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Beyond IQ: The Rising Value of Extraversion

Online Appendix

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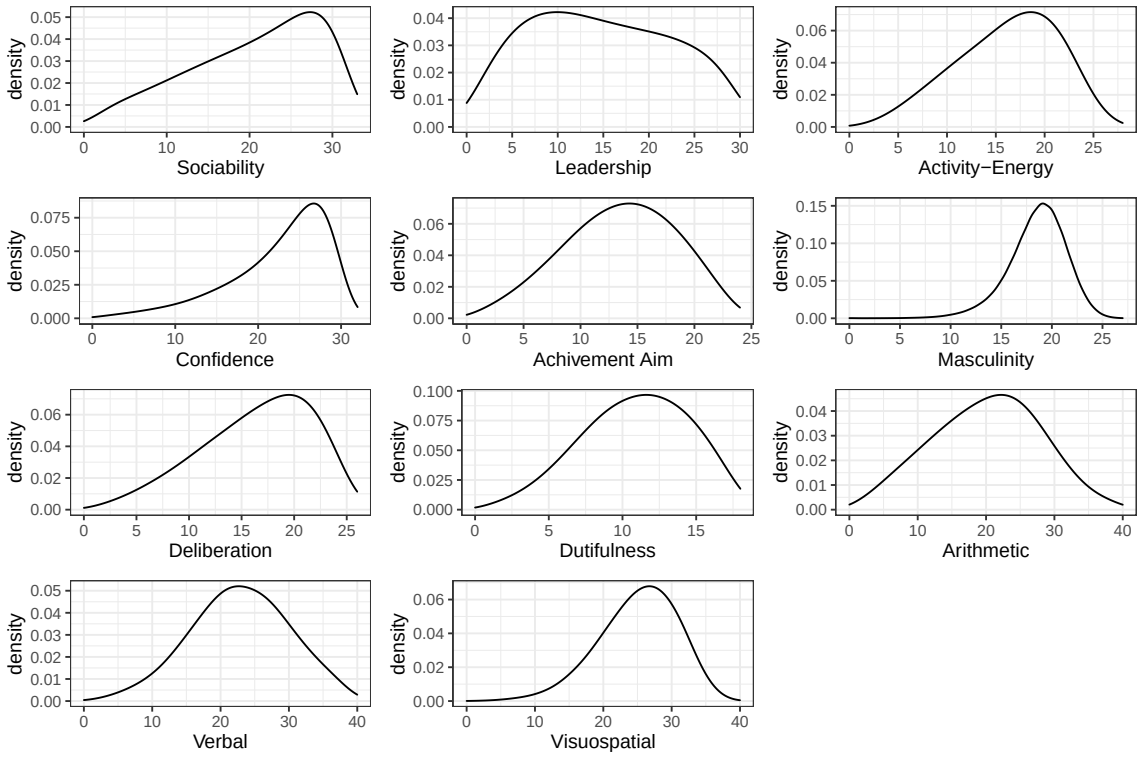
A Supplementary Figures and Tables

Figure A1: Cognitive and Personality Test Score Distributions



Notes: Density plots of the raw test scores. The personality test contains 218 statements with a response scale of yes/no. The raw score for a trait is the sum of affirmative answers in that subscale. The cognitive test contains 40 multiple-choice questions for each scale. Visuospatial, arithmetic, and verbal scores are the number of correct answers. The sample includes all men with valid military test scores ($N \approx 489,000$).

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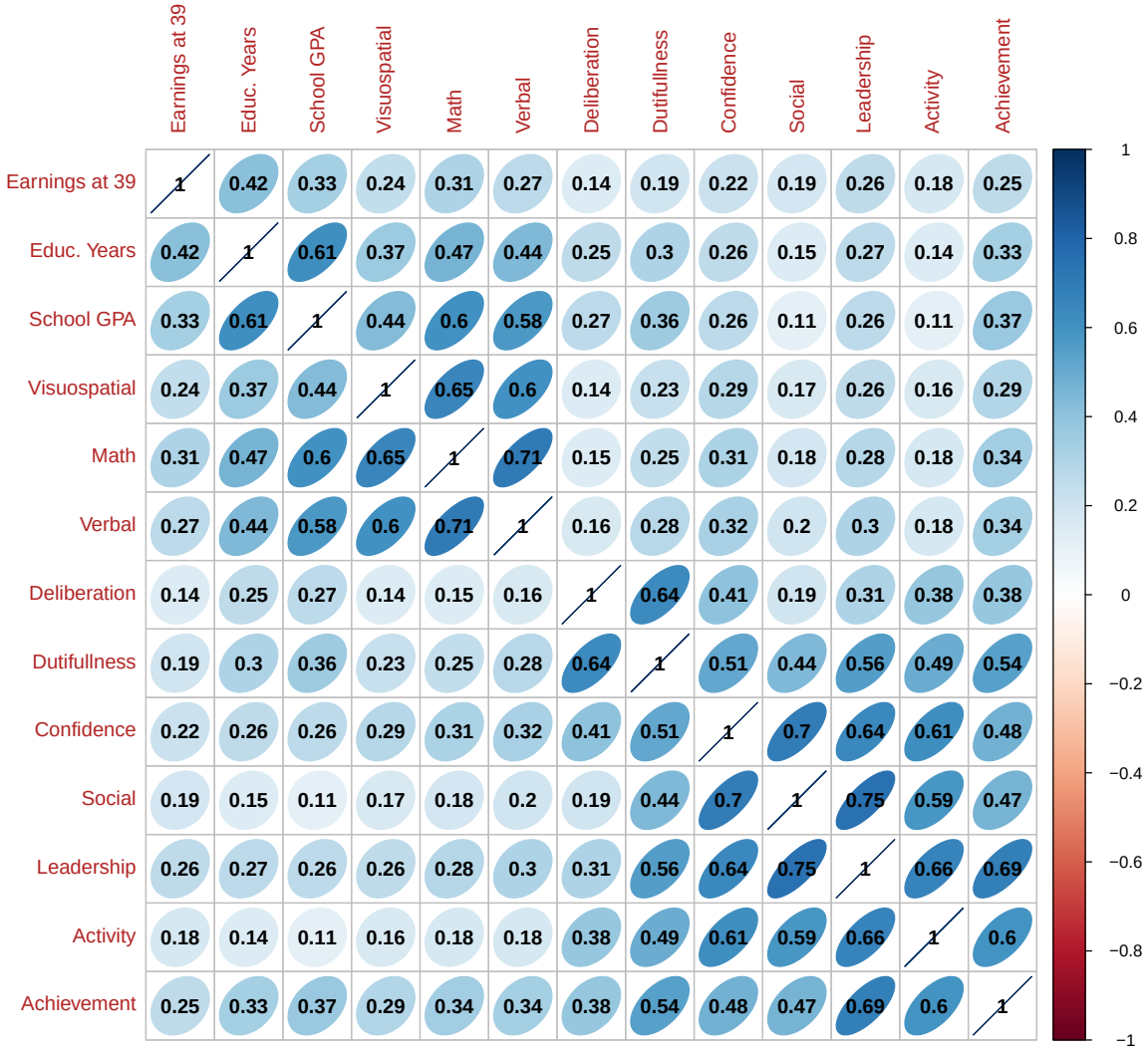
Figure A2: Cross-Correlations



Notes: Each number is a pairwise correlation coefficient with person as the unit of observation. All variables, apart from earnings and education years, are standardized to have mean 0 and standard deviation 1 within cohorts. Earnings are measured by the sum of wage and entrepreneurial income earned at age 39 as recorded by the tax authority. The data include all men for whom we have data for the given pairwise correlation ($N \approx 489,000$).

