The Career Decisions of Young Men (1997, JPE)
Michael Keane and Kenneth Wolpin

Evan Cunningham Katerina Gribbin

Heterogeneous Agent Models (HAM)

University of Minnesota

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What this paper does:

- Estimates dynamic model of schooling, work, and occupational choice
- Starting point: Human capital investment
- Analyzes effect of unobserved heterogeneity on:
  - Welfare
  - Inequality
- It matters!
- Policy experiment: Tuition subsidy

Why Keane and Wolpin?

- Why do people choose the jobs they do?
  - Similar people have vastly different career paths
- Intuition: feedback loop between human capital (skills) investment and occupational choice
  - People choose skills to invest in
  - Investment decisions determine career options
  - Occupational choice determines outcomes (wages)
  - Process repeats over life-cycle
- Keane and Wolpin formalize this intuition

Model — A Basic Human Capital Model

- Reward per period at age a:

$$R(a) = \sum_{m=1}^{5} R_m(a) d_m(a)$$

- $R_m(a)$: reward associated with m^{th} alternative
- Include all benefits and costs
- $d_m(a)$ = 1 if m is chosen (0 otherwise)

Model — A Basic Human Capital Model

Working alternatives (m = 1, 2 or 3)

- $R_m(a) = w_m(a)$
  - $w_m(a)$: Wage
  - $w_m(a) = r_m \times e_m(a)$,
    - r_m: occupation-specific market rental price
    - $e_m(a)$: occupation-specific skill units
      - $e_m(16)$: skill “endowment” at age 16
- $g(a)$: years of schooling completed
- $x_m(a)$: years of work experience in occupation m
- $\epsilon_m(a)$: skill technology shock

Model — A Basic Human Capital Model

Working alternatives (m = 1, 2 or 3)

- Skill-production function:

$$e_m(a) = \exp\left[e_m(16) + e_{m1}g(a) + e_{m2}x_m(a) - e_{m3}x_m^2(a) + \epsilon_m(a)\right]$$
$$m = 1, 2, 3; a = 16, \ldots, A$$

- Quadratic form - Mincer (1958)
- Higher endowment implies more skill units “produced” per year of schooling or experience

Model — A Basic Human Capital Model

<u>Non-working alternatives (m = 4 or 5)</u>

- $R_4(a)$: rewards to schooling
  - Direct costs (tuition)
  - Indirect costs (effort)
- Adding effort - $R(a)$ interpreted as utility.
  - Given additive form, effort denoted in dollars
- "Learning" and home production skills immutable after age 16
  - Contrast to market skills
- $R_5(a)$: rewards to home production (leisure)

Model — A Basic Human Capital Model

Structure of Rewards:

$$R_m(a) = w_m(a)$$
$$= r_m \exp[e_m(16) + e_{m1}g(a) + e_{m2}x_m(a) - e_{m3}x_m^2 + \epsilon_m(a)]$$

$$R_4(a) = e_4(16) - tc_1 \times I[g(a) \geq 12] - tc_2 \times I[g(a) \geq 16] + \epsilon_4(a)$$

$$R_5(a) = e_5(16) + \epsilon_5(a)$$

- Shocks jointly normal, serially uncorrelated: $N(0, \Omega)$

Model — A Basic Human Capital Model

<u>Notation:</u>

- Endowment vector: $\boldsymbol{e}(16) = \{e_1(16), e_2(16), e_3(16), e_4(16), e_5(16)\}$
- Worker experience vector: $\boldsymbol{x}(a) = \{x_1(a), x_2(a), x_3(a)\}$
- Denote: $\boldsymbol{S}(a) = \{\boldsymbol{e}(16), g(a), \boldsymbol{x}(a), \boldsymbol{\epsilon}(a)\}$
- At age a, the individual maximizes:

$$V(\boldsymbol{S}(a), a) = \max_{d_m(a)} E\left[\sum_{\tau=a}^{A} \delta^{t-a} \sum_{m=1}^{5} R_m(a)\ d_m(a) \,\middle|\, \boldsymbol{S}(a)\right]$$

Model — A Basic Human Capital Model

- All relevant prices and functions known
- Future shocks unknown
- Solution: $(d_m(a))$ for $a = 16, \ldots, A$
- Value function:

$$V(\boldsymbol{S}(a), a) = \max_{m \in M}\{V_m(\boldsymbol{S}(a), a)\}$$

Where:

$$V_m(\boldsymbol{S}(a), a) = R_m(\boldsymbol{S}(a), a) + \delta E[V(\boldsymbol{S}(a+1), a+1) | \boldsymbol{S}(a), d_m(a) = 1], a < A$$

$$V_m(\boldsymbol{S}(A), A) = R_m(\boldsymbol{S}(A), A)$$

Model — A Basic Human Capital Model

Individual's decision process:

1. At age 16, given $\boldsymbol{e}(16)$ and $g(16)$, draw five shocks from joint $\boldsymbol{\epsilon}(16)$ distribution.
2. Calculate current period rewards.
3. Choose alternative yielding highest value.
4. Update state space.
5. Repeat.

- No closed-form solution; estimated numerically.
- Deterministic for individual
- Probabilistic for researcher (Shocks not observable)

Model — A Basic Human Capital Model

For individual, n = 1, …, N, data are set of choices and rewards:

$$\{d_{nm}(a), w_{nm}(a)d_{nm}(a): m = 1, \ldots, 3\}, \text{ and}$$

$$\{d_{nm}(a): m = 4, 5\} \text{ for all ages in a given range } [16, \bar{a}]$$

- $c(a)$: choice-reward combination at age a
- $\overline{\boldsymbol{S}}(a) = \{\boldsymbol{e}(16), g(a), \boldsymbol{x}(a)\}$: predetermined components of the state space

Model — A Basic Human Capital Model

Serial independence of shocks:

$$\Pr[c(16), \ldots, c(\bar{a}) |\, g(16), \boldsymbol{e}(16)] = \prod_{a=16}^{\bar{a}} \Pr[c(a) | \bar{\boldsymbol{S}}(a)]$$

- Sample likelihood: product of these probabilities over N individuals
- Estimation iterative using simulated MLE
- K types of individuals - different $\boldsymbol{e}_k(16)$ (k unobserved)
- π_k - proportion of the population of type k, $k \in \{1, \ldots, K\}$

Model — A Basic Human Capital Model

- **Issue:** Unlikely initial schooling (at age 16) exogenous.
- **Fix:** Assume initial schooling exogenous conditional on age 16 endowment
- Likelihood contribution for the n^{th} individual:

$$\Pr[c_n(16), \ldots, c_n(\bar{a}) |\ g_n(16)] = \sum_{k=1}^{K} \prod_{a=16}^{\bar{a}} \pi_{k|g_n(16)} \Pr[c_n(a) |\ g_n(16), type = k]$$

