A Dynamic Model of Personality, Schooling, and Occupational Choice

by Petra Todd, and Weilong Zhang (2018)

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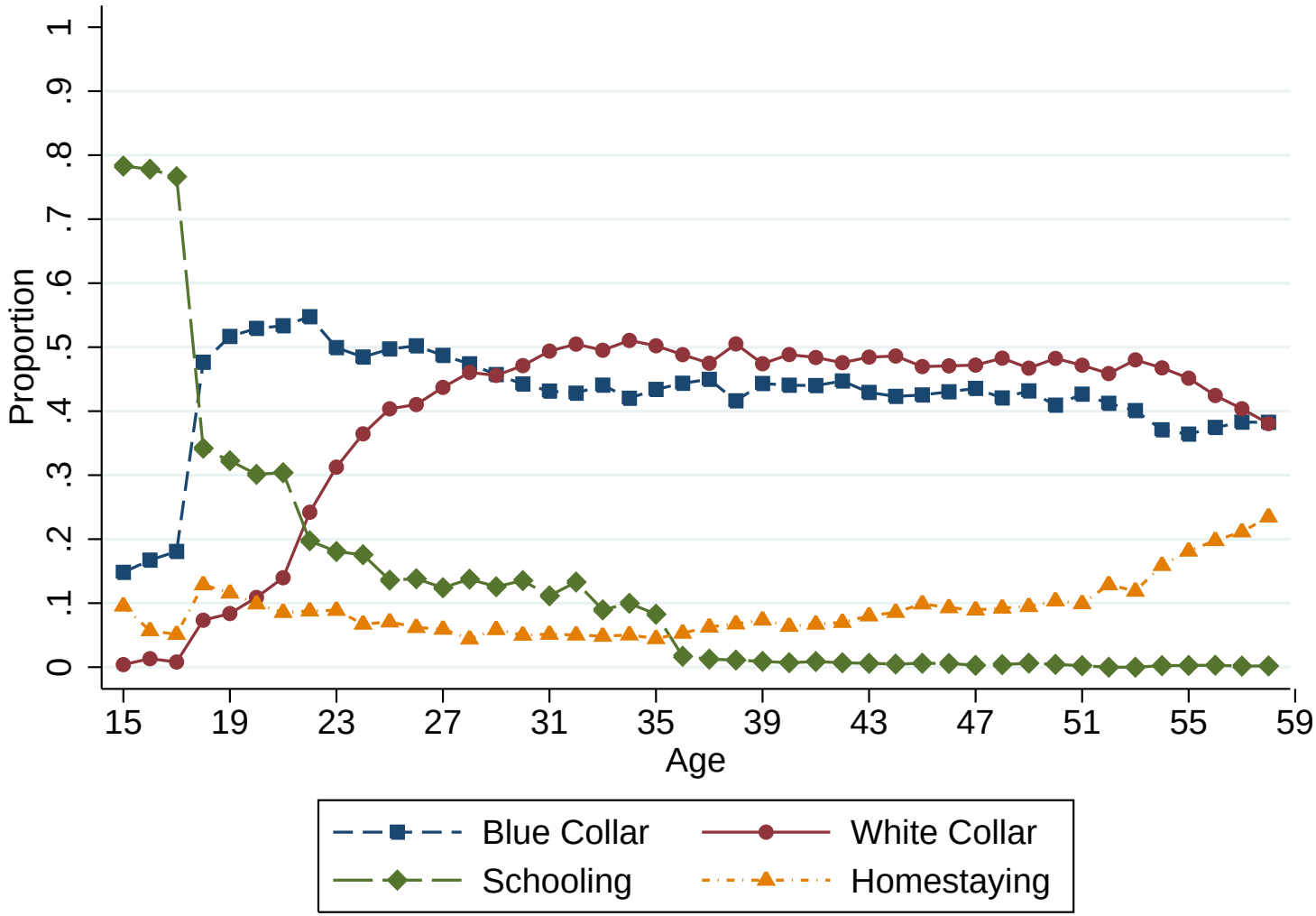
Motivation

- Heterogeneity in initial endowments has been shown to be important in explaining lifetime educational and labor market trajectories.
- Papers showing importance of unobserved heterogeneity in explain lifetime educational and employment outcomes.
  - Keane and Wolpin (1997) find that "unobserved" types account for 90 percent of the variance across individuals in lifetime utility.
  - Yamaguchi (2012) finds that endowment differences prior to labor market entry account for 70% of the log-wage variance in the first year and 35% even after 20 years.
  - Sullivan (2010) finds that 56% of the variance in discounted expected lifetime utility is explained by initial heterogeneity.
  - Huggett et. al. (2011) conclude that 61.5 percent of the variation in lifetime earnings and 64.0 percent of the variation in lifetime utility is attributable to initial conditions.

Key findings

- Unobserved types are malleable during younger ages but stabilize around the mid-30s.
- Attendance at college is associated with changes in certain personality traits, especially with an increase in conscientiousness.
- We find the existence of "super type", individuals who tend to have high levels of cognitive skills and higher than average levels of personality traits in all dimensions. They also tend to complete more education and to work in white collar jobs.
- High cognitive skills go along with more desirable personality traits (noncognitive).



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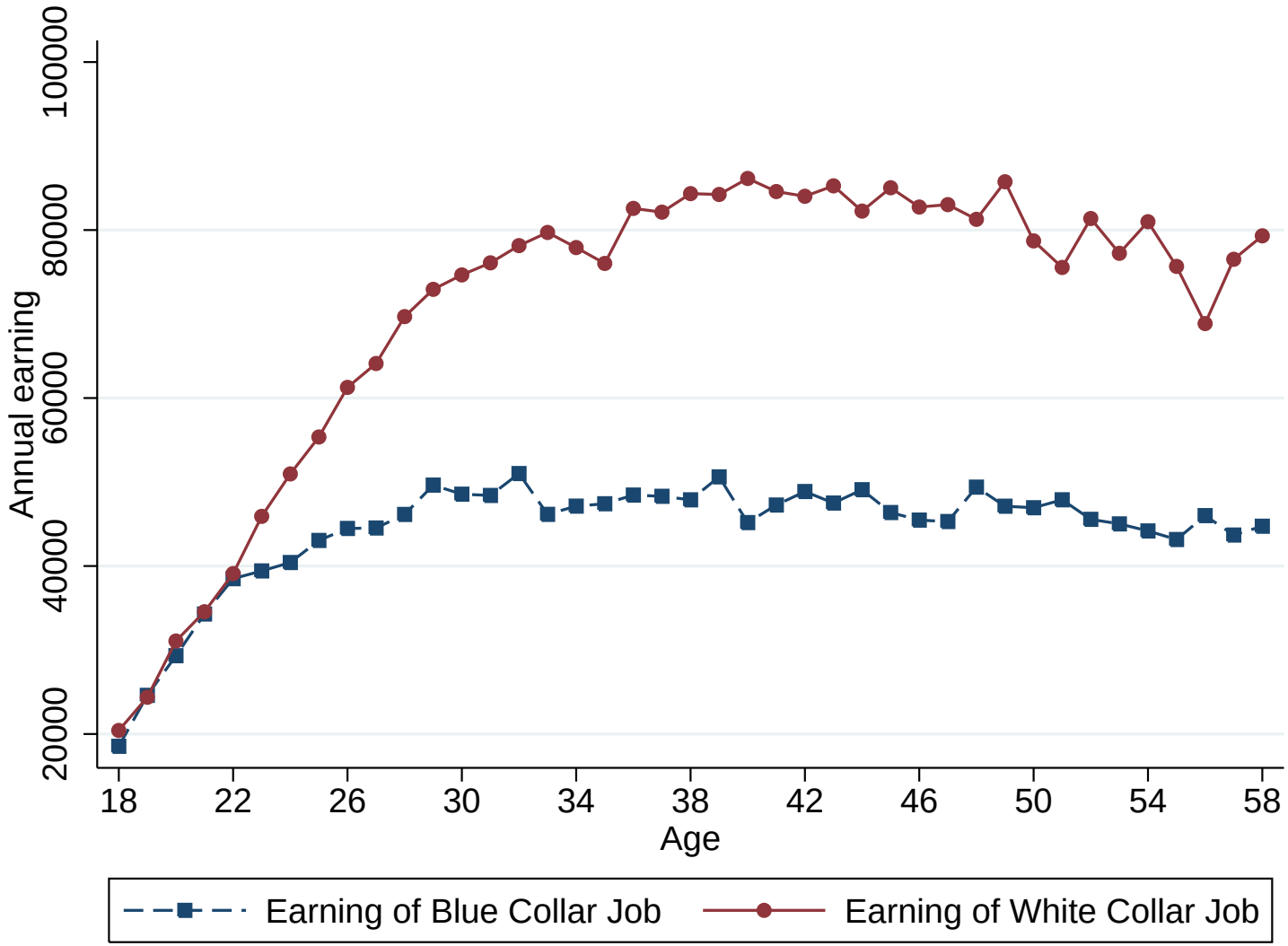
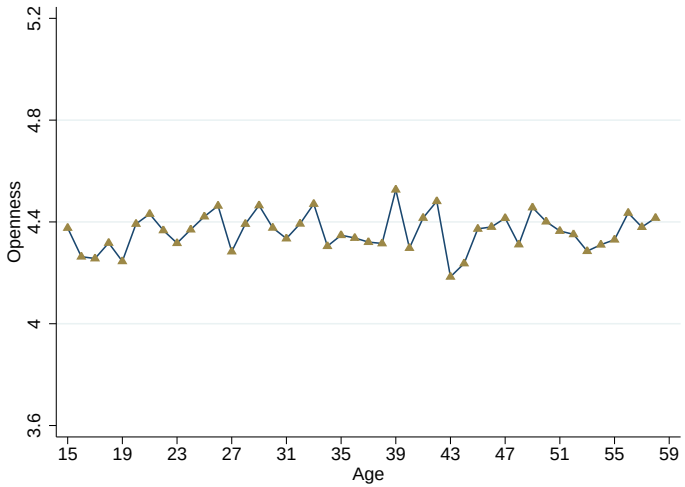


Figure 2: Average wage profile by occupation over life cycle

Figure 3: The scores on "Big-Five" personality traits over time



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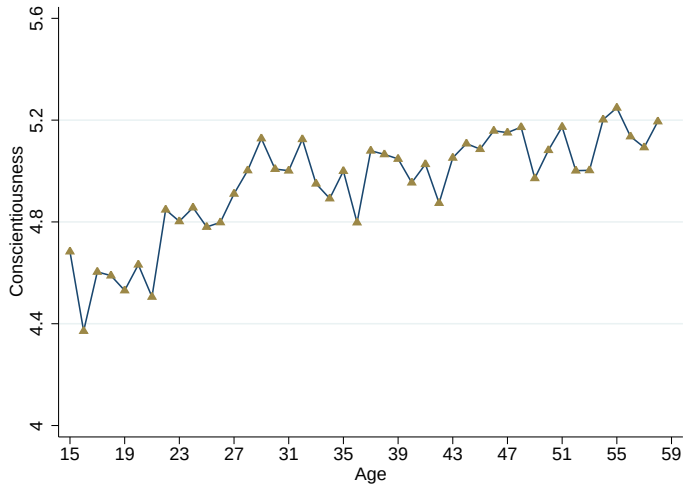