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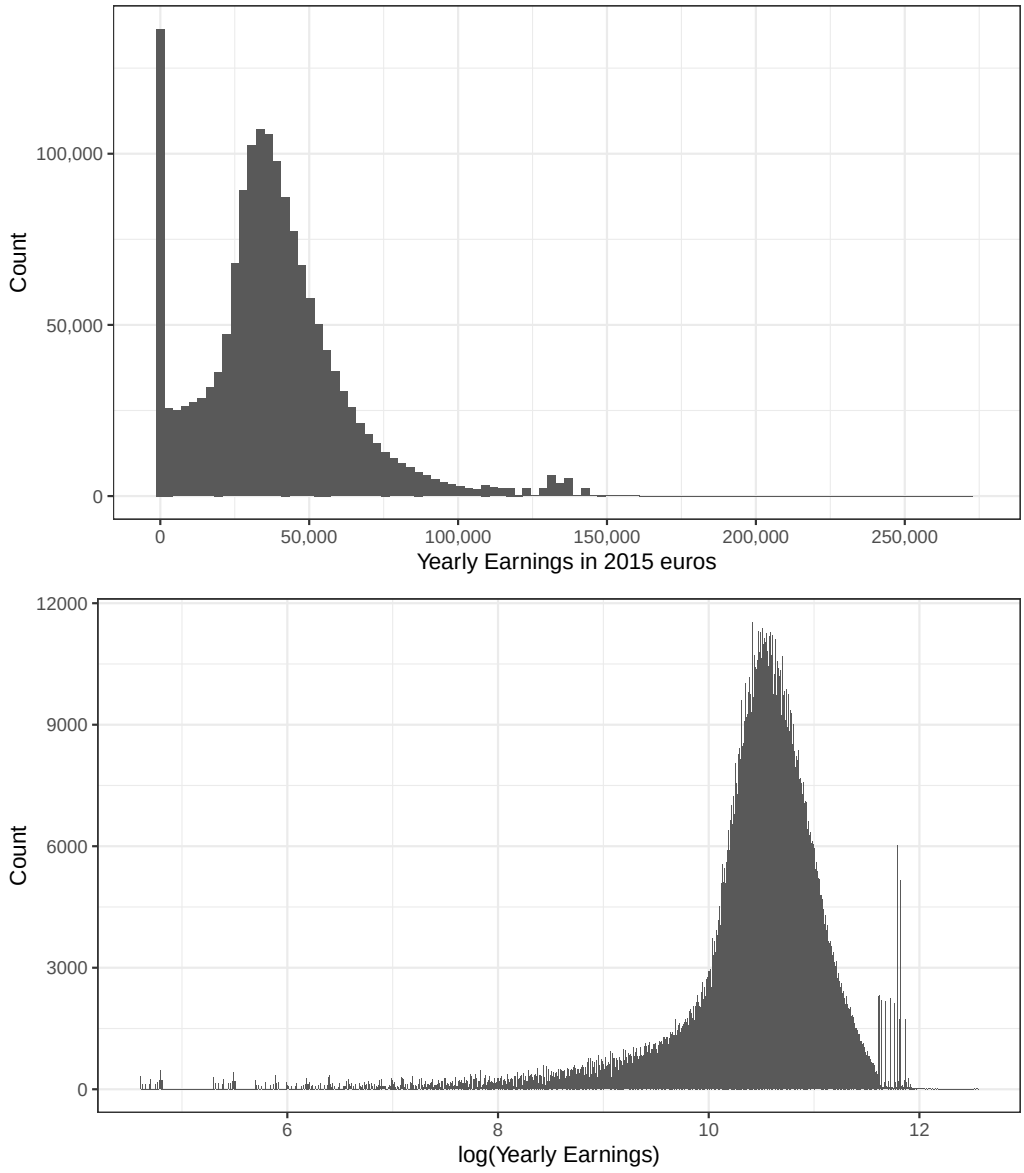
Figure A3: Earnings Distributions



Notes: The histograms show the distribution of earnings and log earnings in the main sample of all males with military test scores. The full sample includes 1,592,000 person-year observations. For logarithmic earnings we restrict the sample to positive values. This removes 7.4% of person-year observations. Earnings are top coded to the median for the top 1% of earners.

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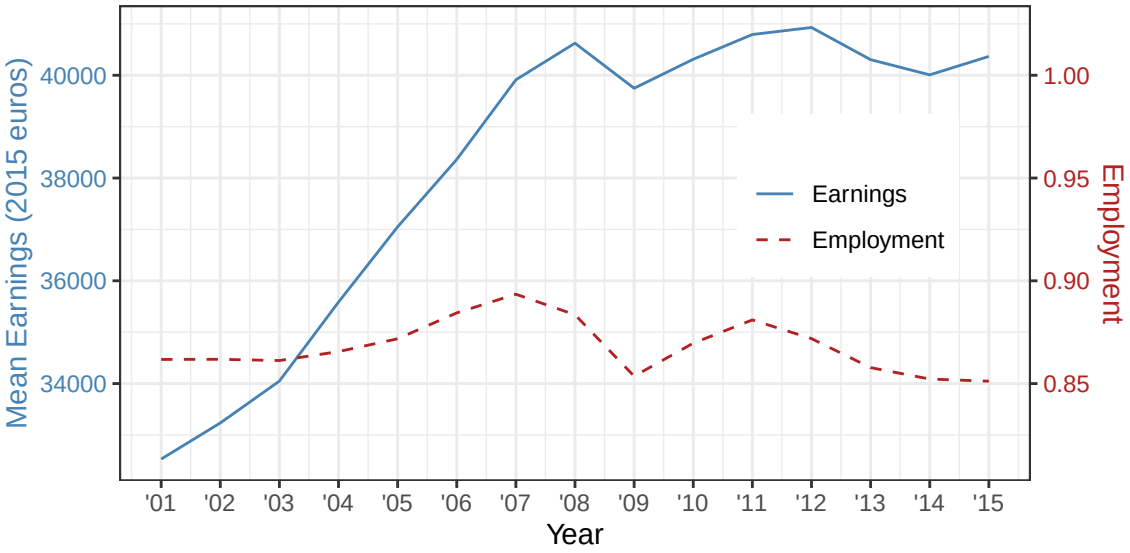
Figure A4: Trends in Earnings and Employment



Notes: Trends in mean earnings and employment from 2001 to 2015 in the main sample of all males with military test scores. The sample contains males aged 36–39 with approximately 100,000 observations per year. Most men appear in four consecutive years. Earnings are measured by the sum of wage and entrepreneurial income earned in a given year of observation as recorded by the tax authority. Employment status is defined by end-of-year employment.

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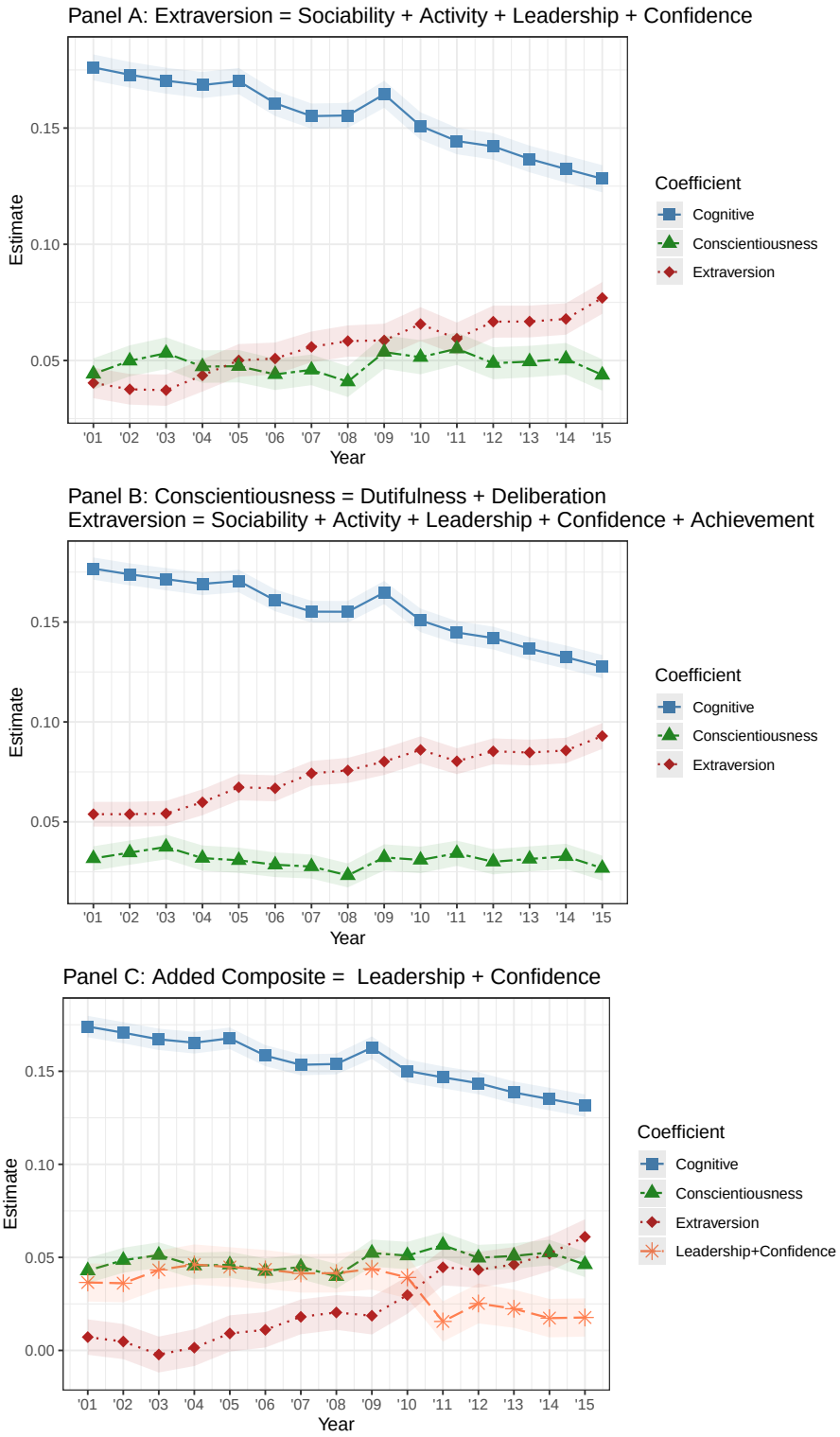
Figure A5: Trends Are Robust to Different Personality Groupings



Notes: This re-estimates Figure 2 with different groupings of the raw trait measures. Panel A includes self-confidence and leadership motivation to extraversion. Panel B uses grouping suggested by exploratory factor analysis. Panel C includes the mean of leadership motivation and self-confidence as an additional term to Equation (1).