- Type proportions are:
  - Estimable parameters
  - Conditioned on schooling

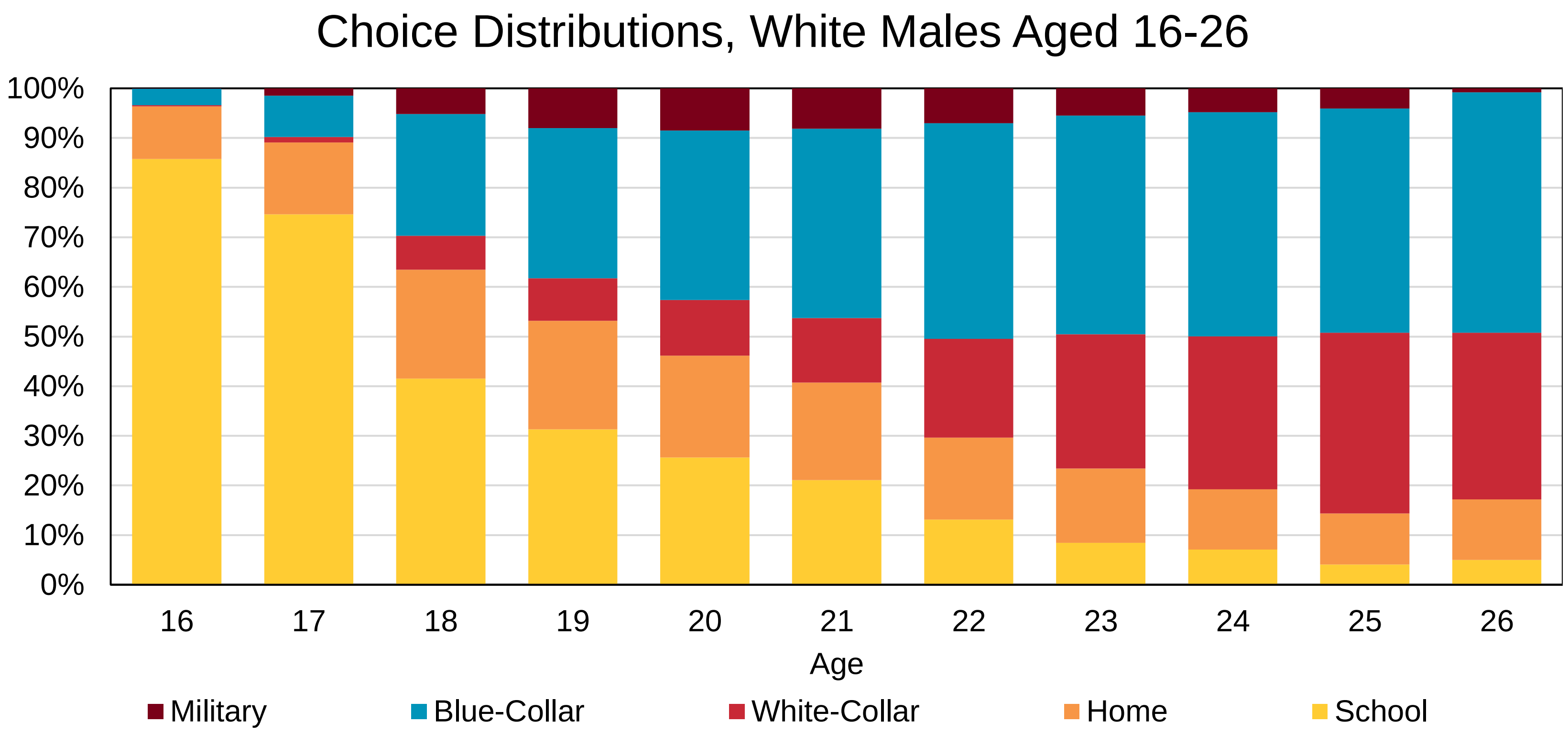
Data

- National Longitudinal Survey of Youth (1979)
  - White males, age 16 or less on 10/1/1977 (n = 1,373)
  - Academic school year (1977-1988)
- Labor market state assigned in hierarchal, mutually exclusive fashion
  1. School attendance
  2. Work
     - 2/3 of weeks, 20 hours per week
  3. Occupational classification
  4. Real wages (FTE)
  5. Home

Data

- Implications of human capital model:
  1. School attendance declines with age
  2. Employment increases with age
  3. Occupational choices exhibit persistence
  4. Occupation-specific wages increase with age

Data



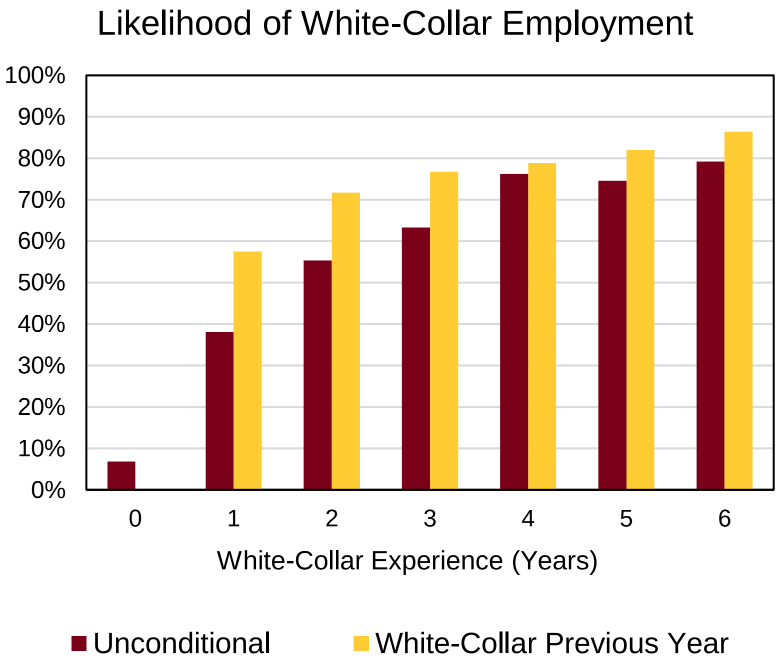
Choice Distributions, White Males Aged 16-26
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
16
17
18
19
20
21
22
23
24
25
26
Age
Military
Blue-Collar
White-Collar
Home
School

