
<tr>
<td>IQ</td>
<td>.279 (.149)</td>
<td>.142 (.266)</td>
<td>.027 (.811)</td>
<td>-.063 (.740)</td>
<td></td>
</tr>
<tr>
<td>Without Background Controls (c)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>.668 (.004)</td>
<td>.540 (.002)</td>
<td>.515 (.005)</td>
<td>.133 (.741)</td>
<td>519</td>
</tr>
<tr>
<td>IQ</td>
<td>.139 (.321)</td>
<td>.100 (.362)</td>
<td>-.011 (.916)</td>
<td>.003 (.985)</td>
<td></td>
</tr>
</tbody>
</table>

Notes:
(a) Choice 1 is a binary choice between (1) high school education and (2) higher degrees (some college to a Doctorate);
Choice 2 is a binary choice between (1) high school or some college education and (2) higher degrees (Bachelor’s degree to a Doctorate);
Choice 3 is a binary choice between (1) high school to Bachelor’s degree and (2) higher degrees (Master’s degree to Doctorate);
Choice 4 is a binary choice between (1) high school to Masters’s degree and (2) a Doctorate;
Calculations are based on the Terman data.
(b) These estimates are conditional on background controls, see Table B-8 and B-9 of the Web Appendix for the remaining estimates.
(c) These estimates are based on a model where only latent Conscientiousness and IQ are used as explanatory variables of the education choice.
References

Ackerman, P. L. and E. D. Heggestad (1997). Intelligence, personality, and interests: Evidence for overlapping traits. Psychological Bulletin 121(2), 219–245.