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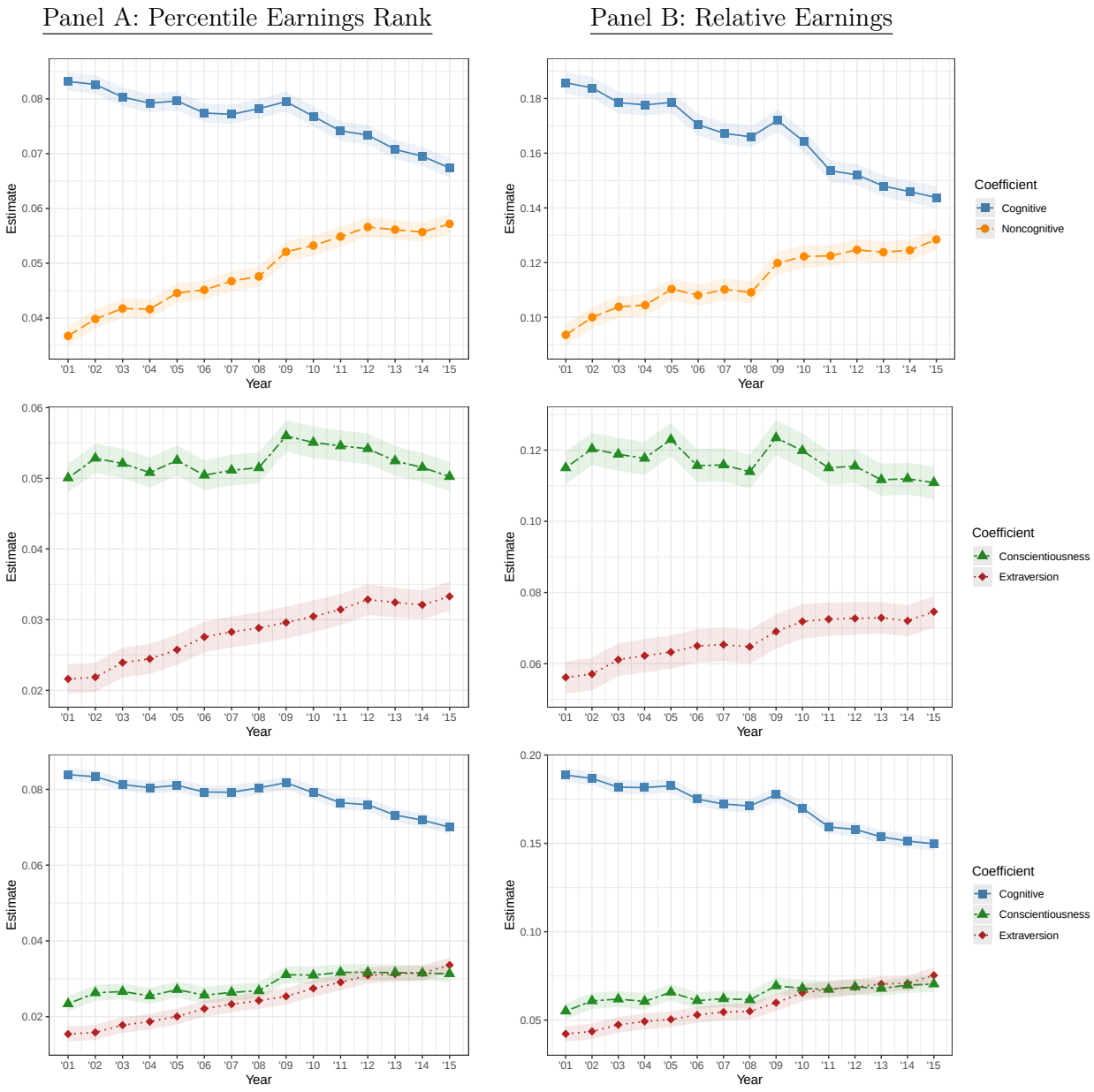
Figure A6: Trends Are Robust to Different Income Measures



Notes: The figures re-estimate Figures 1 and 2 with different measures of income. Panel A estimates regressions with percentile earnings rank as the outcome variable. Panel B estimates regressions with earnings relative to the mean earnings as the outcome variable. Percentile ranks and means are calculated within observation years across men in the estimation sample. Both outcome variables include zeros.

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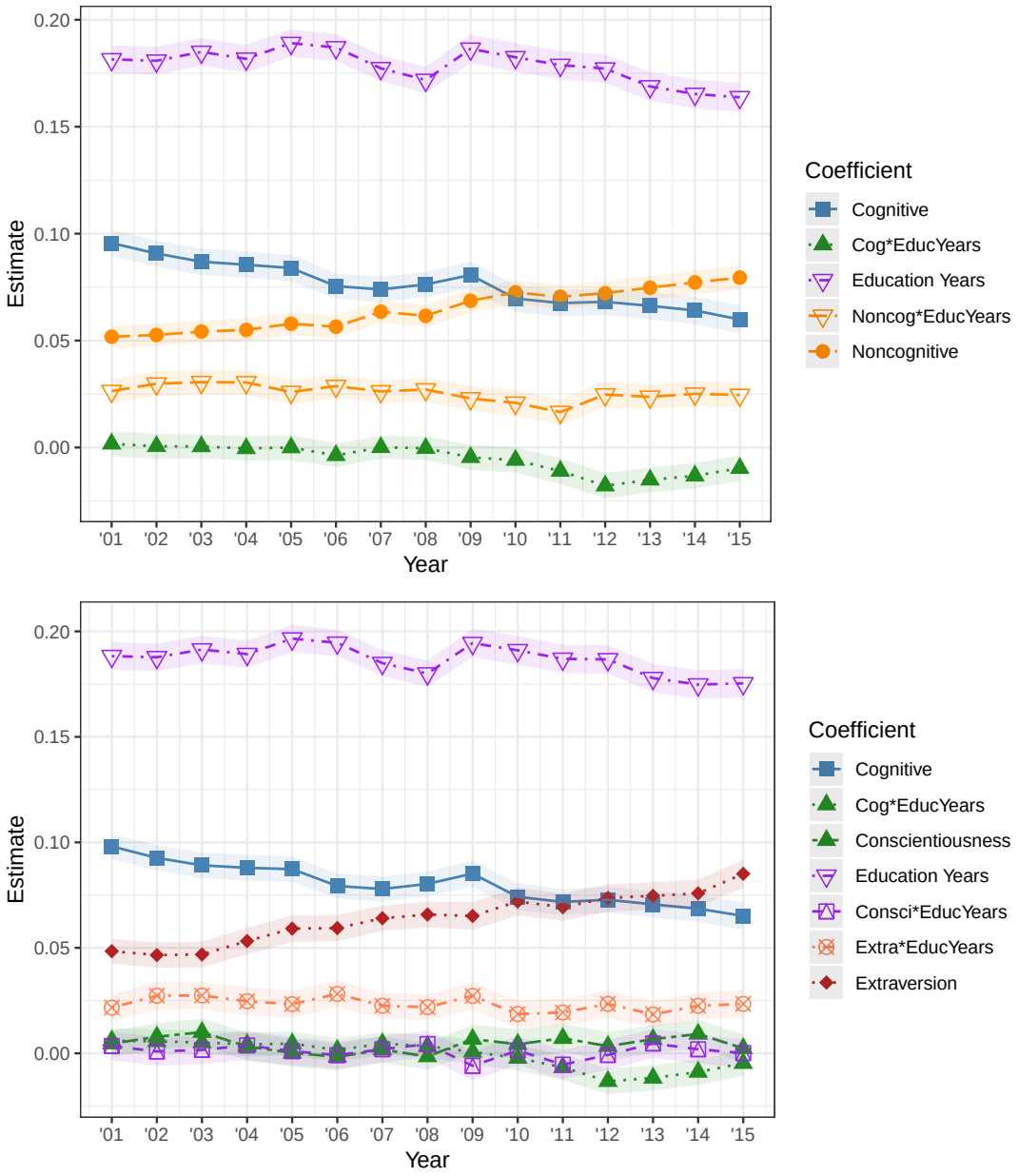
Figure A7: Interactions with Education Years



Notes: Each point in the figure corresponds to a regression coefficient from estimating Equation (1) separately for each year, with individual as the unit of observation. Interaction terms are included as indicated in the legend. The outcome is log earnings. Earnings are measured by the sum of wage and entrepreneurial income earned in a given year of observation as recorded by the tax authority. Zero earnings are removed (7.4% of person-year observations). The sample contains males aged 36–39 with approximately 100,000 observations per year. Most men appear in four consecutive years. Personality traits and cognitive skills are measured by the Finnish Defence Forces during basic training. 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extraversion' is the mean of sociability and activity-energy. 'Conscientiousness' is the mean of dutifulness, deliberation, and achievement striving. 'Noncognitive' is the mean of sociability, activity-energy, dutifulness, deliberation, achievement striving, leadership motivation, and self-confidence. All covariates are standardized to have mean 0 and standard deviation 1 within birth cohorts (including 'EducYears'). Construction of the composite measures is described in more detail in Section 2. Confidence bands are based on robust standard errors.