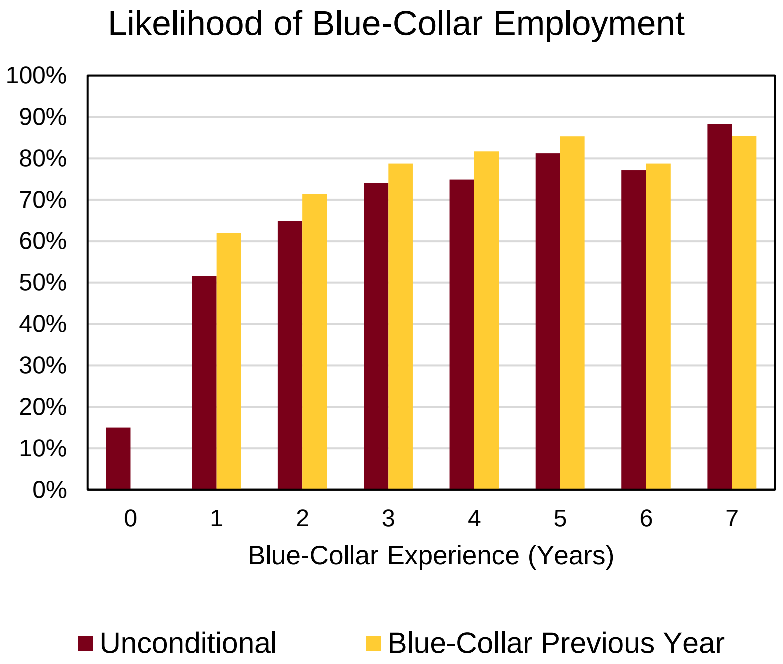
Data

Transition Matrix: White Males Aged 16-26

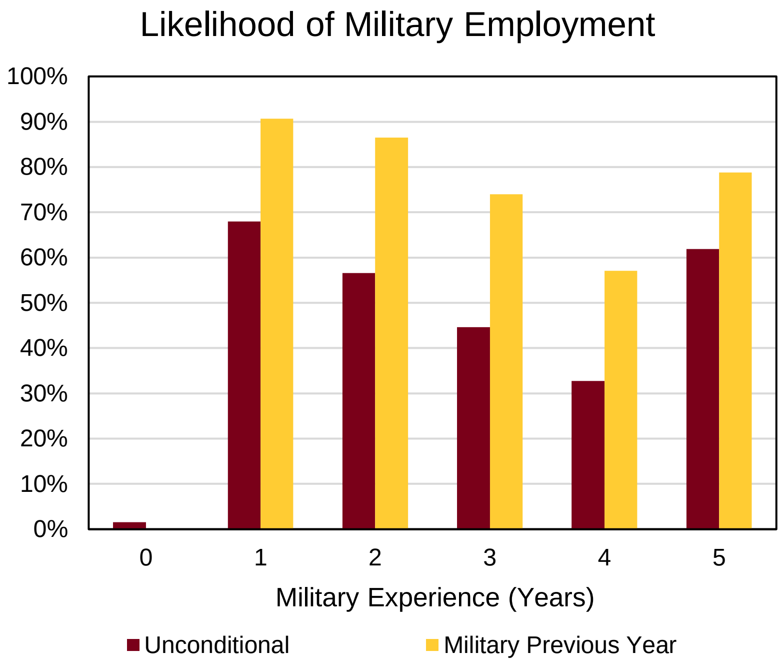
Choice(t)	Choice (t+1) School	Home	White-Collar	Blue-Collar	Military
School	69.9%	12.4%	6.5%	9.9%	1.3%
Home	9.8%	47.2%	8.1%	31.3%	3.7%
White-Collar	5.7%	6.3%	67.4%	19.9%	0.7%
Blue-Collar	3.4%	12.4%	9.9%	73.4%	0.9%
Military	1.4%	5.5%	3.1%	9.6%	80.5%

Data


Likelihood of White-Collar Employment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
White-Collar Experience (Years)
Unconditional
White-Collar Previous Year

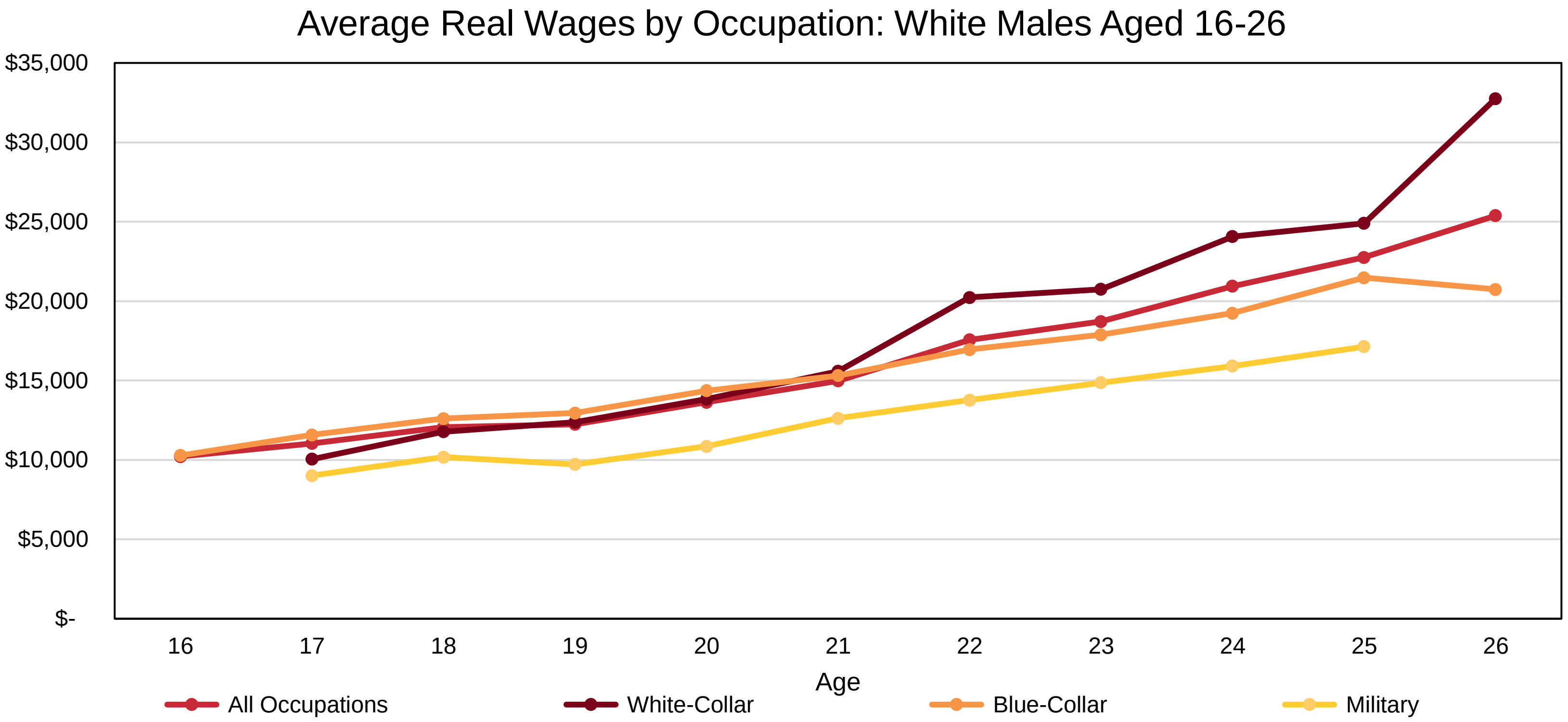

Likelihood of Blue-Collar Employment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
6
7
Blue-Collar Experience (Years)
Unconditional
Blue-Collar Previous Year

Data



Likelihood of Military Employment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
2
3
4
5
Military Experience (Years)
Unconditional
Military Previous Year