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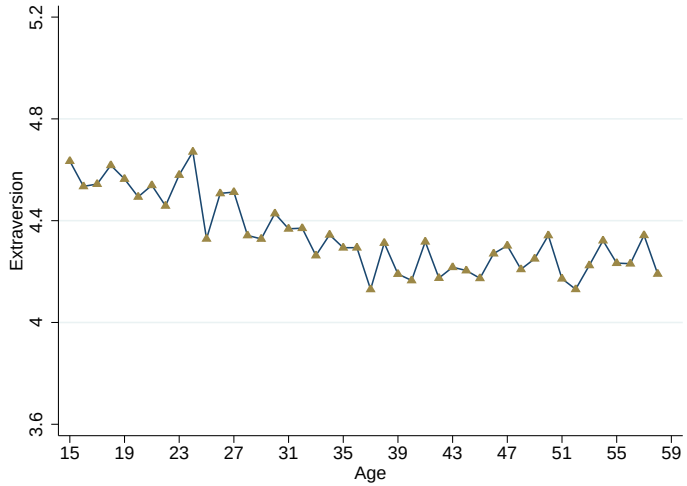

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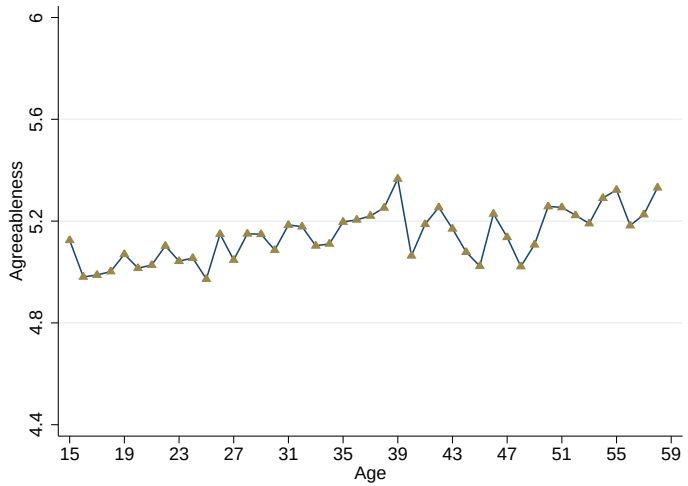
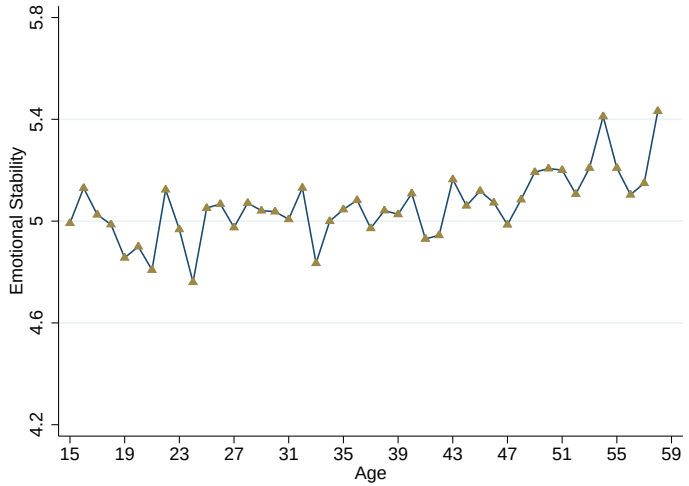


(a) Agreeableness



(b) Emotional Stability

Table 4: Average personality traits by educational level

Occupation	Emotional Stability	Openness	Conscientiousness	Agreeableness	Extroversion
High School	-0.0478	-0.1414	-.0784	-0.0508	0.0393
or Lower	(0.0140)	(0.0139)	(0.0138)	(0.0141)	(0.0133)
College	0.0258	0.0605	0.1033	0.0765	-0.0056
Dropouts	(0.0354)	(0.0338)	(0.0349)	(0.0345)	(0.0358)
College	0.1043	0.3096	0.1430	0.0839	-0.0997
Graduates	(0.0208)	(0.0202)	(0.0217)	(0.0208)	(0.0232)

Note: Each personality trait was standardized to have mean 0, variance 1.
Source: HILDA, waves 5, 9 and 13.

Table 5: Average personality traits by occupation category

Occupation	Emotional Stability	Openness	Conscientiousness	Agreeableness	Extroversion
Blue-collar	-0.0366	-0.1715	-.0464	-0.0208	0.0215
	(0.0166)	(0.0162)	(0.0162)	(0.0168)	(0.0158)
White-collar	0.0797	0.1507	0.1360	0.0573	-0.0127
	(0.0166)	(0.0164)	(0.0171)	(0.0164)	(0.0179)

Note: Each personality trait has been standardized to have mean 0, variance 1.
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Table 6: Medium and long-run changes in Big-Five personality and education/occupation

	Extraversion		Agreeableness		Conscientiousness		Stability		Openness	
	Medium	Long	Medium	Long	Medium	Long	Medium	Long	Medium	Long
Education	-0.009	0.005	0.049**	0.032*	0.022	0.066**	0.004	0.017	0.022	0.012
	(0.022)	(0.017)	(0.023)	(0.018)	(0.023)	(0.018)	(0.026)	(0.020)	(0.023)	(0.018)
White Collar	-0.002	-0.008	0.007	0.006	-0.012	0.002	-0.010	0.001	0.000	-0.001
	(0.013)	(0.008)	(0.014)	(0.008)	(0.014)	(0.008)	(0.016)	(0.009)	(0.014)	(0.008)
Blue Collar	-0.011	−0.016**	0.014	0.011	0.003	0.001	-0.016	0.004	-0.013	-0.006
	(0.014)	(0.008)	(0.015)	(0.008)	(0.014)	(0.008)	(0.016)	(0.009)	(0.014)	(0.008)
Trend	0.004	0.031	-0.052	0.019	0.078	0.105*	0.142**	0.090	-0.039	0.044
	(0.056)	(0.053)	(0.060)	(0.056)	(0.059)	(0.057)	(0.067)	(0.064)	(0.059)	(0.056)

Note: * 10% significance level. ** 5% significance level. Standard errors in parentheses.

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Table 7: How personality traits and cognitive ability relate to schooling decisions

	Probit 1	Marginal	Probit 2	Marginal
Emotional Stability	0.084***	0.026	0.057*	0.017
Openness	0.228***	0.070	0.219***	0.066
Conscientiousness	0.137	0.042	0.142***	0.043
Agreeableness	-0.033***	0.010	0.028	0.008
Extraversion	-0.136***	-0.042	-0.150***	-0.045
Cognitive	0.514***	0.157	0.519***	0.157
Family Characteristics	No		Yes	
Observations	6101		4361	
R Square	0.1117		0.1255	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: How personality traits and cognitive ability relate to occupation

	Probit1	Mgn1	Probit2	Mgn2	Probit3	Mgn3
Emotional Stability	-0.044	-0.015	-0.049	-0.015	-0.074	-0.022
Openness	0.205***	0.072	0.273***	0.093	0.224***	0.066
Conscientiousness	0.122***	0.043	0.103***	0.035	0.083**	0.024
Agreeableness	-0.016	-0.006	0.041	0.014	0.055	0.016
Extraversion	0.042	0.015	-0.012	-0.004	0.030	0.009
Cognitive	0.664***	0.232	0.573***	0.195	0.353***	0.105
College					1.153***	0.401
Family Characteristics	No		Yes		Yes	
Observations	4126		2855		2855	
R Square	0.1142		0.1355		0.2399	

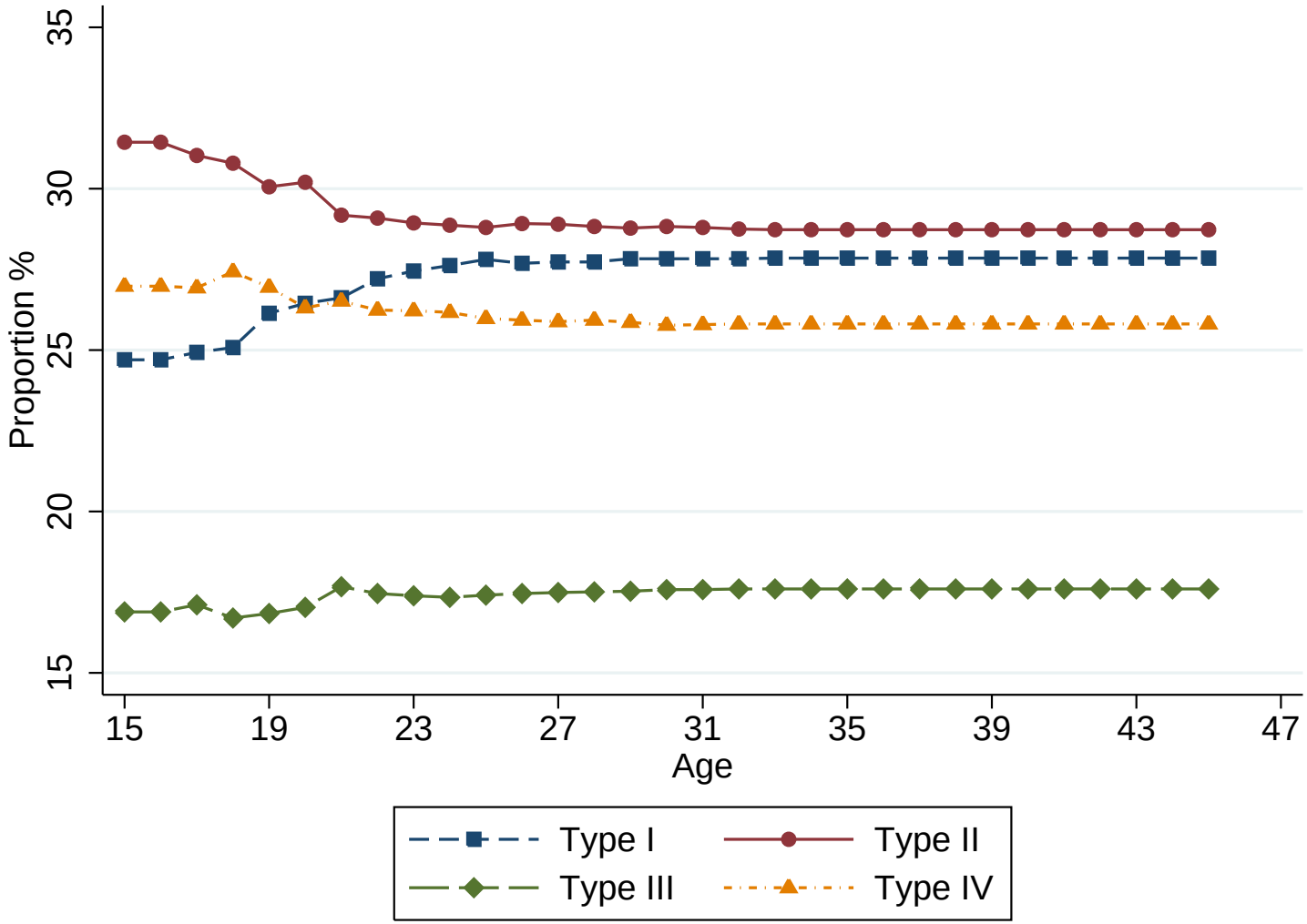
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: How personality and cognitive ability relate to log wages

	Blue Collar No College	White Collar No College	Blue Collar College	White Collar College
Emotional Stability	0.022	-0.045	0.024	0.001
Openness	-0.074***	-0.012	-0.078	-0.097***
Conscientiousness	0.085***	0.111***	0.067	0.092***
Agreeableness	-0.040	-0.021	-0.006	-0.046
Extraversion	0.036	0.030	0.113	0.029
Cognitive	0.017	-0.032	-0.041	0.010
Family Characteristics	Yes	Yes	Yes	Yes
Observations	1138	479	223	830
R Square	0.0593	0.0729	0.3095	0.0971

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 8: The fraction of types by age cohort



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- High cognitive skills go along with more desirable personality traits (noncognitive).