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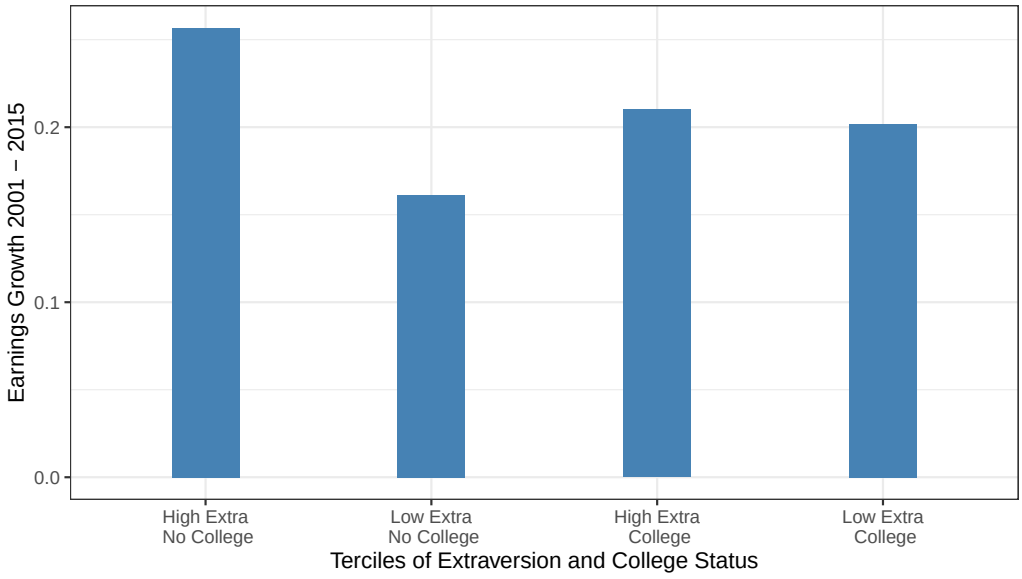
Figure A8: Earnings Growth by Extraversion and College Status



Notes: Each bar corresponds to the change in median earnings of that bundle in year 2015 relative to the base year 2001. The 'High Extra, No College' bundle includes persons who belong to the top tercile in extraversion and with no college degree. Other labels follow a similar logic. Earnings are measured by the sum of wage and entrepreneurial income earned in a given year of observation as recorded by the tax authority. The sample contains males aged 36–39 with approximately 100,000 observations at the start and end years. Personality traits and cognitive ability are measured by the Finnish Defence Forces during basic training. 'Extraversion' is the mean of sociability and activity-energy.

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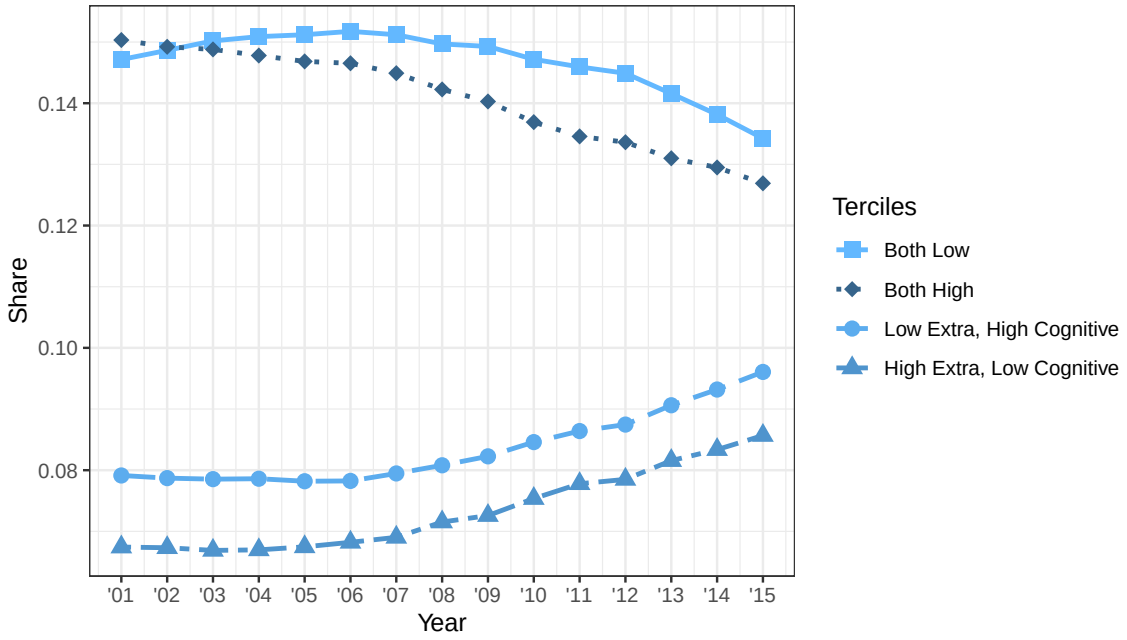
Figure A9: Skill Specialization is Increasing



Notes: Each point corresponds to the share of persons belonging to the indicated group (bundle). The 'High Extra, Low Cognitive' bundle includes persons who belong to the top tercile in extraversion and the bottom tercile in cognitive skills within their birth cohort. Other labels follow a similar logic. The sample contains males aged 36–39 with approximately 100,000 observations per year. Personality traits and cognitive ability are measured by the Finnish Defence Forces during basic training. 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extra' is the mean of sociability and activity-energy.

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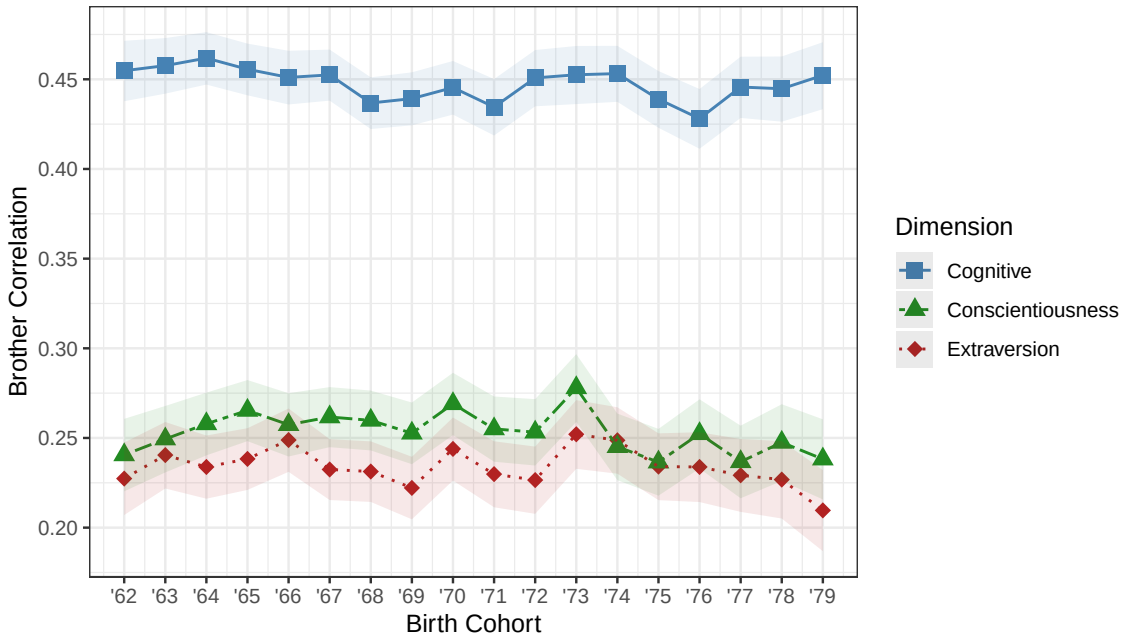
Figure A10: Brother Correlations Have Remained Stable



Notes: Raw pairwise correlations of traits across pairs of brothers. Each point is a separate correlation estimate. In case of multiple brothers, individuals are paired with the brother closest in age. The sample includes 178,000 pairs of brothers. Personality traits and cognitive skills are measured by the Finnish Defence Forces during basic training. 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extraversion' is the mean of sociability and activity-energy. 'Conscientiousness' is the mean of dutifulness, deliberation, and achievement striving. Traits are standardized to have mean 0 and standard deviation 1 within birth cohorts. Construction of the composite measures is described in more detail in Section 2.

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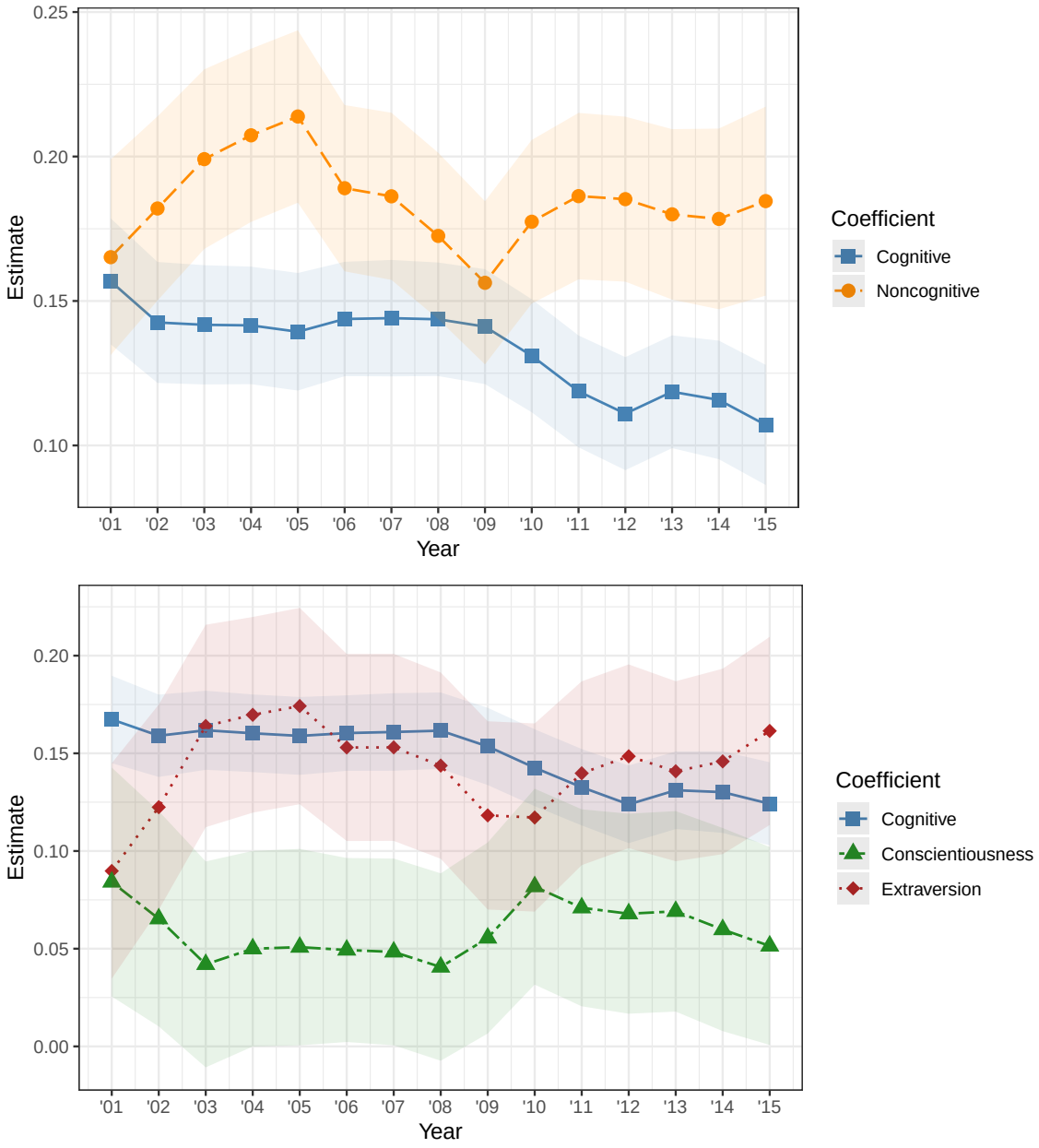
Figure A11: Brother IV Estimates