Data



Average Real Wages by Occupation: White Males Aged 16-26
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
16
17
18
19
20
21
22
23
24
25
26
Age
All Occupations
White-Collar
Blue-Collar
Military

Data

- NLSY oversamples poor whites and military
- Weekly frequency
  - Coding scheme is “somewhat arbitrary”
  - If both in school and employed, only one choice recorded
- Occupation coding is very coarse
- Aggregation implies returns to white-collar (blue-collar) skills identical across white-collar (blue-collar) jobs

Model — A Basic Human Capital Model

- Can the basic human capital model fit the data?
- Model begins at age 16; ends at finite age A
- At each age a, the individual chooses between:
  1) White-collar work
  2) Blue-collar work
  3) Military
  4) Schooling
  5) Home production (leisure)

Estimation — A Basic Human Capital Model

- K = 4
- A = 65
- Type proportions conditioned on two values of initial schooling —
  - g(16) = {grade 7, 8 or 9} or {grade 10 or 11}
- Linear cross-experience terms in skill production function
  - Military experience enters both civilian functions
  - Blue-collar experience enters white-collar function
  - White-collar experience enters blue-collar function

Estimation — A Basic Human Capital Model

- Basic model: parameter values within “reasonable ranges”
- Additional year of school increases skill function by:
  - 9.7% - white-collar
  - 1.9% - blue-collar
  - 4.4% - military
- Cost of college
  - Undergraduate: $3,000
  - Graduate: $26,000
- Discount factor: 0.78
- Within-sample fit poor

Model — An Extended Model

A. Work Alternatives

- Skill technology functions, $e_m(a)$
  - Skill depreciation effect
  - First-year experience effect
  - Age effect
  - High-School and College Graduation Effect
- Mobility and Job Search Costs
  - Job-finding cost (if switching occupations)
  - Additional cost if no experience in occupation

Model — An Extended Model

A. Work Alternatives

- Nonpecuniary Rewards plus Indirect Compensation
  - Nonwage aspects of employment

B. School Attendance

- Consumption value of school attendance
- Allowed to depend systematically on age
- Cost of re-entry into high-school or post-secondary education

C. Remaining at Home

- Payoff allowed to differ by age

Model — An Extended Model

D. Common Returns
  - Psychic value of high-school degree, college diploma
- Cost of leaving the military early (less than two years of service)

Estimation — An Extended Model

Main Empirical Findings:

1. Additional year of schooling increases skill by:
   - 7% - white-collar
   - 2.4% - blue-collar
   - 5.8% – military
2. No diploma effects on wages
3. White-collar experience increases skill by:
   - 21.5% - 1st year
   - [2.7 – 0.8(x_1)] % - 2nd year and above

Estimation — An Extended Model

Main Empirical Findings:

4. Blue-collar experience increases skill by:
   - 24.7% - 1st year
   - [4.6 – 0.16(x_2)]% - 2nd year and above
5. Cross-experience terms:
   - Blue-collar skill; White-collar exp. – 1.9%
   - White-collar skill; Blue-collar exp. – 2.3%
6. White-collar skills depreciate faster
   - White-collar: 30.5% reduction following a year absence
   - Blue-collar: 9.6%

Estimation — An Extended Model

- Job finding cost
  - White-collar
    - $3,951 – No experience
    - $1,181 – Experience
  - Blue-collar
    - $2,141 – No experience
    - $1,647 – Experience
- Net tuition cost of college: $4,168 (relative to high-school)
  - Graduate school: $11,198
- Utility of home production roughly constant with age
- Discount factor: 0.936

TABLE 7

Estimated Occupation-Specific Parameters

	White-Collar	Blue-Collar	Military
1. Skill Functions			
Schooling	.0700 (.0018)	.0240 (.0019)	.0582 (.0039)
High school graduate	−.0036 (.0054)	.0058 (.0054)	. . .
College graduate	.0023 (.0052)	.0058 (.0080)	. . .
White-collar experience	.0270 (.0012)	.0191 (.0008)	. . .
Blue-collar experience	.0225 (.0008)	.0464 (.0005)	. . .
Military experience	.0131 (.0023)	.0174 (.0022)	.0454 (.0037)
"Own" experience squared/100	−.0429 (.0032)	−.0759 (.0025)	−.0479 (.0140)
"Own" experience positive	.1885 (.0132)	.2020 (.0128)	.0753 (.0344)
Previous period same occupation	.3054 (.1064)	.0964 (.0124)	. . .
Age*	.0102 (.0005)	.0114 (.0004)	.0106 (.0022)
Age less than 18	−.1500 (.0515)	−.1433 (.0308)	−.2539 (.0443)
Constants:			
Type 1	8.9370 (.0152)	8.8811 (.0093)	8.540 (.0234)
Deviation of type 2 from type 1	−.0872 (.0089)	.3050 (.0138)	. . .
Deviation of type 3 from type 1	−.6091 (.0143)	−.2118 (.0144)	. . .
Deviation of type 4 from type 1	−.5200 (.0199)	−.0547 (.0177)	. . .
True error standard deviation	.3864 (.0094)	.3823 (.0074)	.2426 (.0249)
Measurement error standard deviation	.2415 (.0140)	.1942 (.0134)	.2063 (.0207)
Error correlation:			
White-collar	1.0000	. . .	. . .
Blue-collar	.1226 (.0430)	1.0000	. . .
Military	.0182 (.0997)	.4727 (.0848)	1.0000
2. Nonpecuniary Values			
Constant	−2,543 (272)	−3,157 (253)	−.0900 (.0448)
Age	. . .	. . .	−.0313 (.0057)
3. Entry Costs			
If positive own experience but not in occupation in previous period	1,182 (285)	1,647 (199)	. . .
Additional entry cost if no own experience	2,759 (764)	494 (698)	560 (509)
4. Exit Costs			
One-year military experience	. . .	. . .	1,525 (151)

Note.—Standard errors are in parentheses.
* Age is defined as age minus 16.

TABLE 8

Estimated School and Home Parameters

	School	Home
Constants:		
Type 1	11,031 (626)	20,242 (608)
Deviation of type 2 from type 1	−5,364 (1,182)	−2,135 (753)
Deviation of type 3 from type 1	−8,900 (957)	−14,678 (679)
Deviation of type 4 from type 1	−1,469 (1,011)	−2,912 (768)
Has high school diploma	804 (137)	. . .
Has college diploma	2,005 (225)	. . .
Net tuition costs: college	4,168 (838)	. . .
Additional net tuition costs: graduate school	7,030 (1,446)	. . .
Cost to reenter high school	23,283 (1,359)	. . .
Cost to reenter college	10,700 (926)	. . .
Age*	−1,502 (111)	. . .
Aged 16–17	3,632 (1,103)	. . .
Aged 18–20	. . .	−1,027 (538)
Aged 21 and over	. . .	−1,807 (568)
Error standard deviation	12,821 (735)	9,350 (576)
Discount factor	.9363 (.0014)	

Note.—Standard errors are in parentheses.
* Age is defined as age minus 16.