Questions of interest

- Are personality traits important in explaining unobserved heterogeneity?
  - Do they affect schooling decisions?
  - Are they rewarded in the labor market?
  - Do they explain occupational choices?
- Is it important to consider personality traits when evaluating the impacts of education policies, such as college tuition subsidies?
  - Carniero and Heckman (2002) summarize the evidence on credit constraints in post-secondary schooling.
  - Keane and Wolpin (1997) found college tuition subsidies to be relatively ineffective in ameliorating inequality.

The "Big-Five" personality traits

- **Openness to Experience** - The tendency to be open to new aesthetic, cultural, or intellectual experiences.
- **Conscientiousness** - The tendency to be organized, responsible, and hardworking.
- **Extroversion** - An orientation of one's interests and energies toward the outer world of people and things rather than the inner world of subjective experience; characterized by positive affect and sociability.
- **Agreeableness** - The tendency to act in a cooperative, unselfish manner.
- **Neuroticism (the opposite of Emotional Stability)** - A chronic level of emotional instability and proneness to psychological distress.

Goals of this paper

- Incorporate personality traits into a dynamic model of schooling, work and occupational choices over the life-cycle.
- Model is similar in structure to Keane and Wolpin (1997) except that it allows for time-varying unobserved heterogeneity (types).
- Personality traits are incorporated as potential determinants of unobserved types.
- The distribution of types is allowed to vary with age, consistent with the fact that some personality traits are known to evolve until around the mid 30s, and to be potentially affected by schooling.

Goals of this paper

- Use the estimated model to evaluate the effects of educational policies
  - Compulsory secondary schooling
  - College tuition subsidy
- Compare results obtained under our benchmark model to those obtained under a restrictive model without time-varying types and personality traits.

Data

Estimation is based on the Household, Income and Labour Dynamics in Australia (HILDA) longitudinal data.

- One in one thousand household-based panel survey.
- Collects information on household and family relationships, income, employment, health and education.
- Surveys individuals three times about their personality traits, so it is possible to observe changes over time.
- Our estimation focuses on males to avoid consideration of fertility decisions along with labor supply decisions.

Key findings

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Key findings

- Evaluation of educational policy interventions (tuition subsidies, compulsory schooling)
  - Individuals are more responsive to both policies when types can vary with age rather than being fixed.
    - ★ Disadvantaged types respond more because there is a possibility of switching to a more advantaged type.
  - Ignoring how educational policies affect personality traits and affects types underestimates the incentives created by educational policies.
- Tuition subsidies mainly affect schooling and labor market outcomes of more advantaged types, whereas compulsory schooling affects less advantaged types.

Related literature

- Sources of ex-ante inequality in lifetime welfare
  - Keane and Wolpin (1997); Yamaguchi (2012); Sullivan (2010); Huggett et al. (2011).
- Using dynamic models to evaluate schooling policies
  - Keane and Wolpin (1997); Heckman, Lochner and Taber (1998), Todd and Wolpin (2006), Heckman and Rong (2017)
- The effect of personality traits on schooling and employment choices
  - Schooling choices: Lundberg (2013).
  - Occupation choices: Cobb-Clark and Tan (2011); Fletcher (2013).
- Dynamic formation of non-cognitive skills
  - Heckman et al. (2006); Cunha and Heckman (2008); Heckman and Raut (2016).

Data: HILDA

The Household Income and Labour Dynamics in Australia (HILDA) longitudinal data set, males between age 15-58.

- General employment and education information annually 2001-2013.
- Personality traits surveyed in waves 2005, 2009 and 2013.
- Cognitive ability measured once in wave 2012.

Table 1: Personality questionnaire

B19 How well do the following words describe you? For each word, cross one box to indicate how well that word describes you. There are no right or wrong answers.

(Cross ☒ one box for each word.)

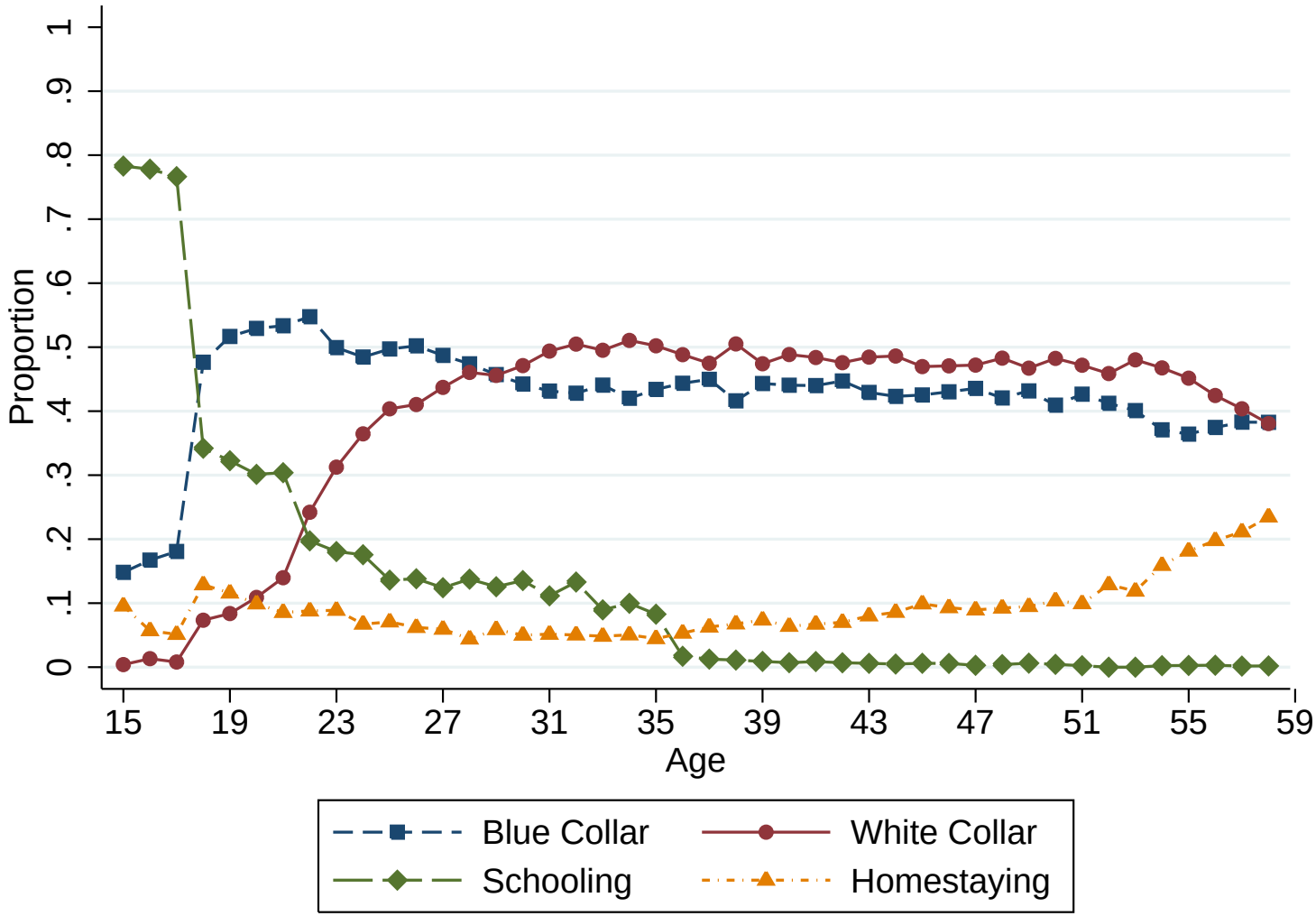
	Does not describe me at all 1 2 3 4 5 6 7 Describes me very well		Does not describe me at all 1 2 3 4 5 6 7 Describes me very well
talkative	1 2 3 4 5 6 7	jealous	1 2 3 4 5 6 7
sympathetic	1 2 3 4 5 6 7	intellectual	1 2 3 4 5 6 7
orderly	1 2 3 4 5 6 7	extroverted	1 2 3 4 5 6 7
envious	1 2 3 4 5 6 7	cold	1 2 3 4 5 6 7
deep	1 2 3 4 5 6 7	disorganised	1 2 3 4 5 6 7
withdrawn	1 2 3 4 5 6 7	temperamental	1 2 3 4 5 6 7
harsh	1 2 3 4 5 6 7	complex	1 2 3 4 5 6 7
systematic	1 2 3 4 5 6 7	shy	1 2 3 4 5 6 7
moody	1 2 3 4 5 6 7	warm	1 2 3 4 5 6 7
philosophical	1 2 3 4 5 6 7	efficient	1 2 3 4 5 6 7
bashful	1 2 3 4 5 6 7	fretful	1 2 3 4 5 6 7
kind	1 2 3 4 5 6 7	imaginative	1 2 3 4 5 6 7
inefficient	1 2 3 4 5 6 7	enthusiastic	1 2 3 4 5 6 7
touchy	1 2 3 4 5 6 7	selfish	1 2 3 4 5 6 7
creative	1 2 3 4 5 6 7	careless	1 2 3 4 5 6 7
quiet	1 2 3 4 5 6 7	calm	1 2 3 4 5 6 7
cooperative	1 2 3 4 5 6 7	traditional	1 2 3 4 5 6 7
sloppy	1 2 3 4 5 6 7	lively	1 2 3 4 5 6 7

Table 2: Definitions and examples of the ANZSCO coding of occupations

Collar	Occupations	Examples
White Collar	Managers	Legislators, senior officials Corporate/general managers
	Professionals	Professionals, Physician, mathematician, Engineer and life science.
	Technicians and tradespersons	Technicians and associate professionals, Physical and engineering scientists, Life science and health association
Blue Collar	Community and personal service workers	Office clerks, Customer service clerks
	Clerical and administrative workers	Service workers and shop workers, Personal and protective service workers Models, salespersons
	Sales workers	Sales representative, insurance brokers, checkout operator, models and telemarketers,
	Machinery operators and drivers	Industrial spraypainter, sewing machinist, motion picture projectionist, crane operator, forklift driver, and train driver
	Labourers	Cleaners, steel fixer, product assembler, packer, slaughter, farm worker, kitchen hand, freight handler and handypersons

Table 3: Sample summary statistics

Variable	Proportion	Variable	Proportion
Geographic Information		Parental Information	
State		***Father Education***	
NSW	0.3125	College	0.5798
VIC	0.2496	Not College	0.4202
QLD	0.2009	***Mother Education***	
SA	0.0928	College	0.3778
WA	0.0871	Not College	0.6222
TAS	0.0275	***Father Working***	
NT	0.0057	Employed	0.9558
ACT	0.0240	Not Employed	0.0209
Family background		Deceased	0.0233
Family Intactness		***Father Occupation***	
Both parents	0.8341	White Collar	0.6485
Father and step	0.0107	Blue Collar	0.3515
Mother and step	0.0427	***Mother Working***	
Father only	0.0233	Employed	0.5488
Mother only	0.0734	Not Employed	0.4139
Other	0.0158	Deceased	0.0720
Sibling Info		Not Asked	0.0302
Sibling dummy		***Mother Occupation***	
Has siblings	0.9637	Not Asked	0.2113
No siblings	0.0373	White Collar	0.2889
Sibling numbers		Blue Collar	0.4990
Not Asked	0.0379	Cohort Information	
1	0.2563	***Year***	
2	0.3071	1940-1949	0.1038
3	0.1820	1950-1959	0.1919
4	0.0994	1960-1969	0.2358
5 or more	0.1173	1970-1979	0.1913
Eldest Sibling		1980-1989	0.1686
Not Asked	0.0373	1990-	0.1040
Oldest	0.3432		
Not Oldest	0.6195	Total Individuals	4215