Notes: Each point corresponds to a 2SLS regression coefficient from estimating Equation (1) separately for each year. We use the traits of the brother as an instrument for own traits and log earnings as the outcome. In case of multiple brothers, individuals are paired with the brother closest in age. To decrease the variability in the estimates, we use data for the year in question $\pm$ 2 years. The sample includes 178,000 pairs of brothers. Earnings are measured by the sum of wage and entrepreneurial income earned in a given year of observation as recorded by the tax authority. Zero earnings are removed (6.9% of person-year observations). 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extraversion' is the mean of sociability and activity-energy. 'Conscientiousness' is the mean of dutifulness, deliberation, and achievement striving. 'Noncognitive' is the mean of sociability, activity-energy, dutifulness, deliberation, achievement striving, leadership motivation, and self-confidence. Traits are standardized to have mean 0 and standard deviation 1 within birth cohorts. Construction of the composite measures is described in more detail in Section 2. Confidence bands are based on robust standard errors, which are clustered at the individual level.

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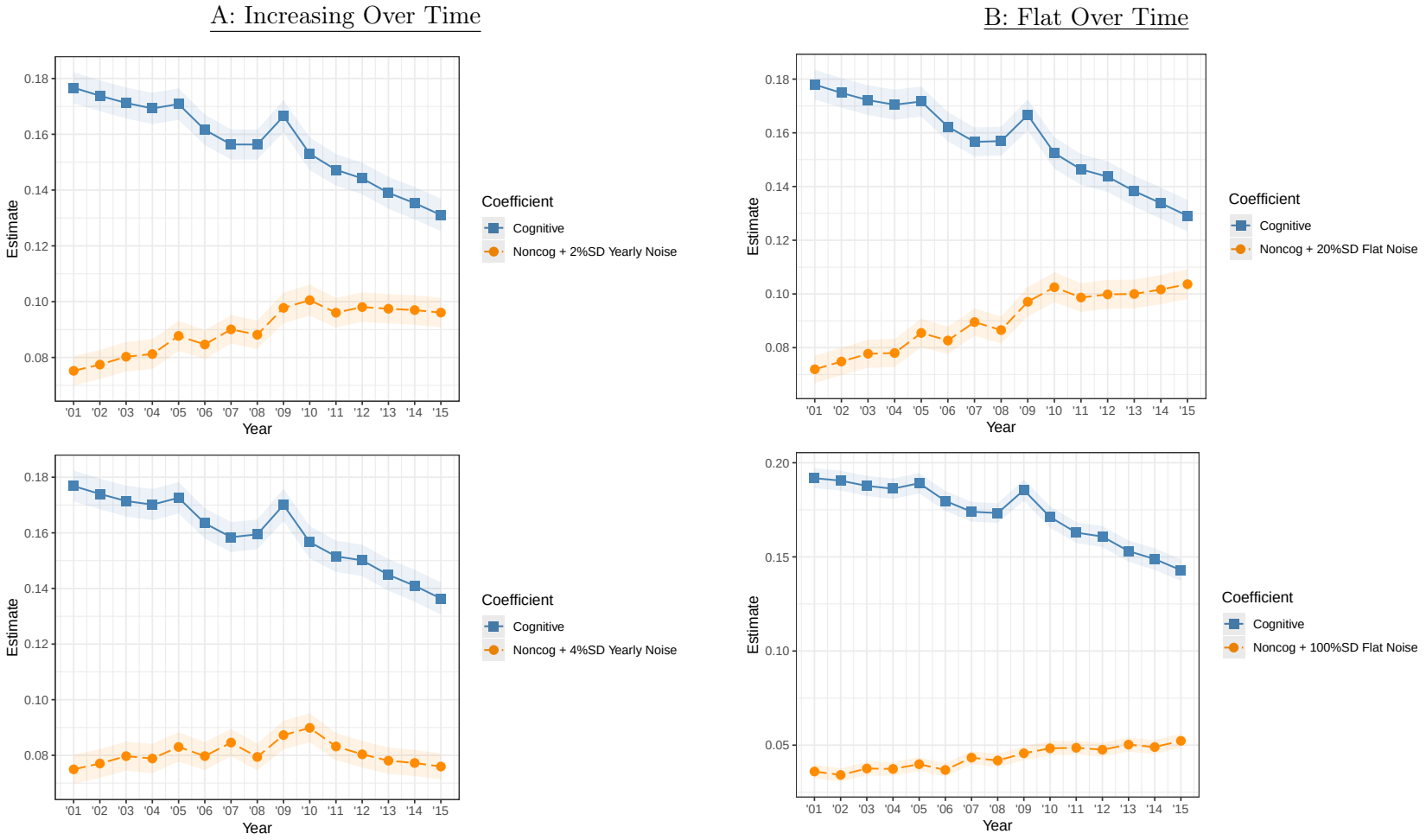
Figure A12: Simulated Measurement Error



Notes: This re-estimates Figure 1 with noise added to the noncognitive dimension. Noise is added for each individual according to the formula $NoncognitiveNoise = Noncognitive + \epsilon_c$, where $\epsilon_c \sim N(0, (cp)^2)$ and c is the birth cohort. For Panel A: $c \in [0..18]$ and $p \in \{2\%, 4\%\}$. For Panel B and $c = 1$ and $p \in \{20\%, 100\%\}$.

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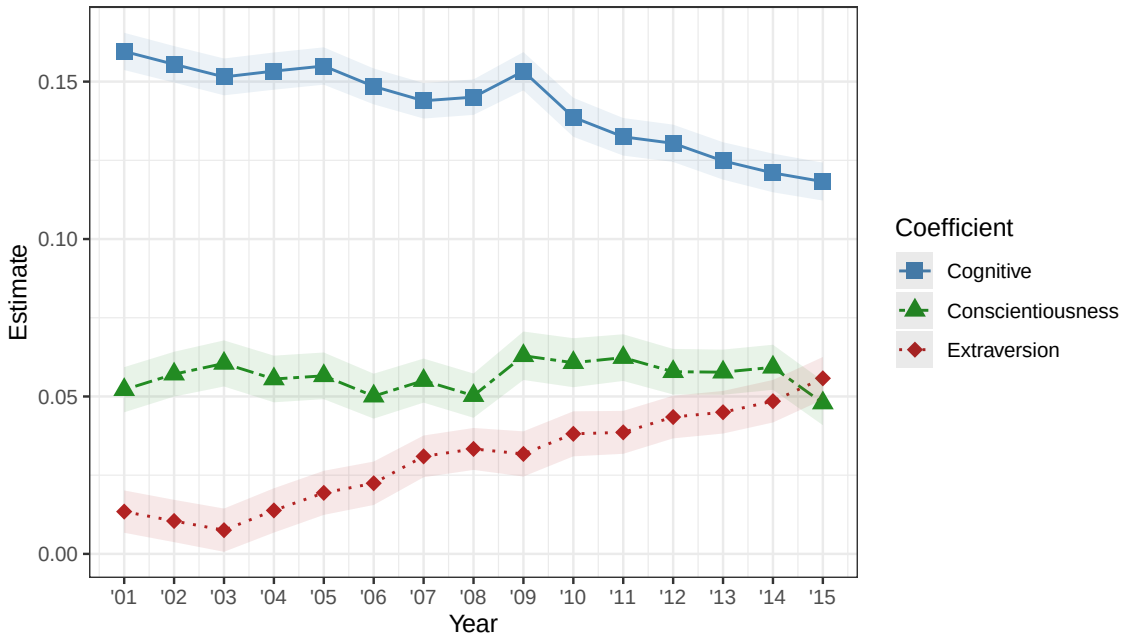
Figure A13: Controlling for Validity Scales



Notes: This re-estimates Figure 2 with additional linear controls for three validity scales included in the FDF data that capture test-taking attitudes: L-scale (intended to identify people who deliberately try to avoid answering the test honestly and in a frank manner), F-scale (intended to detect unusual or atypical ways of answering the test items), and K-scale (designed to identify psychopathology in people who otherwise would have profiles within the normal range). These scales were also included in the original MMPI (Hathaway & McKinley, 1951). The scales are standardized to have mean 0 and standard deviation 1 within birth cohorts.