Note: Standard errors are downward biased

Estimation — An Extended Model

Explanation of Models:

- **Data**: NLSY panel
- **Dynamic Programming (Basic Model):** Basic human capital model
- **Dynamic Programming**: Augmented human capital model
- **Static Solution**: Same as dynamic programming, but discount factor zero
- **Approximate Solution**: Probit model only using choice data (no wage data)

Estimation — An Extended Model

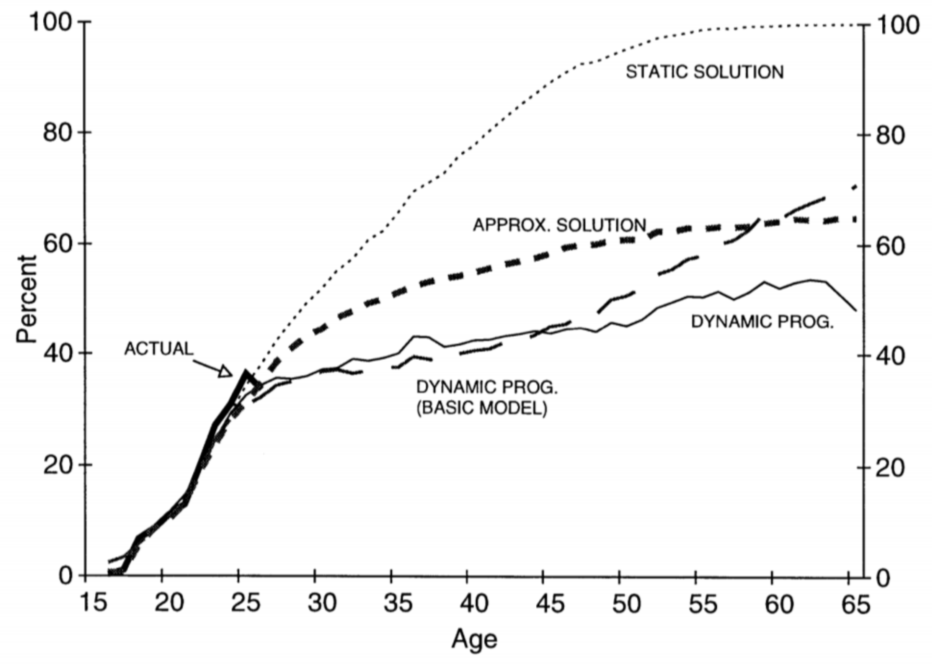


FIG. 1.—Percentage white-collar by age

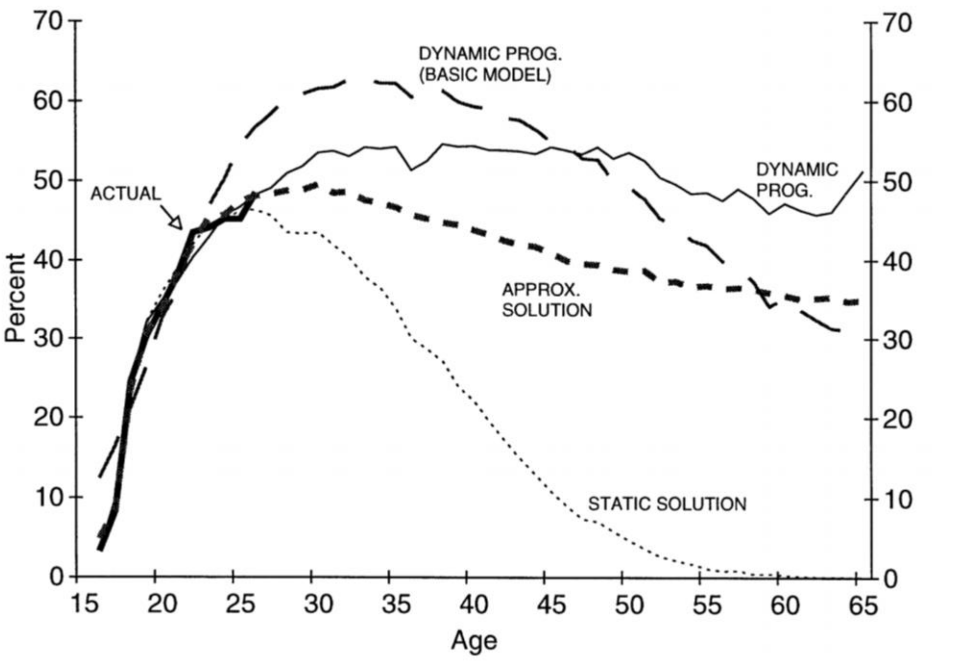


FIG. 2.—Percentage blue-collar by age

Estimation — An Extended Model

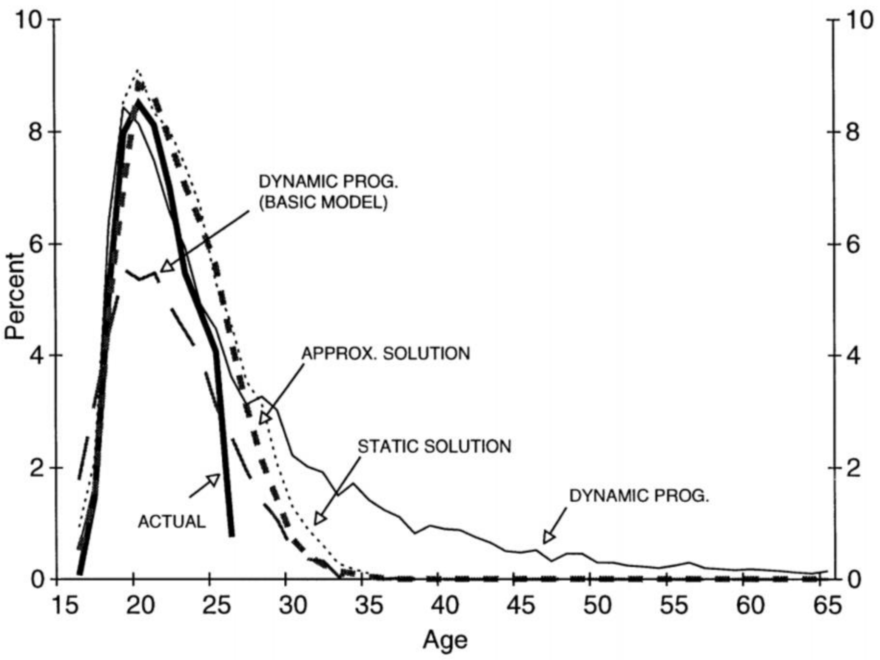