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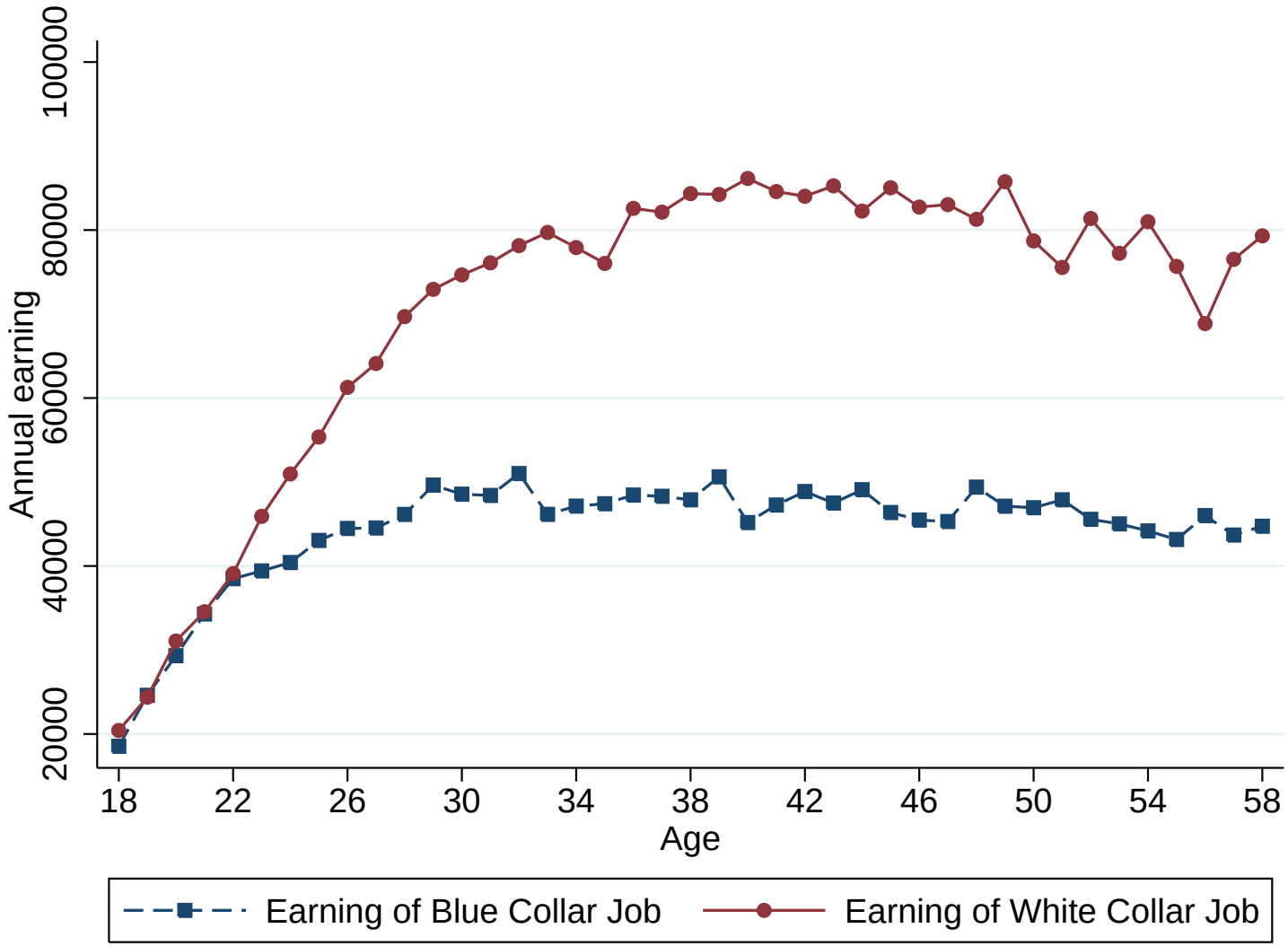

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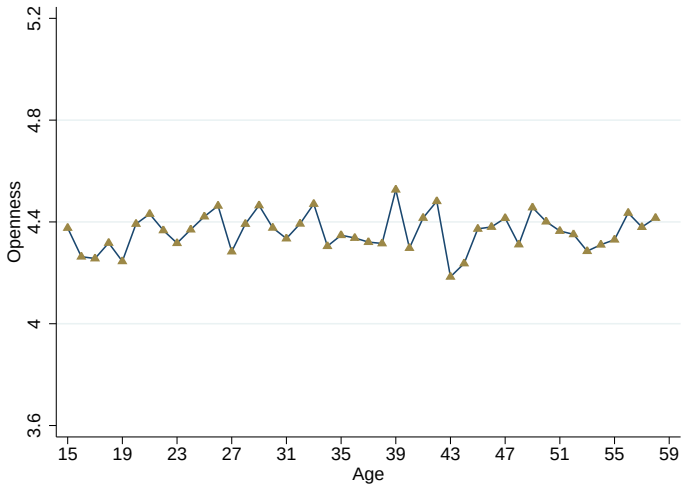

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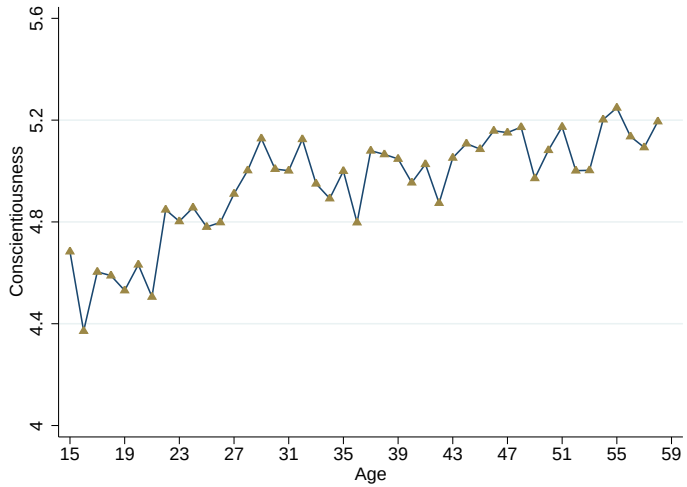

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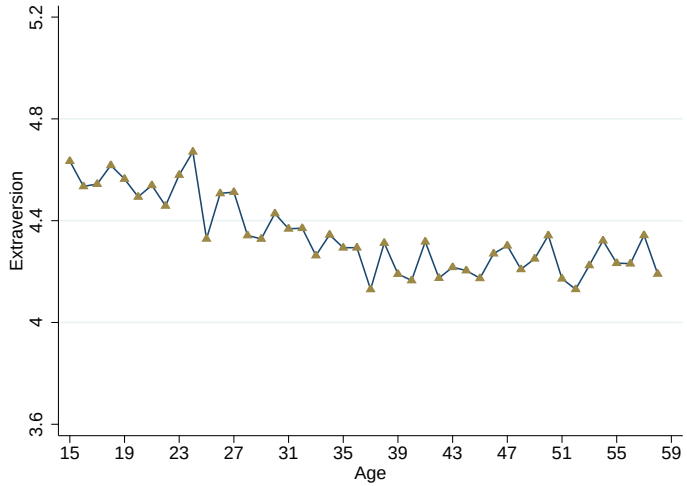

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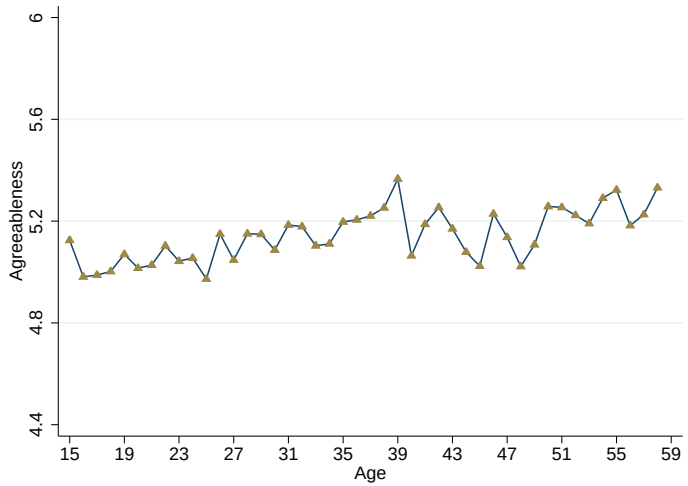

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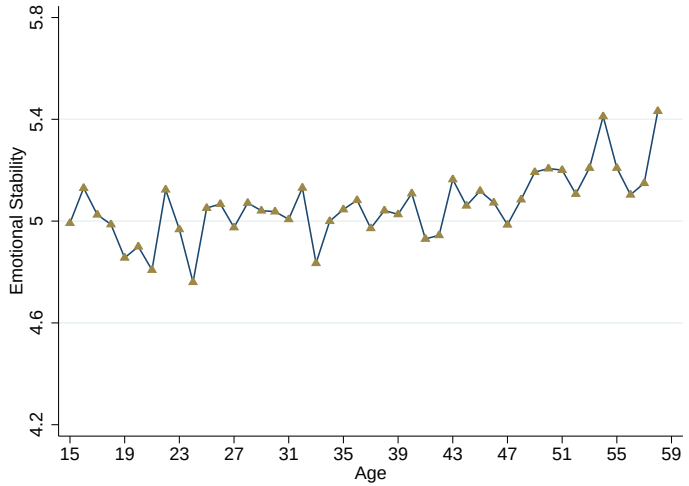

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	Probit1	Mgn1	Probit2	Mgn2	Probit3	Mgn3
Emotional Stability	-0.044	-0.015	-0.049	-0.015	-0.074	-0.022
Openness	0.205***	0.072	0.273***	0.093	0.224***	0.066
Conscientiousness	0.122***	0.043	0.103***	0.035	0.083**	0.024
Agreeableness	-0.016	-0.006	0.041	0.014	0.055	0.016
Extraversion	0.042	0.015	-0.012	-0.004	0.030	0.009
Cognitive	0.664***	0.232	0.573***	0.195	0.353***	0.105
College					1.153***	0.401
Family Characteristics	No		Yes		Yes	
Observations	4126		2855		2855	
R Square	0.1142		0.1355		0.2399	

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: How personality and cognitive ability relate to log wages

	Blue Collar No College	White Collar No College	Blue Collar College	White Collar College
Emotional Stability	0.022	-0.045	0.024	0.001
Openness	-0.074***	-0.012	-0.078	-0.097***
Conscientiousness	0.085***	0.111***	0.067	0.092***
Agreeableness	-0.040	-0.021	-0.006	-0.046
Extraversion	0.036	0.030	0.113	0.029
Cognitive	0.017	-0.032	-0.041	0.010
Family Characteristics	Yes	Yes	Yes	Yes
Observations	1138	479	223	830
R Square	0.0593	0.0729	0.3095	0.0971

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Model

- DCDP model of decision-making with regard to education, employment, and occupation sector over ages 15 to 58.
- At each age, individuals maximize their remaining discounted lifetime utility.
- Four mutually exclusive options $m \in M$: working in either a blue- or white-collar occupation, attending school, or staying home.
- Let $d_m(a) = 1$ if the alternative m is chosen at age a, $d_m(a) = 0$ otherwise.
- Individual endowments at age 15 consist of personality traits, cognitive ability, and family background characteristics (parental schooling, the number of siblings, sibling order and whether the person lived with both parents at age 14).