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Table A1: Decomposing the Changes in Skill Premia

	Cognitive		Extraversion		Conscientiousness	
	Within	Residual	Within	Residual	Within	Residual
A. Industry	-0.0166	-0.0030	0.0107	0.0029	0.0032	-0.0042
B. Firm	-0.0143	-0.0053	0.0104	0.0033	0.0041	-0.0052
C. Occupation	-0.0139	-0.0057	0.0144	-0.0007	0.0002	-0.0013
D. Education	-0.0041	-0.0155	0.0109	0.0028	0.0046	-0.0057
Overall change:	-0.0196		0.0137		-0.0011	

Notes: Each row reports the difference between OLS estimates from Equation (1) estimated at the end (2013–2015) and in the beginning (2004–2006) of the observation period. The 'Overall change' row reports the difference in the OLS estimates without fixed effects. All regressions contain all three skill measures (cognitive, extraversion, and conscientiousness). The 'Within' column refers to the difference between the end and the beginning coefficients with the fixed effects included. These fixed-effects in each regression are indicated by the row name. The 'Residual' column is the difference between the bottom row baseline change (coefficient change without fixed-effects) and the 'Within' change. The sample contains males aged 36–39 with non-missing values for all fixed-effects. This limits the sample to private sector individuals post 2003; a sample for whom occupation and firm codes are available. $N \approx 200,000$ person-year observations in each three-year period. Industry and occupation are included at the two-digit level. Education is included at the field-of-study×degree-level. Personality traits and cognitive skills are measured by the Finnish Defence Forces during basic training. 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extraversion' is the mean of sociability and activity-energy. 'Conscientiousness' is the mean of dutifulness, deliberation, and achievement striving. Traits and subtraits are standardized to have mean 0 and standard deviation 1 within cohorts. Construction of the composite measures is described in more detail in Section 2.

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Table A2: Brother IV Estimates

	Dependent Variable: Log Earnings				
	(1)	(2)	(3)	(4)	(5)
Variables					
Cognitive	0.134		0.150		0.053
	(0.005)		(0.005)		(0.006)
Noncognitive	0.184				
	(0.008)				
Extraversion		0.146	0.145		0.185
		(0.013)	(0.013)		(0.013)
Conscientiousness		0.162	0.057		-0.072
		(0.012)	(0.013)		(0.015)
Education Years				0.097	0.083
				(0.0007)	(0.002)
Fixed-effects					
Year-Cohort (60)	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	561,114	566,087	566,087	571,229	566,087
R^2	0.06206	0.01284	0.05835	0.09729	0.09596
Within R^2	0.05022	0.00019	0.04627	0.08551	0.08436
Dep. Mean	10.4	10.4	10.4	10.4	10.4

Notes: Each column reports the 2SLS estimates from Equation (3), with person-year as the unit of observation. We use the traits of the brother as an instrument for own traits and log earnings as the outcome. In case of multiple brothers, individuals are paired with the brother closest in age. The sample includes 178,000 pairs of brothers. Earnings are measured by the sum of wage and entrepreneurial income earned in a given year of observation as recorded by the tax authority. Zero earnings are removed (6.9% of person-year observations). Personality traits and cognitive skills are measured by the Finnish Defence Forces during basic training. 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extraversion' is the mean of sociability and activity-energy. 'Conscientiousness' is the mean of dutifulness, deliberation, and achievement striving. Traits and subtraits are standardized to have mean 0 and standard deviation 1 within cohorts. Construction of the composite measures is described in more detail in Section 2. Standard errors are clustered at the individual level and reported in parentheses.

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Table A3: Earnings in Levels

	Dependent Variable: Earnings (2015 euros)				
	(1)	(2)	(3)	(4)	(5)
Variables					
Cognitive	6,281		6,458		3,025
	(35)		(35)		(36)
Noncognitive	4,345				
	(35)				
Extraversion		2,545	2,228		2,948
		(41)	(40)		(38)
Conscientiousness		4,423	2,456		200
		(42)	(41)		(40)
Education Years				4,162	3,325
				(15)	(17)
Fixed-effects					
Year-Cohort (60)	Yes	Yes	Yes	Yes	Yes
Fit statistics					
Observations	1,580,916	1,587,535	1,587,535	1,592,223	1,587,535
R^2	0.13779	0.07729	0.13627	0.18197	0.21198
Within R^2	0.12547	0.06391	0.12375	0.17000	0.20055
Dep. Mean	38,090	38,060	38,060	38,038	38,060

Notes: Each column reports the OLS regression results from Equation (3), with person-year as the unit of observation. The outcome is earnings in 2015 euros. Earnings are measured by the sum of wage and entrepreneurial income earned in a given year of observation as recorded by the tax authority. The sample contains males aged 36–39 in years 2001-2015. Most men appear in four consecutive years. Personality traits and cognitive skills are measured by the Finnish Defence Forces during basic training. 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extraversion' is the mean of sociability and activity-energy. 'Conscientiousness' is the mean of dutifulness, deliberation, and achievement striving. 'Noncognitive' is the mean of sociability, activity-energy, dutifulness, deliberation, achievement striving, leadership motivation, and self-confidence. Traits and subtraits are standardized to have mean 0 and standard deviation 1 within cohorts. Construction of the composite measures is described in more detail in Section 2. Standard errors are clustered at the individual level and reported in parentheses.

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Table A4: Personality and Earnings within Occupations

Group:	Managers	Professionals	Tech./Clerical	Service/Sales	Production	Other
ISCO classes:	(1)	(2)	(3–4)	(5)	(7–8)	(0,6,9)
Variables						
Cognitive	0.142	0.079	0.083	0.048	0.031	0.051
	(0.004)	(0.002)	(0.002)	(0.004)	(0.001)	(0.005)
Extraversion	0.034	0.050	0.048	0.057	0.016	0.053
	(0.004)	(0.002)	(0.002)	(0.004)	(0.002)	(0.006)
Conscientiousness	0.068	0.034	0.023	0.016	0.003	-0.057
	(0.004)	(0.002)	(0.002)	(0.004)	(0.002)	(0.006)
Fixed-effects						
Year-Cohort	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	76,612	219,309	219,206	80,406	365,958	68,271
R^2	0.08388	0.03428	0.03873	0.02226	0.00705	0.01058
Within R^2	0.07688	0.03193	0.03096	0.01805	0.00409	0.00643
Dep. Mean	11.1	10.8	10.6	10.3	10.4	10.1

Notes: Each column reports the OLS regression results from Equation (3), with person-year as the unit of observation. The column name indicates the estimation sample. Each sample is limited to individuals working in the indicated occupation at the end of the calendar year. Occupation codes are available in the data after 2003. The outcome is log earnings. Earnings are measured by the sum of wage and entrepreneurial income earned in a given year of observation as recorded by the tax authority. Personality traits and cognitive skills are measured by the Finnish Defence Forces during basic training. 'Cognitive' is the mean of visuospatial, arithmetic, and verbal test scores. 'Extraversion' is the mean of sociability and activity-energy. 'Conscientiousness' is the mean of dutifulness, deliberation, and achievement striving. Traits and subtraits are standardized to have mean 0 and standard deviation 1 within cohorts. Construction of the composite measures is described in more detail in Section 2. Standard errors are clustered at the individual level and reported in parentheses.

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B Supplementary Details on Data

B.1 The Finnish Defence Forces Psychological Test Data

Background Military conscription in Finland is universal and grants relatively few exceptions. The available data cover 79% of Finnish men born between 1962 and 1979 (n = 489,252). Finnish men are drafted in the year they turn 18, and most start their service at age 19 or 20. Military service lasts for 6–12 months, and most conscripts do not continue service in the military.

The Finnish Defence Forces (FDF) use psychological tests as one of the criteria to assess conscripts' suitability for officer training and to collect information about the military force. FDF has conducted psychological tests on all conscripts since 1955. Between 1955 and 1982, FDF used one test that measured cognitive skills: logical, mathematical, and verbal skills. Since 1982, the FDF has used two tests: a cognitive and a personality test. The test data have been described in Jokela et al. (2017) and validated in FDF's internal reports summarized in Nyman (2007). Our description here is closely based on Jokela et al. (2017).

Test Administration The cognitive ability and personality tests are typically taken in the second week of military service in a 2-h paper-and-pencil format in standardized group-administered conditions. The personality test contains 218 statements with a response scale of yes/no. The cognitive test contains 120 multiple-choice questions. The test questionnaires and test administration have been unchanged from 1982 to 2000 (the data available to this study), and the scores are designed to be comparable across cohorts. The main change in the test administration during the timeline of this study is that between 1995 and 2000, the personality test was administered already at the conscription, on average 18 months before entering the FDF service.

The Cognitive Ability Test The cognitive ability test has three subtests: visuospatial, arithmetic and verbal reasoning. The FDF cognitive ability test is similar to the Armed Services Vocational Aptitude Battery (ASVAB), administered by the United States Military Entrance Processing Command. Each subtest has 40 multiple-choice questions. FDF reports internal-consistency reliabilities of the subtests between 0.76 and 0.88 (Nyman, 2007). The descriptions of tests are based on Nyman (2007) and Jokela et al. (2017):

1. *The visuospatial subtest* is similar to Raven's Progressive Matrices (Raven et al., 2000). The test shows a set of matrices, each with one removed part, and the participant chooses a figure that completes the matrix.
2. *The arithmetic subtest* contains different tasks: executing arithmetic operations, identifying patterns in number sequences, interpreting and solving brief word problems, and recognizing relationships among numbers.
3. *The verbal subtest* assesses language skills, including understanding of synonyms and antonyms, categorical grouping, outlier identification in word groups, and recognition of analogous word pairs.