Unobservable heterogeneity

- Each individual is assumed to be one of four types $k(a) = \{1, 2, 3, 4\}$.
- An individual's type can affect their pecuniary and nonpecuniary reward from choosing particular alternatives.
- Types can evolve over time in a way that may depend on age and changing personality traits.

Notation

- $\Theta(a)$ represent the vector of personality traits at age a (observed)
- $k(a)$ denotes the unobserved type at age a (known by the individual but not known by econometrician).
- $s_o(a)$ represents all other observed state variables.
- $g(a)$ represents accumulated education
- $x_1(a)$ and $x_2(a)$ represent accumulated blue-collar and white-collar experience at age a.

Timing

- Initial type $k(15)$ is determined by the initial endowment $s_o(15)$.
- Given the initial type $k(15)$ and observed state variables $s_o(15)$, the agent chooses the alternative $d_m(a)$ that gives the highest current period reward plus continuation value.
- State variables, $s_o(16)$, updated according to the choice $d_m(15)$.
- The new type $k(16)$ is drawn depending on $s_o(16)$ and the previous period type $k(15)$.
- Continues in the same way until the last period.

Laws of Motion

- The time-varying part of $s_o(a)$ consists of four components, $s_o(a) = (g(a), x_1(a), x_2(a), \Theta(a))$.
- Years of schooling and occupation-specific experience evolve in a deterministic way.

$$\begin{aligned} g(a) : g(a+1) &= g(a) + d_3(a) \\ x_i(a) : x_i(a+1) &= x_i(a) + d_i(a), i = \{1, 2\} \end{aligned} \tag{1}$$

Laws of Motion

- We assume that the true $n-th$ personality trait $\theta_n \in \Theta, \{n = 1, 2, 3, 4, 5\}$ is measured with error, with the measurement error shock denoted $\zeta_n(a)$.
- The evolution of each trait:

$$\theta_n^M(a+1) = \theta_n(a+1) + \zeta_n(a+1)$$
$$\theta_n(a+1) = \theta_n(a) + \gamma_{0n} + \gamma_{1n}(a-15) + \gamma_{2n}d_3(a) + \gamma_{3n}(a-15)d_3(a) \quad (2)$$

where $\theta_n^M(a+1)$ is the measure of the nth personality trait at age $a+1$ and $\theta_n(a+1)$ is the true trait without measurement error. γ_{0n} and γ_{1n} capture the age effects. The term $\gamma_{2n} + \gamma_{3n}(a-15)$ captures potential education and age*education interaction effects.

Time-Varying Types

- Types may change through a Markov process that depends potentially on age and on personality traits.
- After the initial period, the type $k(a)$ can stay the same with probability $1 - p(a)$ or change to a new type with probability $p(a)$.
- $q_k(a)$ represents the probability of becoming type $k \in \{1, 2, 3, 4\}$.
- $L(a)$ denotes the Markov transition matrix of types between period a and period a+1.

Time-Varying Types

$$L(a) = p(a) \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} + (1 - p(a)) \begin{bmatrix} q_{k=1}(a) & q_{k=1}(a) & q_{k=1}(a) & q_{k=1}(a) \\ q_{k=2}(a) & q_{k=2}(a) & q_{k=2}(a) & q_{k=2}(a) \\ q_{k=3}(a) & q_{k=3}(a) & q_{k=3}(a) & q_{k=3}(a) \\ q_{k=4}(a) & q_{k=4}(a) & q_{k=4}(a) & q_{k=4}(a) \end{bmatrix} \quad (3)$$

where

$$p(a) = \frac{1}{1 + \exp(\gamma_7 + \gamma_8(a - 15) + \gamma_9(a - 15)^2)} \quad (4)$$

$$q_k(a) = \frac{\bar{v_k^a}(\Theta, c)}{\Pi_{k=1}^{K=4} \bar{v_k^a}(\Theta, c)} \quad (5)$$

$$\log \bar{v_k^a}(\Theta, c) = \gamma_{3k} + \sum_{n=1}^{N=5} \gamma_{4kn}\theta_n(a) + \gamma_{5k}c + \sum_{z=1}^{Z} \gamma_{6zk}d_z + \eta_k(a)$$

Time-Varying Types

- At age 15, the initial types are directly drawn from the distribution $q_k(15)$.
- In subsequent ages, types are updated following the Markov transition matrix $L(a)$.
- When $p(a)$ is close to 0, then $L(a)$ corresponds to an identity matrix $I_{4\times4}$ and the types, k, are fixed.
- When $p(a) = 1$, types do not persist from previous period.
- We estimate $p(a)$ in a flexible way, allowing for the possibility that types can become more or less persistent with age.

Rewards associated with working alternatives

- An individual can choose to work in either a blue-collar occupation or a white-collar occupation.
- The reward to occupational sector m includes the wage compensation $w_m(a)$ and any non-pecuniary reward $r_m(a)$.
- $\epsilon_m(a)$ is the preference shock when choosing $m-th$ alternative.
- $m = 1$ denotes the blue-collar alternative and $m = 2$ the white-collar alternative.

$$u_m(a) = w_m(a) + r_m(a) + \epsilon_m(a), m = \{1, 2\} \tag{5}$$

- As in Keane and Wolpin (1997), the wage is specified as a human capital pricing equation, $w_m(a) = p_m e_m(a)$.
- Human capital is accumulated through work experience and by attending school.

$$e_m(a) = exp(e_m^k + \sum_{i=1}^{I} \beta_{m0i} d_i + \beta_{m1} g(a) + (\beta_{m2} + \beta_{m3} I\{x_m(a) \leq 2\}) x_m(a) + \beta_{m4} x_m^2(a) + \beta_{m5} x_m(a) g(a) + \xi_m(a))$$

- Log-wage offer equation:

$$\log w_m(a) = \log p_m + e_m^k + \sum_{i=1}^{I} \beta_{m0i} d_i + \beta_{m1} g(a) + (\beta_{m2} + \beta_{m3} I\{x_m(a) \leq 2\}) x_m(a) + \beta_{m4} x_m^2(a) + \beta_{m5} x_m(a) g(a) + \xi_m(a)$$

Wage equation

- $d_i, i \in \{state \times cohort\}$ denotes a fixed effect of being a member of particular age cohort and residing in a particular state.
- e_m^k is the type-specific component of reward
- $g(a)$ represents years of schooling and $x_m(a)$ denotes working experience in sector m.
- $\beta_{m3} I\{x_m(a) \leq 2\} x_m(a)$ captures a potential differential in returns to experience when the agent is new in an occupation (two years or less experience).
- $\beta_{m5} x_m(a) g(a)$ captures the interaction term between working experience $x_m(a)$ and education $g(a)$.
- $\xi_m(a)$ is a i.i.d. normal shock
- $r_m(a)$, represents nonpecuniary aspects of choosing a certain occupation, expressed in monetary equivalent units.

School-going reward

- Utility consists of two parts: a nonpecuniary component, which may reflect such as physical and mental costs when attending school, and a pecuniary component, such as tuition costs and fees.
- School utility at age a:

$$u_3(a) = e_3^k + \sum_{z=1}^{Z} \alpha_z d_z + \sum_{r=1}^{R} \alpha_r d_r + \alpha_0 I(age < 19) - \alpha_1 I(college) - \alpha_2 I(graduate) + \epsilon_3(a) \tag{6}$$

- d_z captures the potential effect of family background on a person's preference for attending school. d_r is a cohort-specific effect.
- $\alpha_0 I(age < 19)$ captures extra utility of attending school when under age 19.
- α_1 and α_2 are per period schooling costs of attending college and attending graduate school.
- e_3^k is the type-specific reward from attending school.

Staying home

- The reward from staying home, $u_4(a)$, consists of the type-specific component e_4^k, an age effect and an age squared effect, α_3 and α_4, and a home-staying preference shock $\epsilon_4(a)$:

$$u_4(a) = e_4^k + \alpha_3 \cdot age + \alpha_4 \cdot age^2 + \epsilon_4(a) \tag{7}$$

- Personality traits do not directly appear in the choice-specific utilities. Instead, they affect the choices indirectly through their influence on an individual's type probability.
- This structure reduces the dimensionality of the state space as it avoids the need to include a five-dimensional personality trait vector in the time-varying state space.
- Different types have different type-specific component e_m^k in each choice m.
- Heterogeneity comes from two sources: ex-ante endowments and ex-post realized shocks.
- In terms of timing, we assume that the shocks governing the evolution of personality and of types are realized first, allowing individuals to learn their type. After that, individuals observe preference shocks and choose their preferred sector. After that, wage shocks are realized.

Estimation Strategy

- At the beginning of age a, an individual has the state vector $s(a)$, determined by his choices up to age a.
- The value function at age a is the maximum over all possible sequences of future choices:

$$V(s(a), a, \Omega) = \max_{\{d_m(t)\}} E\left[\sum_{t=a}^{A} \delta^{\tau-a} \sum_{m=1}^{4} u_m(t) d_m(t) | s(a),\right]$$

where

Ω denotes a set of parameter values. The summation over t denotes the ages and the summation over m denotes the different sector choices.

The problem can be written in Bellman equation form. The alternative specific value function is for $a < A$

$$V_m(s(a), a, \Omega) = \tilde{u}_m(s(a), a) + \delta E\left[V(s(a+1), a+1, \Omega)|s(a), d_m(a)\right]$$

where

$$\tilde{u}_m(s(a), a) = \int_{\xi_m(a)} u_m(s(a), a) f(w(\xi_m(a)))d\xi_m(a)$$

In the last time period A,

$$V_m(s(A), A, \Omega) = \tilde{u}_m(S(A), A)$$

- Wages in the white. and blue collar sectors are assumed to be normally distributed and uncorrelated.
- The expectation in the Bellman equation is taken over future wage and preference shocks and over the random process that governs personality trait transitions and unobserved type transitions.
- The value function is the max over the alternative specific value functions:

$$V(s(a), a, \Omega) = \max_{m \in M} V_m(s(a), a, \Omega)$$

- Preference shocks enter additively into $u_m(s(a), a)$ (i.i.d. type I extreme value distribution).

$\tilde{V}_m(s(a), a, \Omega)$ denotes the choice-specific value function excluding the contemporaneous sector-specific preference shock $\epsilon_m(a)$,.

$$V_m(s(a), a, \Omega) = \tilde{V}_m(s(a), a, \Omega) + \epsilon_m(a).$$

Because of the preference shock distributional assumptions,

$$\Pr(d_m(a) = 1 | s(a), \Omega) = \frac{\exp(\tilde{V}_m(s(a), a, \Omega)/\sigma_c)}{\sum_{j=1}^{4} \exp(\tilde{V}_j(s(a), a)/\sigma_c)}$$

- The dynamic programming problem is solved using backward recursion for each set of parameter values under consideration.
- In the last period A, when there is no future expected value function and using the previous equation, one obtains $E\left[V(s(A), A)|s(A-1), d_m(A-1)\right]$ for each possible point in the state space.
- Plugging in $E\left[V(s(A), A)|s(A-1), d_m(A-1)\right]$ into $\tilde{V}_j(s(A-1), A-1)$, one can then use the same expression to obtain $E\left[V(s(A-1), A-1)|s(A-2), d_m(A-2)\right]$ and so on, back until the first time period.
- After solving the dynamic programming problem, one obtains the expected future value functions for all possible state points and it is then possible to use the model to simulate choices and to implement a simulated method of moments optimization algorithm to estimate the parameters.

Simulated Method of Moments estimation

- We use an unconditional simulation approach starting from age 15, because occupation-specific experience stocks are not observed at the time of sampling.
- We then compute R moments using the N simulated samples and the data, calculating the weighted difference between the R simulated moments $\tilde{M}_{N,R}(\Omega)$ and the analogous data moments M_R.
- We use the variance information of each data moment in forming the weighting matrix, W_R.

Moments

- In total, we match 505 moments to estimate 124 parameters for four-year age groups.
- The following types of moments are used in our estimation:
  1. Sequential life-time choices:
     - ★ The fraction of individuals in the blue-collar occupation sector by age (15-58).
     - ★ The fraction of individuals in the white-collar occupation sector by age (15-58).
     - ★ The fraction of individuals in school by age (15-58).
     - ★ The fraction of individuals at home by age (15-58).
  2. Earning profiles
     - ★ Average log earnings of blue-collar workers by age (18-58).
     - ★ Average log earnings of white-collar workers by age (18-58).
     - ★ The standard error of log earnings of blue-collar jobs by age (18-58).
     - ★ The standard error of log earnings of white-collar jobs by age (18-58).
  3. Personality traits
     - ★ Mean value of openness to experience by four-year age groups and by waves.
     - ★ Mean value of conscientiousness by four-year age groups and by waves.

Table 10: Model parameter estimates: reward functions

	1. *White-Collar*	2. *Blue-Collar*	*3. Schooling*	
	Skill Function		Tuition cost: college	13.5199(0.7885)
Mincer Equation			Additional cost:graduate school	10.6251(0.6737)
Schooling	0.0447(0.0047)	0.0399(0.0052)	Additional utility before age 19	1.5554(0.1181)
White-Collar exp	0.0105(0.0054)	-0.0013(0.0058)	**Constant:**	
Blue-Collar exp	0.0385(0.0048)	0.0244(0.0054)	Type I	8.1760(0.4348)
"Own" exp squared/100	-0.0293(0.0058)	-0.0304(0.0061)	Deviation of type 2	-3.7180(0.0059)
"Own" exp× edu	0.0103(0.0058)	0.0106(0.0054)	Deviation of type 3	-7.6862(0.0055)
"Own" exp ≤ 2	0.1624(0.0094)	0.2932(0.0185)	Deviation of type 4	-0.8058(0.0058)
Standard Error	0.4750(0.0246)	0.3773(0.0254)	**Family Background**	
Constant:			Family Intactness Dummy	0.0911(0.0060)
Type I	9.8638(0.0684)	9.3990(0.0807)	**Sibling(Omitted cat: only child)**	
Deviation of type 2	-0.0771(0.0058)	0.3893(0.0248)	multiple children, eldest one	-0.1054(0.0065)
Deviation of type 3	-0.6018(0.0061)	-0.3572(0.0063)	multiple($N < 4$), not eldest one	-0.0489(0.0068)
Deviation of type 4	-0.5935(0.0056)	-0.5772(0.0053)	multiple($N \geq 4$), not eldest one	-0.1947(0.0300)
State(Omitted cat:NSW)			**Parental Education(Omitted cat:no college)**	
VIC	-0.1267(0.0056)	-0.1593(0.0057)	One college	0.0750(0.0199)
QLD	-0.0306(0.0062)	-0.5000(0.0055)	Two colleges	0.3830(0.0090)
SA	-0.5045(0.0057)	0.5000(0.0333)	**Cohort(Omitted cat:40-49)**	
WA	0.0135(0.0060)	-0.0044(0.0060)	50-59	-0.1562(0.0058)
TAS	-0.2544(0.0053)	0.5007(0.0298)	60-69	-0.2539(0.0058)
NT	-0.5027(0.0054)	-0.5054(0.0045)	70-79	0.5064(0.0300)
ACT	0.2370(0.0153)	-0.0306(0.0059)	80-89	1.6202(0.0855)
Cohort(Omitted cat:40-49)			After 90	1.6620(0.1557)
50-59	0.1980(0.0134)	0.3038(0.0189)	*4. Home-staying*	
60-69	0.3508(0.0201)	0.4859(0.0250)	Age	0.0138(0.0056)
70-79	0.5334(0.0299)	0.6351(0.0369)	Age squared/100	0.0092(0.0059)
80-89	0.3010(0.0182)	0.5295(0.0305)	**Constant:**	
After 90	0.0003(0.0058)	0.0009(0.0058)	Type I	4.4872(0.1761)
	Non-pecuniary Values		Deviation of type 2	-1.0019(0.0059)
Constant	...	2.3388(0.1145)	Deviation of type 3	-2.2900(0.0055)
College Premium	...	-2.0011(0.1293)	Deviation of type 4	-1.1334(0.0065)
Preference Shock	0.9195(0.0594)		Discount Factor	0.8960(0.0284)

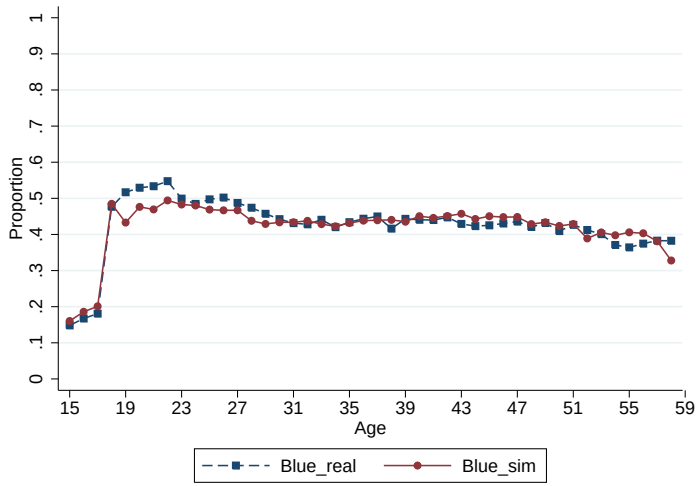
Table 11: Estimated coefficients on unobserved type probabilities

Types	I(baseline)	II	III	IV
Constant term	...	0.030	0.001	-0.010
		(.0058)	(.0060)	(.0062)
Cognitive	...	-0.508	-0.990	-1.520
		(.0063)	(.0058)	(.0060)
Openness to Experience	...	-1.500	-1.000	0.000
		(.0067)	(.0064)	(.0051)
Conscientiousness	...	-0.900	-0.520	-1.110
		(.0060)	(.0060)	(.0057)
Extraversion	...	-0.020	-0.026	-0.880
		(.0053)	(.0058)	(.0061)
Agreeableness	...	1.500	0.510	0.510
		(.0968)	(.0285)	(.0295)
Emotional Stability	...	-0.100	-0.110	-0.209
		(.0056)	(.0062)	(.0057)
Parental Background(baseline)				
Middle	0.001	0.007	0.000	-0.010
	(.0065)	(.0058)	(.0058)	(.0066)
High	0.020	0.020	-0.070	0.030
	(.0058)	(.0061)	(.0061)	(.0056)
Family Intactness	0.030	0.020	0.040	0.010
	(.0057)	(.0059)	(.0057)	(.0063)
Type Persistence	Time shift term		$Age-15$	$\frac{(Age-15)^2}{100}$
Values	0.40		0.12	1.00
	(.0164)		(.0085)	(.0654)

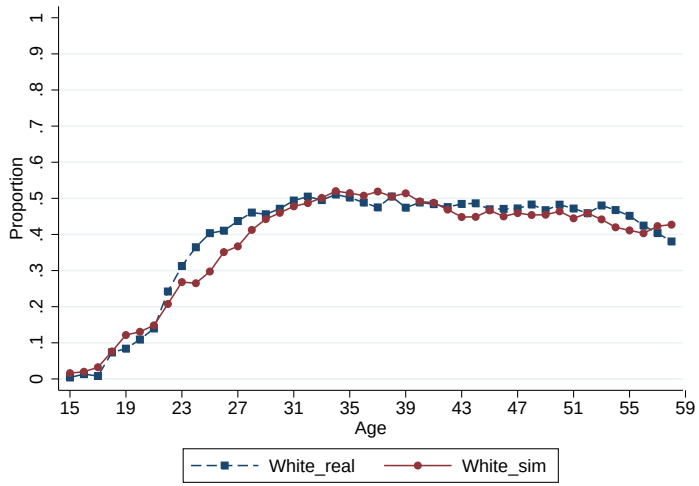
Table 12: Estimated coefficients for personality trait transition matrix

Traits	Edu	$Edu * (Age - 15)/100$	$Age - 15$	$(Age - 15)^2/100$
Openness to Experience	0.0022	-0.0042	-0.0022	0.0116
	(.0056)	(.0056)	(.0060)	(.0055)
Conscientiousness	0.0460	-0.1159	0.0342	-0.0694
	(.0051)	(.0052)	(.0050)	(.0070)
Extraversion	0.0049	-0.0057	-0.0167	0.0384
	(.0058)	(.0058)	(.0055)	(.0055)
Agreeableness	0.0364	-0.0968	0.0086	0.0136
	(.0059)	(.0061)	(.0053)	(.0061)
Emotional Stability	0.0079	-0.0141	0.0108	0.0075
	(.0054)	(.0057)	(.0052)	(.0062)

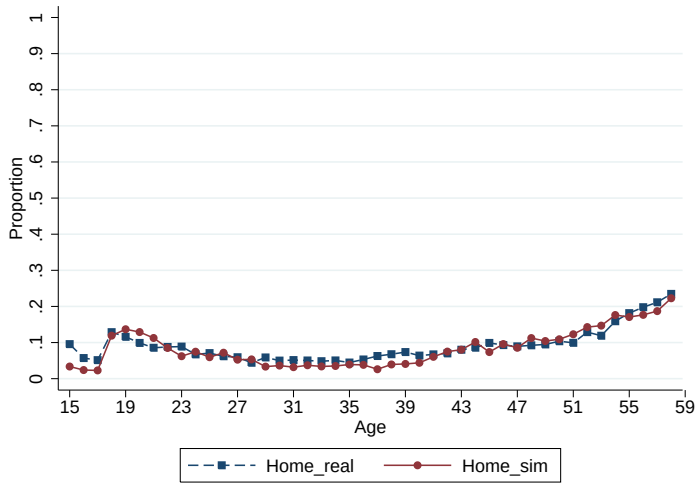
Figure 5: Comparison of choice distribution and earnings profile between data and model