The Personality Test The personality test measures 8 personality traits. The test is similar to and partly based on the Minnesota Multiphasic Personality Inventory (MMPI). It contains 218 statements with a yes/no response, between 18 and 33 items for each personality trait. The test score for each personality trait is the sum of the binary answers aligned with the trait (for example, in reverse-coded statements, these mean cases where the test-taker disagrees). The data available for this study contain these sums of scores. FDF reports that internal reliability varies between 0.60 and 0.90 by trait (Nyman, 2007). The 8 personality traits measured in the test are, as described by Jokela et al. (2017):

1. *Sociability*: the person's level of gregariousness and preference for socializing with others (33 items; e.g., whether the person likes to host parties and not withdraw from social events).

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2. *Activity-energy*: how much the person exerts physical effort in everyday activities and how quickly the person prefers to execute activities (28 items; e.g., whether the person tends to work fast and vigorously and prefers fast-paced work).
3. *Masculinity*: the person's occupational and recreational interests that are traditionally considered as masculine (27 items; e.g., whether the person would like to work as a construction contractor).
4. *Dutifulness*: how closely the person follows social norms and considers them to be important (18 items; e.g., whether the person would return money if given back too much change at a store).
5. *Deliberation*: how much the person prefers to think ahead and plan things before acting (26 items; e.g., whether the person prefers to spend money carefully).
6. *Achievement motivation*: how strongly the person wants to perform well and achieve important life goals (24 items; e.g., whether the person is prepared to make personal sacrifices to achieve success).
7. *Leadership motivation*: how much the person prefers to take charge in groups and influence other people; it includes 30 items.
8. *Self-confidence*: the person's self-esteem and beliefs about his abilities (32 items; e.g., whether the person feels to be as good and able as others and can meet other people's expectations).

The FDF personality test also includes questions about mental health and questions targeted at evaluating the answers' validity. The mental health part has four scales from the Minnesota Multiphasic Personality Inventory (MMPI): hypochondriasis, psychopathic deviate, psychasthenia, and schizophrenia. The validity part has three scales: L-scale ("Lie" scale, intended to identify people who deliberately try to avoid answering the test honestly and in a frank manner), F-scale (intended to detect unusual or atypical ways of answering the test items), and K-scale (designed to identify psychopathology in people who otherwise would have profiles within the normal range).

Selection Concerns The data are subject to two selection concerns. The first concern is selection into military service: Only those who enter the FDF service take the tests. It is possible to be exempted from military service due to severe health conditions, most often related to mental health problems, or due to religious or ethical convictions. For the analysis, this means that the sample is generally more representative of men with relatively higher labor-market prospects. Over the timeline of this study, selection into military service has been stable (Jokela et al., 2017).

The second concern is selective test performance. The military uses the test results as one of the elements to select conscripts for officer training. To some extent, this feature is likely to induce higher performance from those who would like to be selected and lower performance from those who would like to avoid it. For personality data, the concern is alleviated by the fact that the scoring rules are not revealed to the conscripts. For cognitive data, test performance may reflect motivation-related factors, as is the case for most cognitive tests. Finally, the data exclude Finnish Defence Forces personnel and Finnish Border Guard soldiers.

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B.2 Harmonizing the High-School Mathematics Data

In high school, students can select between two mathematics tracks: basic and advanced. The exit exams are different for both tracks, and a small fraction opt out of both. We aim to construct a single measure of mathematics test scores that is commensurable across the three options. We do this by regressing:

$$\begin{aligned}\text{MilitaryMathScore}_{it} = {} & \delta_1 D_i^{\text{BasicMath}} + \delta_2 D_i^{\text{AdvancedMath}} \\ & + \delta_3 D_i^{\text{BasicMath}} \text{BasicMathScore}_i \\ & + \delta_4 D_i^{\text{AdvancedMath}} \text{AdvancedMathScore}_i + \delta_t\end{aligned}$$

where D indicates that person i has participated in the exam. The indicator is interacted with the normalized test score. For those who did not participate, number -1 is imputed for the test score (the scalar used here does not matter for the estimation). Finally, δ_t is a fixed effect for the test-taking year.

The left-hand side variable is the military arithmetic test score. We use the fact that this standardized test is administered to everyone in our data. The military test is low stakes, relatively easy, and only moderately correlated with the high-school test scores (less than 0.4 with either track). While it does not share the same patterns as our main results (results not shown), it is a reasonable tool for this purpose.

Table B1: Math Anchoring

Outcome: FDF Arithmetic Test	
δ_1	0.334
	(0.006)
δ_2	0.810
	(0.005)
δ_3	0.255
	(0.003)
δ_4	0.270
	(0.002)
Num. obs.	165934
Adj. R^2 (full model)	0.269
Adj. R^2 (proj model)	0.255

Notes: Robust standard errors are in ().

Table B1 shows the estimation results. The marginal weights for better test scores are similar in both tracks. Both predict around a 0.26 standard deviation increase in the military test for each standard deviation increase in the high school score. The differences arise from a mean shift in the military arithmetic test. The mean performance of students taking the advanced mathematics track is almost 0.5 standard deviations higher than the mean performance of students taking the basic track ($\delta_2 - \delta_1$). The 'math' variable in all results except for Table 2 is the weighted average of the right hand side variables, where the weights are given by the δ values. The cohort fixed effects are not included.

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C Model

We develop a simple model of multidimensional skill specialization that provides a structure for the relationships between personality, education, and labor-market performance.[1] We focus on the distinction between the production of human capital and productive activities in the labor market. Personality traits are viewed as a fixed type and skills are viewed as endogenous. For concreteness, the context can be thought of as students in high school and the labor market.

At the center of the model, there are two production functions for two types of human capital, formal skills ('education', H) and informal skills ('social capital', S),[2]

$$H(h; C, E) = a(C, E) \times h \tag{1}$$
$$S(s; C, E) = b(C, E) \times s \tag{2}$$

Formal skills H are produced by time investment h ('studying') and informal skills S are produced by time investment s ('socializing'). The productivities of human capital production, a and b, depend on the endowment of personality traits (C for 'conscientiousness' and E for 'extraversion').

In making a decision, the students face a time-allocation constraint:

$$h + s = T. \tag{3}$$

Time spent on studying is away from time spent on socializing. We normalize the time endowment as $T = 1$.

The objective function is:

$$U(s; C, E) = H(1 - s; C, E) + S(s; C, E) + V(s; C, E) \tag{4}$$

The students value both types of human capital, H and S, but also derive direct utility (or disutility) from studying and socializing, V, that depends on their endowment of traits.[3] We further assume that the direct utility function depends only on the relative allocation between h and s.[4]

Students choose how much time to spend on socializing (s) to maximize the objective function under the constraint. With no strategic behavior or dynamics, the optimal time-allocation decision between studying and socializing is a static individual optimization problem.[5] The first-order condition for socializing is:

$$\frac{\partial V(s; C, E)}{\partial s} = a(C, E) - b(C, E) \tag{5}$$
$$s^*(C, E) = g_s(a(C, E) - b(C, E); C, E) \tag{6}$$

where g_s is the inverse function of $\partial V(s, C, E)/\partial s$ with respect to s. For an interior solution to exist, Expression 5 must be positive. Intuitively, if at the optimal s^*, socializing is not only more fun ($\partial V(s; C, E)/\partial s > 0$) but also more productive ($b(C, E) > a(C, E)$), there would be no reason

[1] The model is related to Lleras-Muney et al. (2023).

[2] For simplicity, we consider two 'technologies of skill formation' (Cunha & Heckman, 2007). The case for more technologies is analogous.

[3] If U reflects log utility, the objective function arises under the canonical CES preferences. At this point, to keep the notation clear, we abstract from potential return multipliers for H and S in the objective function.

[4] Because time is spent between studying and socializing, V captures all direct costs/benefits of studying/socializing. For example, extraverted students could dislike studying but conscientious students might enjoy it.

[5] The model has an implied timing that corresponds to a typical path from adolescence to adulthood. Students enter a schooling period with an initial personality endowment (C, E). They then decide how much time to spend on socializing s. Their H and S are realized at the end of the schooling period. After the schooling period, they enter the labor market and receive earnings Y.

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to study at all.

The theoretical analysis focuses on the decision to socialize, s; the analysis for the inverse decision of studying, $h = 1 - s$, is symmetric. We provide proofs at the end of the text.

This setup provides some flexibility by admitting at least three distinct interpretations. In the classic view, students gain utility from formal skills H and informal skills S because there is a return to different human-capital types in the labor market. Students also face a direct cost or benefit from studying and socializing V that depends on their endowments. In this view, socializing is an investment: students socialize not just because studying may be laborious but also because socializing builds people-skills and networks rewarded in the labor market.

From a more modern perspective (see, for example, Lavecchia et al. 2016), students might not be sufficiently forward-looking to consider their future earnings. However, the terms H and S can be interpreted as social norms that guide their choices, for example, through parental pressure. In this interpretation, the cost function V is the direct utility of socializing over and above the social-norm component S.[6]

Finally, we could abstract entirely from the source of utility derived from either type of human capital *stock*. Students simply enjoy the activity of spending time s with their friends. Performing well in tests requires time to study (h), which may be uninteresting and incurs a cost $-V$. From this perspective, V reflects the direct utility of time spent socializing, which may be different for students with different personality endowments.