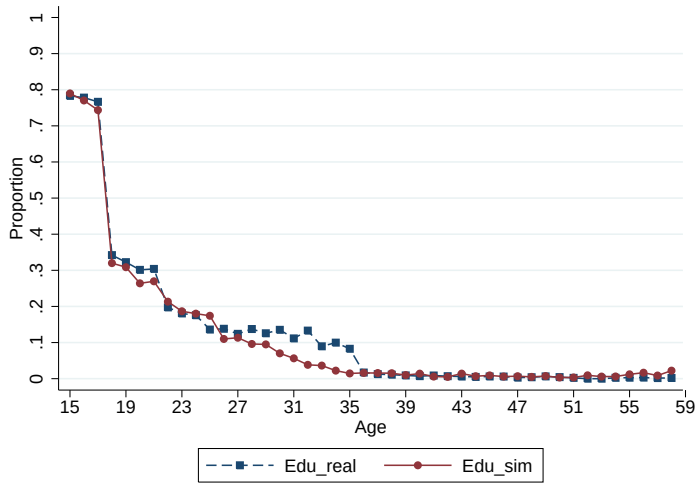
(a) Blue Collar Occupation



(b) White Collar Occupation

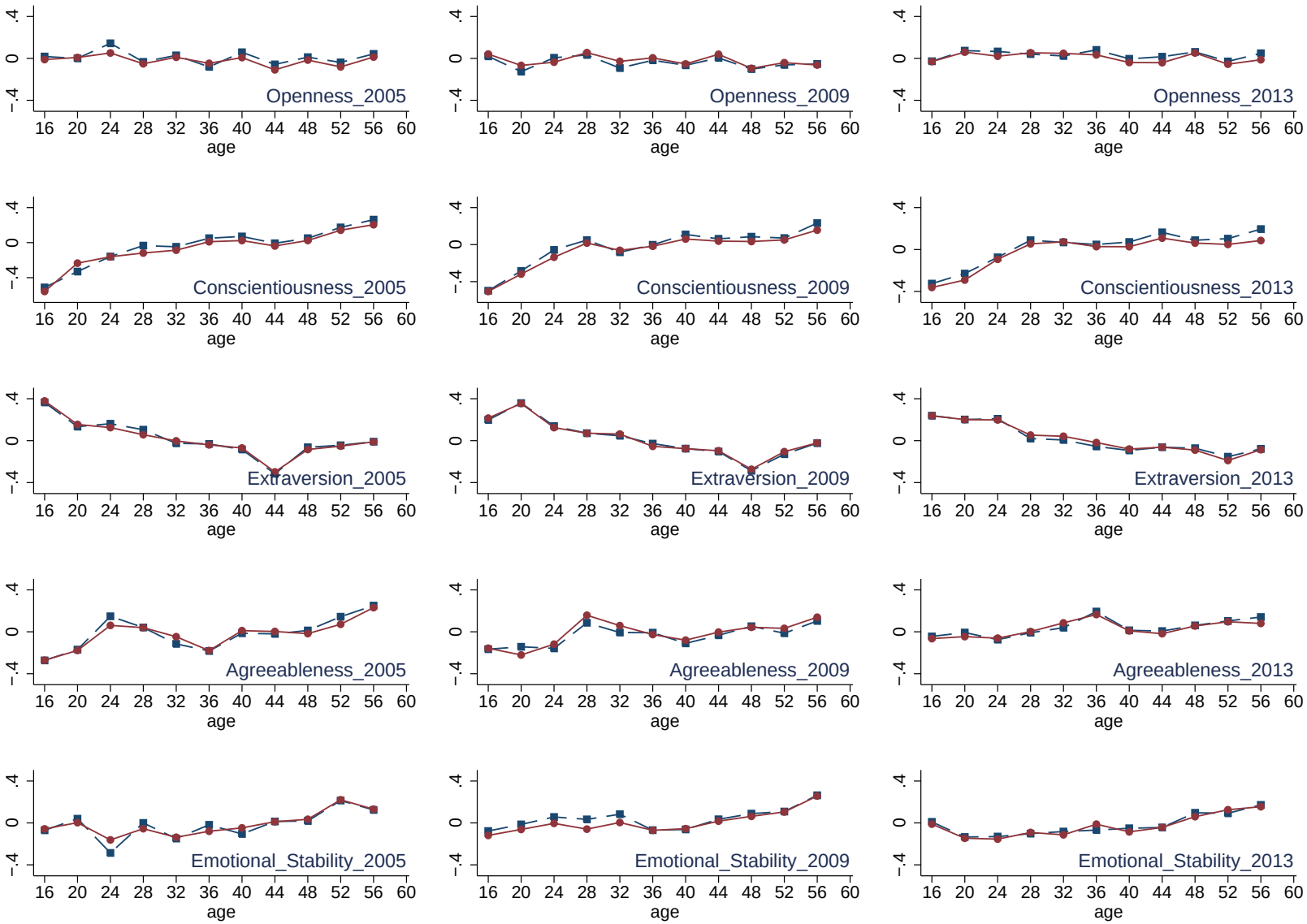


(c) home-staying



(d) Schooling

Figure 6: Comparison of personality traits between data and model



How type relates to sector choices

- Table 13 examines the type distributions within different alternatives.
- The row labeled "original" shows the proportions of the four types within each alternative. The row labeled "adjusted" gives the fractions of each choices adjusted by the fraction of each type in the population.
- Type I (27% of the population) has a comparative advantage in schooling and in the white-collar sector.
- Type II has a comparative advantage in the blue-collar sector.
- Type III is more likely to be in the blue-collar sector or to stay at home.
- Type IV is more often at school or at home.

Table 13: Simulated type proportions for different sector choices

Occupation		Type I	Type II	Type III	Type IV
White-collar	Original	47.89	17.58	9.00	25.53
	Adjusted	43.87	15.05	12.92	24.45
Blue-collar	Original	8.61	48.03	26.47	16.89
	Adjusted	7.89	41.12	38.01	16.18
School	Original	37.53	15.28	4.17	43.03
	Adjusted	34.38	13.08	5.99	41.22
Home	Original	7.46	9.17	29.37	54.00
	Adjusted	6.83	7.85	42.17	51.72
Total		27.29	29.20	17.41	26.10

Table 14: Average personality traits and cognitive ability by type

		Type I	Type II	Type III	Type IV
Openness	Mean	0.466	-0.614	-0.253	0.324
	SE	(0.004)	(0.004)	(0.004)	(0.004)
Conscientiousness	Mean	0.453	-0.274	0.069	-0.406
	SE	(0.004)	(0.004)	(0.005)	(0.004)
Extraversion	Mean	0.289	0.113	0.168	-0.427
	SE	(0.004)	(0.004)	(0.005)	(0.004)
Agreeableness	Mean	0.300	-0.201	0.002	-0.059
	SE	(0.004)	(0.004)	(0.005)	(0.004)
Stability	Mean	0.127	0.022	0.088	-0.318
	SE	(0.004)	(0.004)	(0.005)	(0.004)
Cognition	Mean	0.473	-0.165	0.056	0.011
	SE	(0.004)	(0.004)	(0.005)	(0.004)