Skill Specialization The fundamental trade-off between time investments in this model leads to skill specialization, where students with a comparative advantage in extraversion invest more time on socializing relative to students with a comparative advantage in conscientiousness. Taking a derivative of the first order condition in Equation 5 and solving for $\partial s^*(C,E)/\partial E$ gives:

$$\frac{\partial s^*(C,E)}{\partial E} = -\left[\underbrace{\frac{\partial^2 V(.)}{\partial s^2}}_{<0}\right]^{-1}\left[\underbrace{b^E(C,E) + \frac{\partial^2 V(.)}{\partial s \partial E}}_{\text{marginal benefit of } \Delta E} - \underbrace{a^E(C,E)}_{\text{marginal cost of } \Delta E}\right] > 0. \tag{7}$$

The first term is the gradient in the marginal direct utility of socializing (or marginal cost of studying). We assume the standard decreasing marginal utility. Hence, for socializing: $\partial^2 V(.)/\partial s^2 < 0$. We also assume that the productivity of informal-skill accumulation $b(C,E)$ is increasing in the extraversion trait-endowment E. This assumption is based on the idea that learning social skills, creating networks, and improving their social hierarchy position is easier for students who already have sociable and proactive personalities. Likewise, we assume that extraverted students enjoy a larger marginal utility of socialization s. Formally, $\partial^2 V(.)/\partial s \partial E > 0$. This reflects the idea that the opportunity cost for studying is higher for extraverted students who could be having fun with their friends instead. Finally, we assume that productivity of studying, $a(C,E)$, does not depend on extraversion, so that $a^E(C,E) = a^E(C) = 0$. With these key assumptions, the right-hand side of Equation 7 is positive, and an increase in extraversion leads to an increase in the time spent socializing.

Immediately following from these assumptions we also have:

$$\frac{\partial H(1-s;C,E)}{\partial E} = \frac{\partial a(C)(1-s^*(C,E))}{\partial E} = -a(C)\frac{\partial s^*(C,E)}{\partial E} < 0. \tag{8}$$

In other words, conditional on conscientiousness C, more extraverted students have worse test scores. It implies that comparative advantage determines the time-allocation decision.

[6] The cost of studying and the direct utility of socializing mirror each other, because students allocate time T between the two.

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Figure C1 simulates the model with a quadratic cost function and linear productivity functions. Each line represents an isoquant where the optimal time allocation decision s^* does not change. Along each line, as long as the *comparative* proportion of endowments does not change, the *absolute* levels can vary substantially, still resulting in the same optimum allocation. For example, at the bottom right-hand corner, investment in s is highest; these are students who are high in E but low in C. At the upper left-hand corner are students high in C but low in E; their investment in s is lowest.

Returns to Personality The labor market rewards both types of human capital, H and S, and also directly the endowments, C and E. Earnings are determined by:

$$Y = r_H H(1-s;C,E) + r_S S(s;C,E) + r_N C + r_J E \tag{9}$$
$$= r_H a(C)(1-s^*(C,E)) + r_S b(C,E)s^*(C,E) + r_N C + r_J E \tag{10}$$

where r_H and r_S are the returns to the respective dimensions of human capital and r_N and r_J are the direct returns to the respective traits.

The marginal returns to extraversion are:

$$\frac{\partial Y}{\partial E} = \underbrace{r_S b^E(C,E)s^*(C,E) + r_J}_{\text{direct effect of } \Delta E} + \underbrace{(r_S b(C,E) - r_H a(C))}_{\text{net earnings change for } \Delta s} \underbrace{\frac{\partial s^*(C,E)}{\partial E}}_{\Delta s} \lessgtr 0. \tag{11}$$

The first term is the direct effect: the effect of the increase in the productivity of informal-skill production and the direct return from the increase in extraversion. By assumption, productivity $b(E)$ is increasing in extraversion, so this term is positive. The second term is the indirect effect: the change in earnings due to changes in the optimal time allocation s^*. As shown earlier, an increase in extraversion leads to an increase in the time investment (Δs). This reallocation results in a shift from formal skills to informal skills. However, at the optimum, as shown in Expression 5, the productivity of informal skills must be lower than the productivity of formal skills. Taken together, the indirect effect is negative.

Intuitively, students with a lower initial comparative advantage in socializing (low extraversion in relative terms) take a larger hit from investing more in s, because their comparative advantage is in formal skills (or educational capital), from which they are substituting away by increasing s. At the same time, $\partial s^*(C,E)/\partial E$ is smaller for students with a comparative advantage in studying.

In total, the sign of Expression 11 is ambiguous. If the gains from the direct effect are larger than the losses from the indirect effect, we should expect a positive return to extraversion conditional on conscientiousness.

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Proofs

Optimal time allocation s^*

Proof. Using equation 5:

$$\begin{aligned}\frac{\partial U(s;C,E)}{\partial s} &= -a(C,E) + b(C,E) + \frac{\partial V(s;C,E)}{\partial s} = 0\\ \frac{\partial V(s;C,E)}{\partial s} &= a(C,E) - b(C,E)\\ s^* &= g_s(a(C,E) - b(C,E);C,E)\end{aligned}$$

■

Comparative static: Optimal response of s to a change in E

Proof. Differentiate with respect to E from both sides of equation 5:

$$\begin{aligned}\frac{\partial^2 V(.)}{\partial s^2}\frac{\partial s^*}{\partial E} + \frac{\partial^2 V(.)}{\partial s \partial E} &= a^E(C,E) - b^E(C,E)\\ -\frac{\partial^2 V(.)}{\partial s^2}\frac{\partial s^*}{\partial E} &= b^E(C,E) + \frac{\partial^2 V(.)}{\partial s \partial E} - a^E(C,E)\\ \frac{\partial s^*}{\partial E} &= -\left[\frac{\partial^2 V(.)}{\partial s^2}\right]^{-1}\left[b^E(C,E) + \frac{\partial^2 V(.)}{\partial s \partial E} - a^E(C,E)\right]\end{aligned}$$

■

Comparative static: Marginal returns to a change in E

Proof. Earnings are given by

$$\begin{aligned}Y &= r_H H(1-s;C,E) + r_S S(s;C,E) + r_N C + r_J E\\ &= r_H a(C,E)(1 - s^*(C,E)) + r_S b(C,E)s^*(C,E) + r_N C + r_J E\\ &= r_H a(C) - r_H a(C)s^*(C,E) + r_S b(C,E)s^*(C,E) + r_N C + r_J E\end{aligned}$$

Differentiate with respect to E:

$$\begin{aligned}\frac{\partial Y}{\partial E} =& - r_H a(C)\frac{\partial s^*(C,E)}{\partial E}\\ &+ r_S\left[b^E(C,E)s^*(C,E) + b(C,E)\frac{\partial s^*(C,E)}{\partial E}\right] + r_J\\ =& \underbrace{r_S b^E(C,E)s^*(C,E) + r_J}_{\text{direct effect}} + \underbrace{(r_S b(C,E) - r_H a(C))}_{\text{net earnings change}}\underbrace{\frac{\partial s^*(C,E)}{\partial E}}_{\text{change in } s}\end{aligned}$$

■

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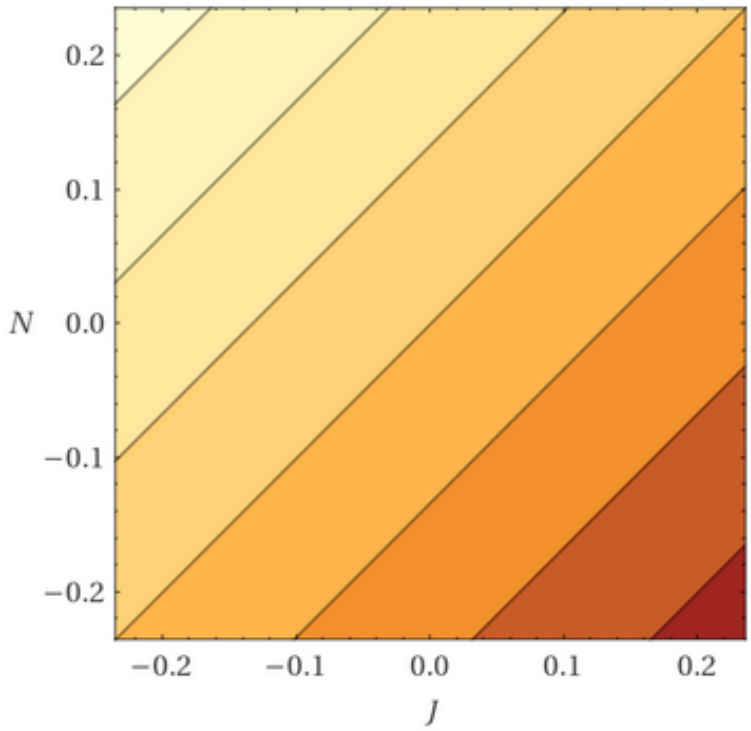
Figure C1: Comparative Advantage



Notes: Each line represents an isoquant in a plane where E and C are in the x and y axes and $s^*(C, E)$ is in the z-axis. Darker shades indicate higher values of z. Functional form choices are $a(C, E) = C$, $b(C, E) = E$, and $V(s; C, E) = -(E + (1 - s))^2$.

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