Figure 7: Average personality traits of each type

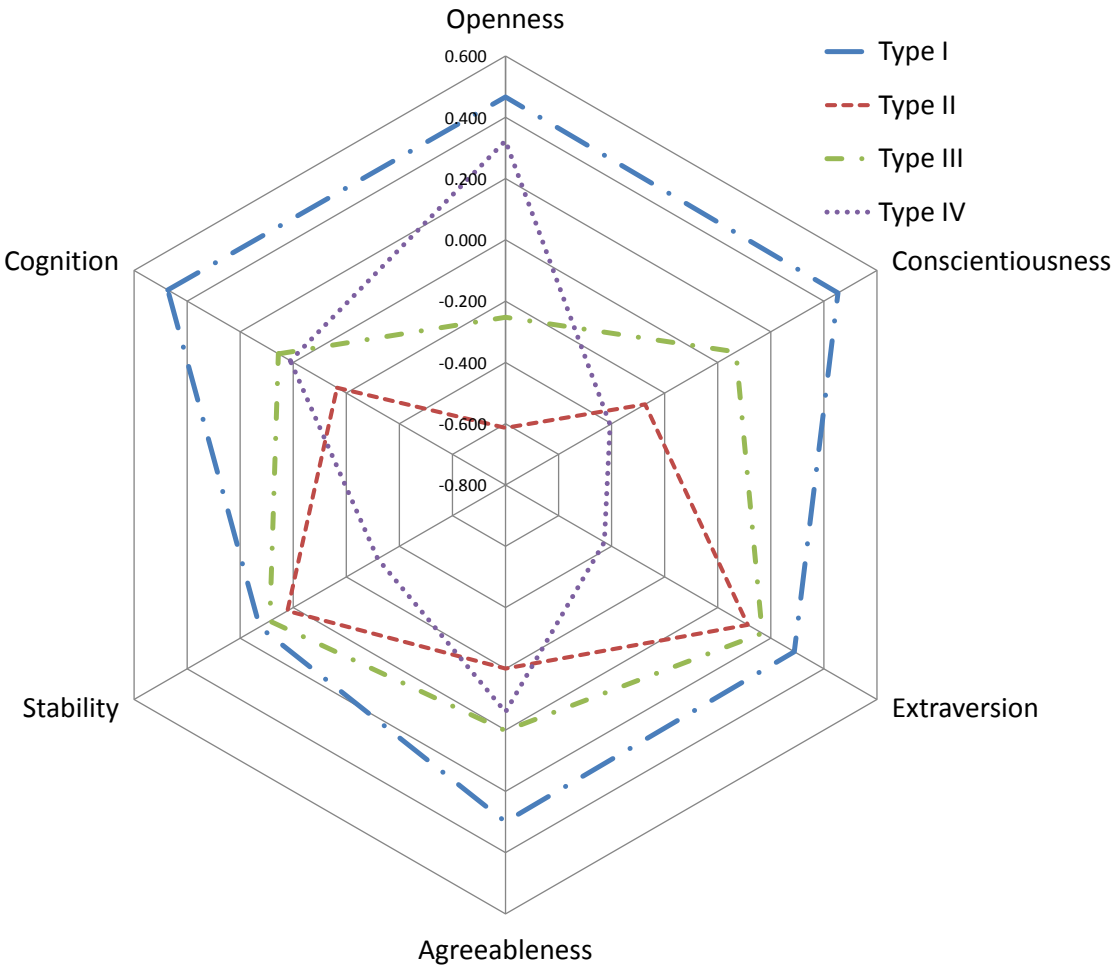


Figure 8: The fraction of types by age cohort

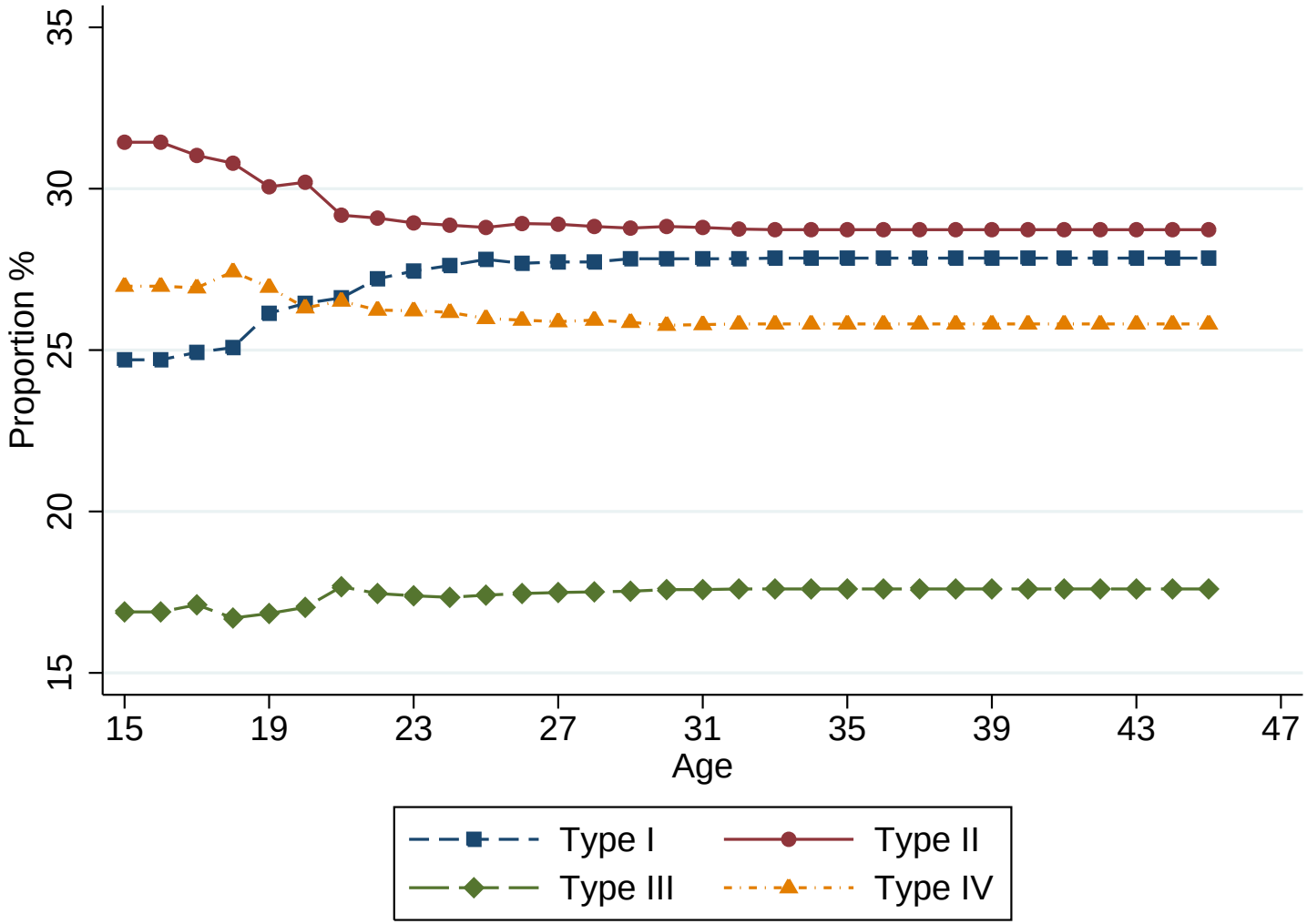


Table 15: Determinants of ex-ante utility variation

	Spec. 1	Spec. 2	Spec. 3
Intactness	-0.814*	-0.612	-0.579
Father Occupation	0.476	0.264	0.300
Parental Education	0.546**	0.284	0.235
Sibling	-0.417**	-0.337*	-0.297*
Cohort	1.454***	1.452***	1.406***
State	0.850***	0.844***	0.836***
Cognitive		2.080***	1.975***
Openness			0.245
Conscientiousness			1.210***
Extraversion			0.905***
Agreeableness			0.347*
Emotional Stability			-0.234
Observation	4215	4215	4215
R square	0.095	0.121	0.154

Table 16: Model specification test

	Baseline model	"Fixed type" model
Null Hypothesis		H0: $P_a = 0, \gamma_{4kn} = 0$
Distance Measure	2279.976	2406.325
LR test		126.349
The number of restrictions		18
$\chi^2(0.01)$ criteria		34.80

Table 17: The effect of educational policies on schooling and labor market outcomes, by type

Model	Type I	Type II	Type III	Type IV	Total
			Percentage Finishing High school		
Benchmark	98.4	78.4	75.5	97.9	88.2
50% college subsidy	0.2	0.5	0.5	0.2	0.2
Compulsory schooling	1.6	21.6	24.5	2.1	11.8
			Percentage College Graduates		
Benchmark	43.6	19.5	21.8	43.9	32.4
50% college subsidy	32.1	19.1	21.6	28.3	25.2
Compulsory schooling	0.5	1.9	4.2	0.8	1.7
			Years of Education		
Benchmark	14.347	12.132	12.072	14.832	13.431
50% college subsidy	1.003	0.593	0.687	0.924	0.799
Compulsory schooling	0.031	0.477	0.635	0.051	0.279
			Annual Earnings (for workers)		
Benchmark	96852.8	71946.8	34145.8	44211.4	66324.1
50% college subsidy	6672.8	2389.8	2340.0	8208.7	4718.7
Compulsory schooling	606.2	3616.2	2804.3	451.0	2210.4
			Utility Change(Unit: AU$10,000)		
Benchmark	80.132	73.908	68.623	73.786	74.520
50% college subsidy	1.758	0.574	0.687	0.477	1.135
Compulsory schooling	-0.831	-3.434	-5.328	-0.882	-2.423

Table 18: The effect of educational policies on personality traits, by type

Model	Type I	Type II	Type III	Type IV	Total
	Openness to experience (at age 30)				
Benchmark	0.458	-0.634	-0.262	0.319	-0.018
50% college subsidy	0.002	-0.001	0.003	0.001	0.001
Compulsory schooling	-0.007	0.003	0.005	0.000	0.001
	Conscientiousness (at age 30)				
Benchmark	0.388	-0.357	-0.008	-0.450	-0.113
50% college subsidy	0.031	0.010	0.017	0.034	0.026
Compulsory schooling	0.000	0.027	0.020	0.001	0.015
	Extraversion (at age 30)				
Benchmark	0.338	0.144	0.212	-0.374	0.075
50% college subsidy	0.003	-0.001	-0.002	0.004	0.004
Compulsory schooling	0.007	-0.008	0.004	-0.001	0.002
	Agreeableness (at age 30)				
Benchmark	0.251	-0.279	-0.058	-0.103	-0.048
50% college subsidy	0.024	0.012	0.005	0.030	0.020
Compulsory schooling	0.005	0.016	0.018	0.003	0.011
	Emotional Stability (at age 30)				
Benchmark	0.027	-0.073	0.003	-0.406	-0.118
50% college subsidy	0.001	0.009	-0.008	0.008	0.005
Compulsory schooling	0.002	0.001	0.012	-0.006	0.003

Table 19: The effects of educational policies under the restricted model with fixed types

model simulation	Type I	Type II	Type III	Type IV	Total
	Percentage Finishing High school				
Benchmark	100.0	73.6	41.2	100.0	81.8
50% college subsidy	0.0	0.0	0.0	0.0	0.0
Compulsory senior secondary school	0.0	26.4	58.8	0.0	18.2
	Percentage College Graduates				
Benchmark	55.8	0.2	0.0	77.1	34.9
50% college subsidy	35.0	8.3	0.0	17.0	15.9
Compulsory senior secondary school	0.8	0.0	0.0	1.2	0.5%
	Years of Education				
Benchmark	14.637	11.813	10.993	15.409	13.354
50% college subsidy	1.053	0.249	0.004	0.547	0.487
Compulsory senior secondary school	0.023	0.484	1.150	0.039	0.361
	Annual Earnings(for workers)				
Benchmark	100481.5	69533.0	29793.3	47273.6	66004.0
50% college subsidy	4656.1	909.5	9.4	7232.8	2943.7
Compulsory senior secondary school	484.9	2390.3	2565.4	760.0	1592.8
	Utility Change(Unit: AU$10,000)				
Benchmark	83.971	77.209	53.354	65.214	71.559
50% college subsidy	2.504	0.064	0.000	2.246	1.251
Compulsory senior secondary school	-0.261	-2.196	-4.386	-0.396	-1.597

Table 20: The effect of education policies on type proportions at different ages

Age		Type I	Type II	Type III	Type IV
15	Benchmark	24.70	31.44	16.89	26.98
	50% college subsidy	24.70	31.44	16.89	26.98
	Compulsory senior secondary school	24.70	31.44	16.89	26.98
21	Benchmark	26.14	30.06	16.84	26.95
	50% college subsidy	26.19	30.04	16.92	26.86
	Compulsory senior secondary school	26.43	29.94	17.13	26.50
27	Benchmark	27.45	28.94	17.39	26.22
	50% college subsidy	27.69	28.75	17.58	25.98
	Compulsory senior secondary school	27.73	28.78	17.58	25.91
> 33	Benchmark	27.83	28.78	17.53	25.86
	50% college subsidy	28.09	28.61	17.77	25.53
	Compulsory senior secondary school	28.11	28.61	17.67	25.60

Table 21: The effect of educational policies on labor market outcomes by SES background

	Socio Economic Status (SES)			
Model simulation	I	II	III	Total
	Percentage of Finishing High school			
Benchmark	84.7%	87.9%	91.8%	88.1%
50% college subsidy	0.3%	0.2%	0.4%	0.3%
Compulsory senior secondary school	15.3%	12.1%	8.2%	11.9%
	Percentage of College Graduates			
Benchmark	25.4%	30.2%	41.6%	32.4%
50% college subsidy	25.1%	26.9%	23.5%	25.3%
Compulsory senior secondary school	0.9%	2.1%	1.9%	1.7%
	Education Years			
Benchmark	13.081	13.346	13.865	13.431
50% college subsidy	0.778	0.854	0.756	0.799
Compulsory senior secondary school	0.324	0.301	0.210	0.278
	Annual Earning(for workers)			
Benchmark	62861.9	66433.2	69580.6	66324.1
50% college subsidy	4410.2	4860.8	4869.0	4718.7
Compulsory senior secondary school	2148.4	2434.2	2000.8	2210.4
	Utility Gain(Unit: AU$10,000)			
Benchmark	73.135	74.380	76.014	74.500
50% college subsidy	0.878	1.091	1.434	1.155
Compulsory senior secondary school	-2.812	-2.426	-2.044	-2.403

Table 22: The effect of educational policies on personality traits by SES background

	Socio Economic Status (SES)			
Model simulation	I	II	III	Total
	Personality Traits at age 30			
	Openness to experience			
Benchmark	-0.180	0.019	0.138	-0.018
50% college subsidy	0.002	-0.036	0.002	0.001
Compulsory senior secondary school	0.001	-0.037	0.001	0.001
	Conscientiousness			
Benchmark	-0.128	-0.127	-0.084	-0.113
50% college subsidy	0.025	0.028	0.025	0.026
Compulsory senior secondary school	0.017	0.016	0.011	0.014
	Extraversion			
Benchmark	0.037	0.066	0.121	0.075
50% college subsidy	0.003	0.004	0.004	0.004
Compulsory senior secondary school	0.002	0.003	0.002	0.002
	Agreeableness			
Benchmark	-0.098	-0.063	0.019	-0.047
50% college subsidy	0.018	0.021	0.020	0.020
Compulsory senior secondary school	0.013	0.012	0.009	0.011
Emotional Stability				
Benchmark	-0.194	-0.102	-0.064	-0.118
50% college subsidy	0.006	0.006	-0.005	0.005
Compulsory senior secondary school	0.003	0.003	0.001	0.002

Conclusions

- Estimated DCDP model of schooling, work and occupational sector choice.
- Model allowed for unobserved types that may depend on personality traits and may change over time.
- Types are found to be malleable for young adults but to stabilize after age 36.
- Reject assumption that types do not vary with age.
- One “super-type" of individual (27% of the population) tends to have high cognitive skills, high non-cognitive skills, to obtain a college education and to work in the white collar sector.

Conclusions

- Evaluate the effects of two education policies: 50% tuition subsidy, compulsory secondary school.
- Both are effective in increasing educational attainment but distributional effects differ substantially.
- Policies also affect personality traits, especially conscientiousness
- Education policy evaluation that does not consider the effects of education on personality traits and on changes in types tends to underestimate the effectiveness of these kinds of policies and to overstate the observed heterogeneity in policy impacts.