FIG. 3.—Percentage in the military by age

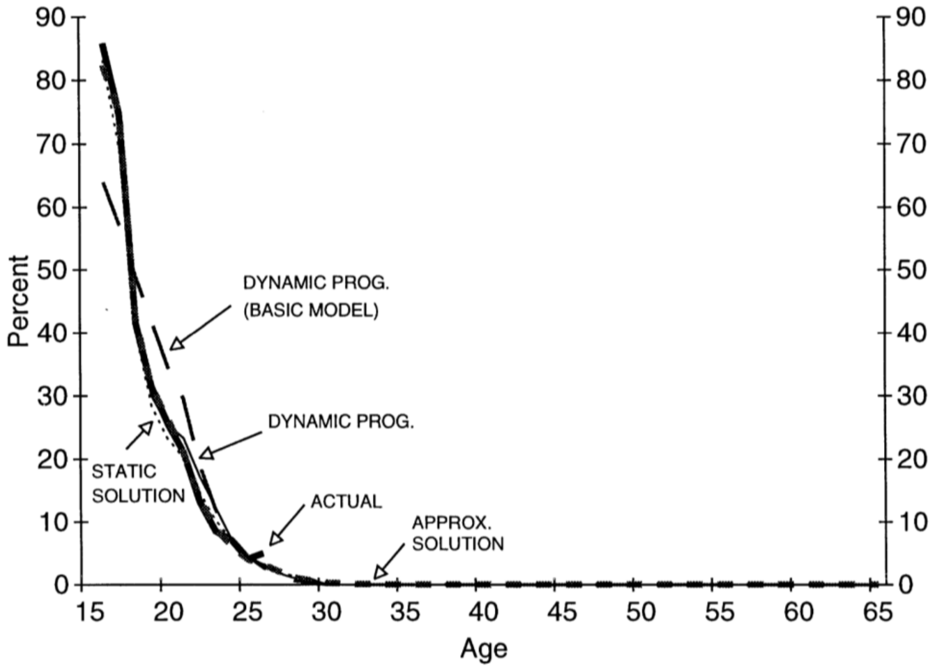


FIG. 4.—Percentage in school by age

Estimation — An Extended Model

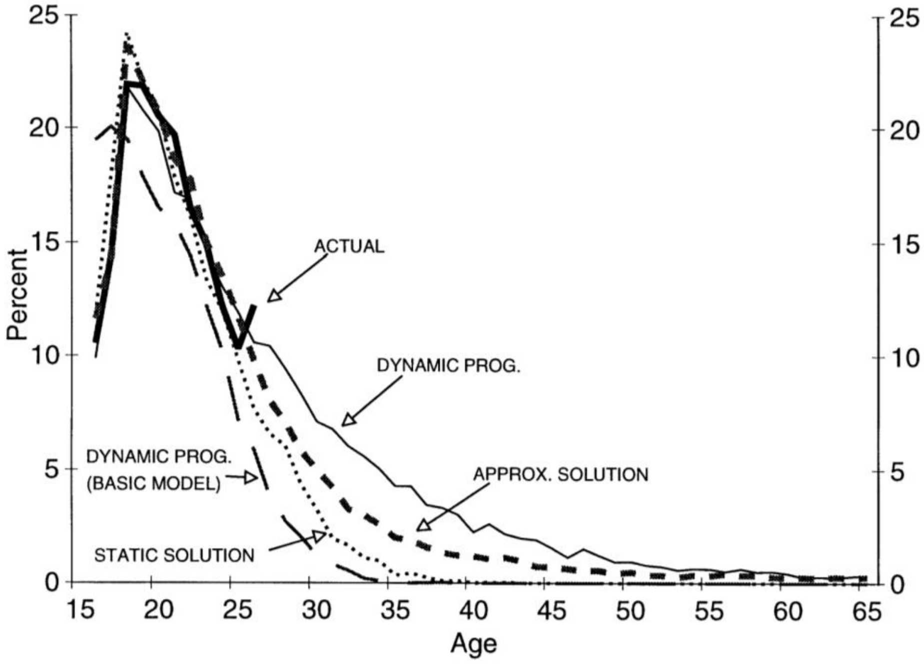


FIG. 5.—Percentage at home by age

Estimation — An Extended Model

Within-sample fit:

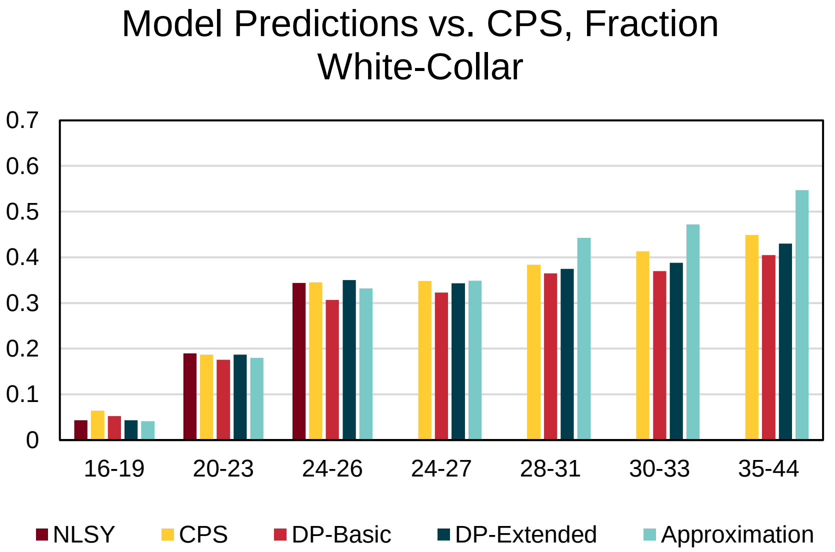
- Three new specifications fit approximately equally well
  - Use χ^2 goodness of fit test
- Extended model:
  - 8 more parameters than approx. model
  - Must also fit wage data
  - Restricted in how well it can fit choices

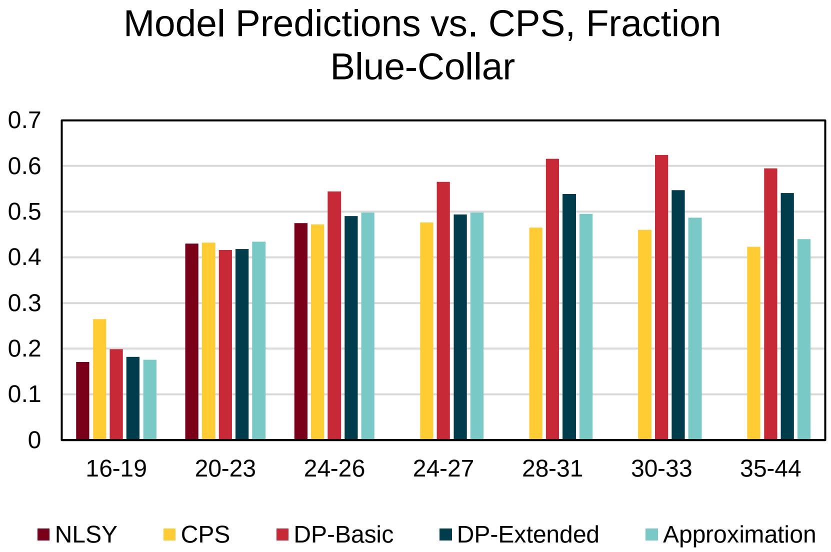
Estimation — An Extended Model

Out-of-Sample Fit:

- **Issue**: Short history of data
- **Fix:** Use CPS March Supplement data to follow NLSY cohort through age 33
- Authors claim dynamic prog. and approx. models fit data well

Estimation — An Extended Model



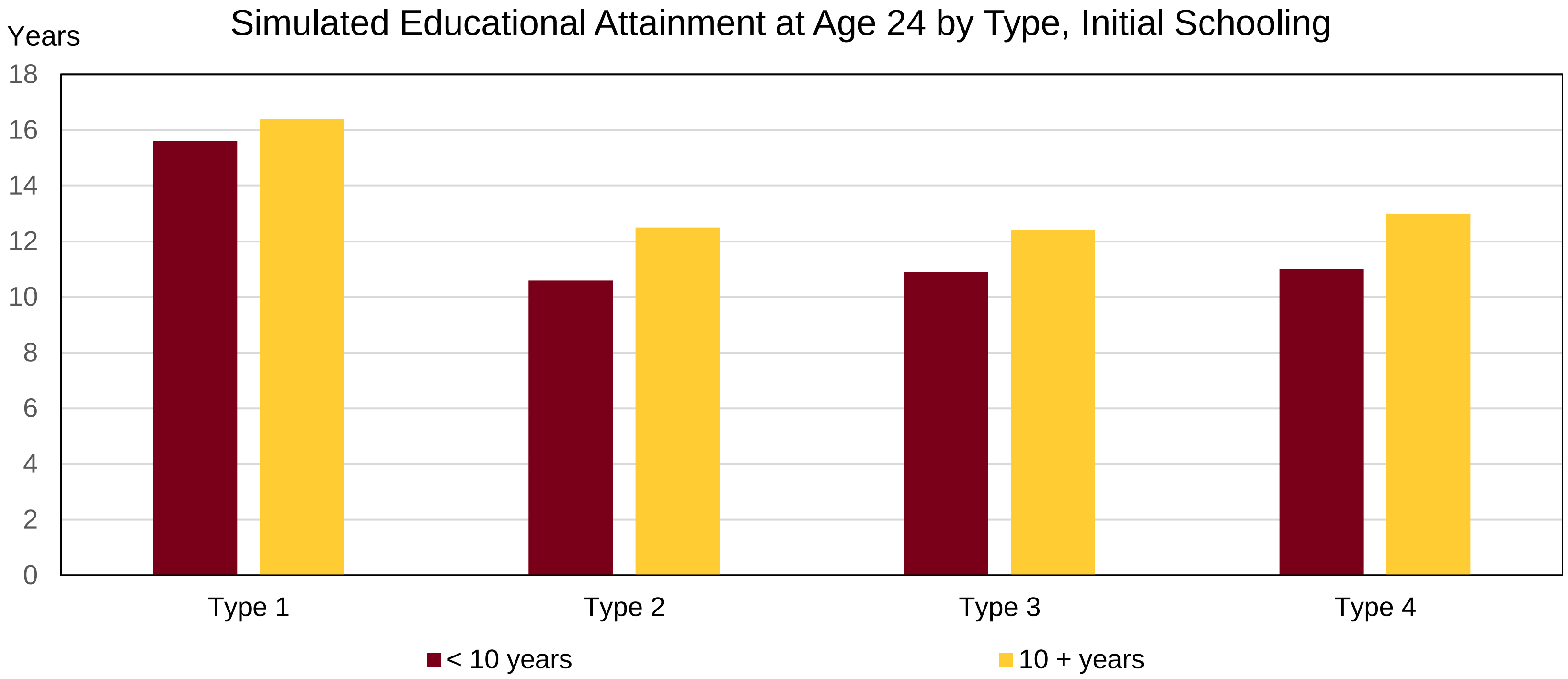


Discussion: Unobserved Skill Heterogeneity

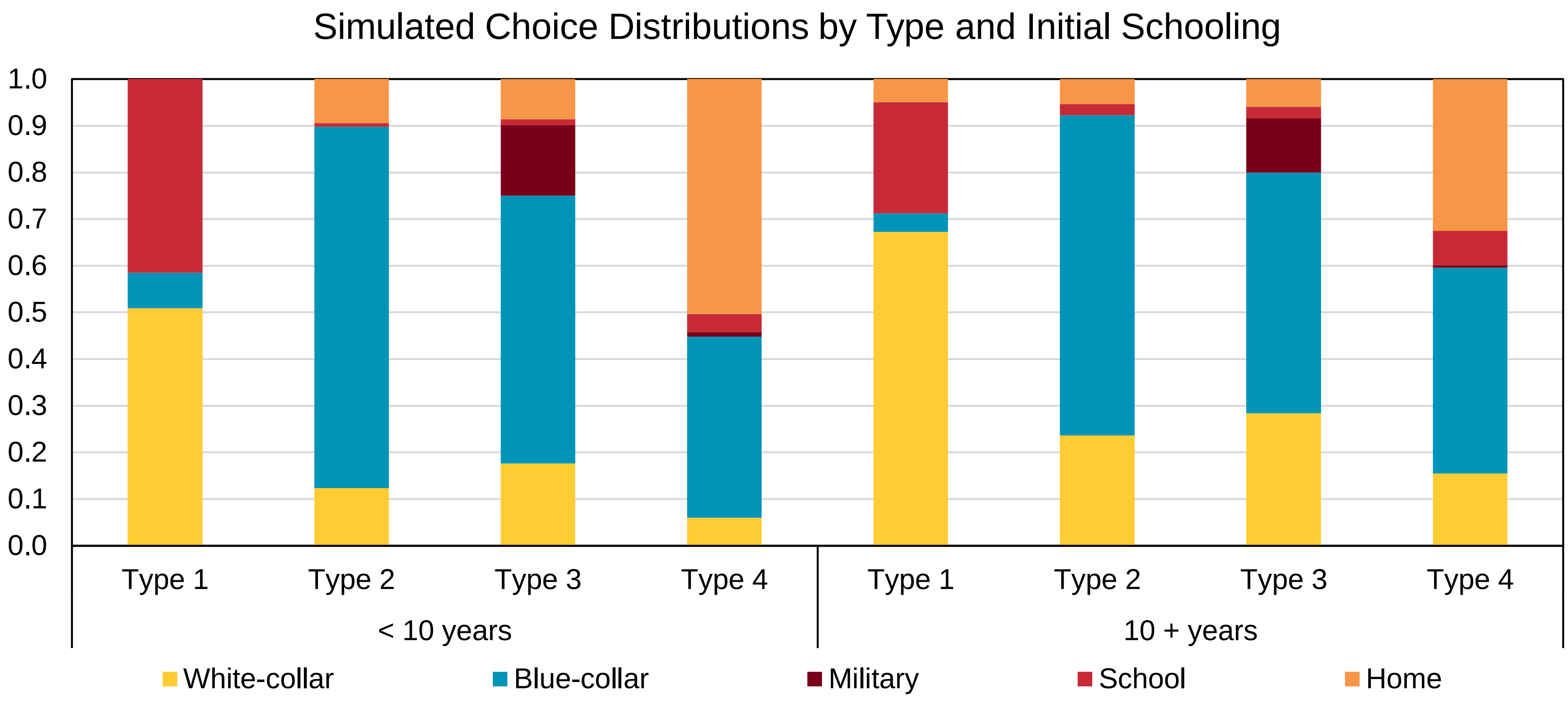
Using simulated data:

- Age 24, conditional on initial (age 16) schooling:
  - Type 1: college grad; more white-collar experience
  - Type 2: high school grad; blue-collar experience
  - Type 3: Only type in military, but also civilian experience
  - Type 4: Most likely at home or in school
- Specialization even more apparent by age 40

Discussion: Unobserved Skill Heterogeneity



Discussion: Unobserved Skill Heterogeneity



Discussion: Unobserved Skill Heterogeneity

- Using estimated parameters, calculate expected discounted PV of utility stream
- Variation in welfare from initial schooling differences small
- Variation from skill endowment heterogeneity significant
- Type 1
  - High initial schooling $28 K larger payoff than with low initial schooling
  - Type 1 EPDV of utility $185 K larger than Type 2
- Type 2 EPDV > Type 3 EPDV
  - Difference in blue-collar skill endowments
- School best choice at age 16; Work best choice at 26

Discussion: Unobserved Skill Heterogeneity

TABLE 12

Expected Present Value of Lifetime Utility for Alternative Choices at Age 16 and at Age 26 by Type ($)

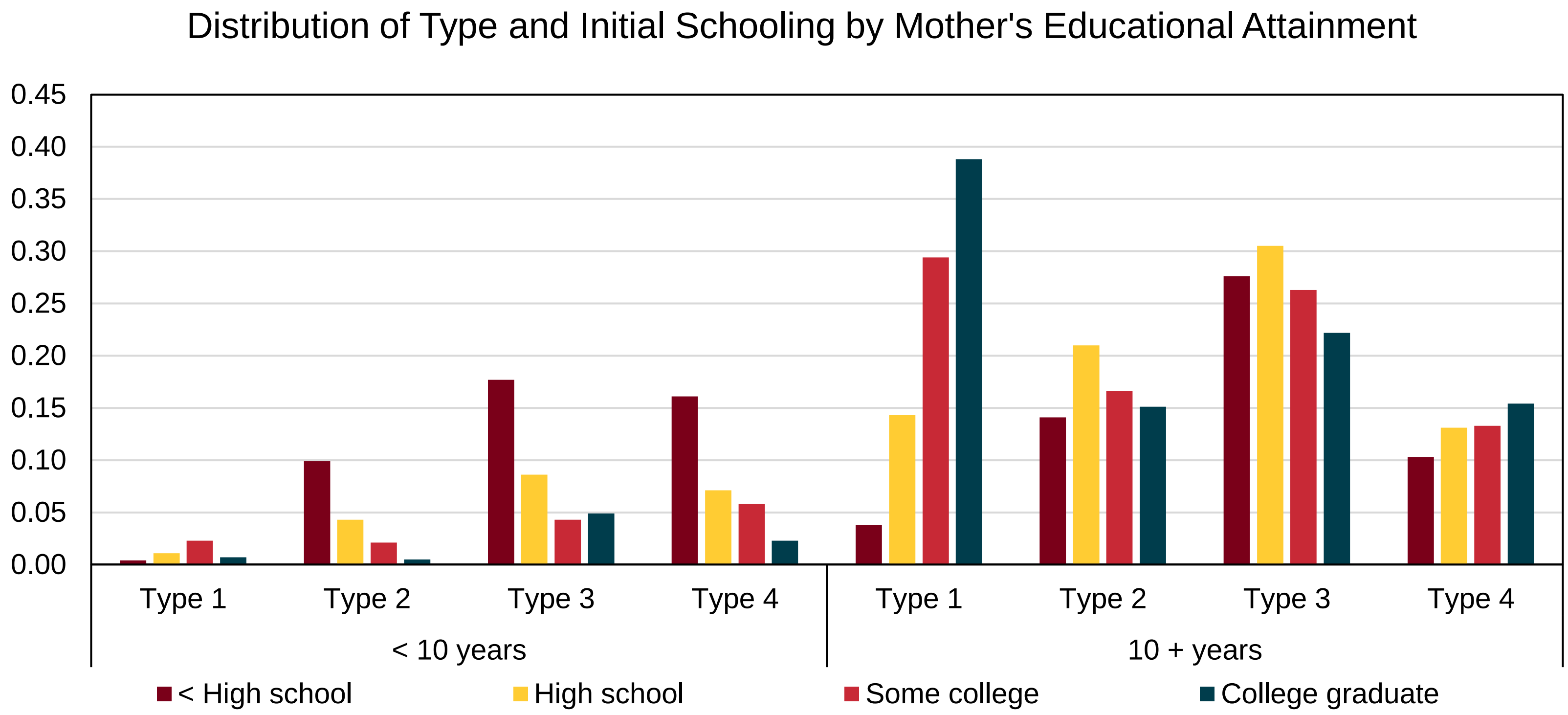
	All Types	Type 1	Type 2	Type 3	Type 4
	Initial Schooling 10 Years or More				
School:					
Age 16	321,008	415,435	394,712	228,350	289,683
Age 26	384,352	499,162	494,107	272,985	314,708
Home:					
Age 16	298,684	380,660	376,945	207,768	274,901
Age 26	426,837	611,167	516,547	291,932	338,653
White-collar:					
Age 16	293,683	372,544	372,733	207,586	262,370
Age 26	439,970	637,616	528,107	303,228	338,967
Blue-collar:					
Age 16	296,736	373,156	377,618	210,699	266,206
Age 26	438,240	617,873	534,578	305,641	342,195
Military:					
Age 16	285,686	350,655	356,202	210,461	261,944
Age 26	415,374	581,996	492,531	298,431	329,938
Maximum over choices:					
Age 16	321,921	415,503	396,108	229,265	291,122
Age 26	445,488	638,820	537,226	308,259	346,695
	Initial Schooling Nine Years or Less				
School:					
Age 16	273,186	387,384	371,369	211,942	276,040
Age 26	308,808	564,590	446,163	243,734	274,979
Home:					
Age 16	260,668	352,274	360,495	197,288	268,047
Age 26	334,643	578,637	468,465	268,815	305,262
White-collar:					
Age 16	253,764	342,833	354,261	196,294	253,686
Age 26	339,093	602,915	474,796	277,488	300,917
Blue-collar:					
Age 16	257,720	343,873	359,370	199,945	257,697
Age 26	344,179	583,895	486,456	282,223	305,520
Military:					
Age 16	251,710	322,293	340,126	199,737	254,386
Age 26	328,916	550,521	447,443	275,660	295,996
Maximum over choices:					
Age 16	275,634	387,384	374,154	213,823	286,311
Age 26	347,741	604,549	487,466	284,073	310,598

Note.—Based on a simulation of 5,000 persons.

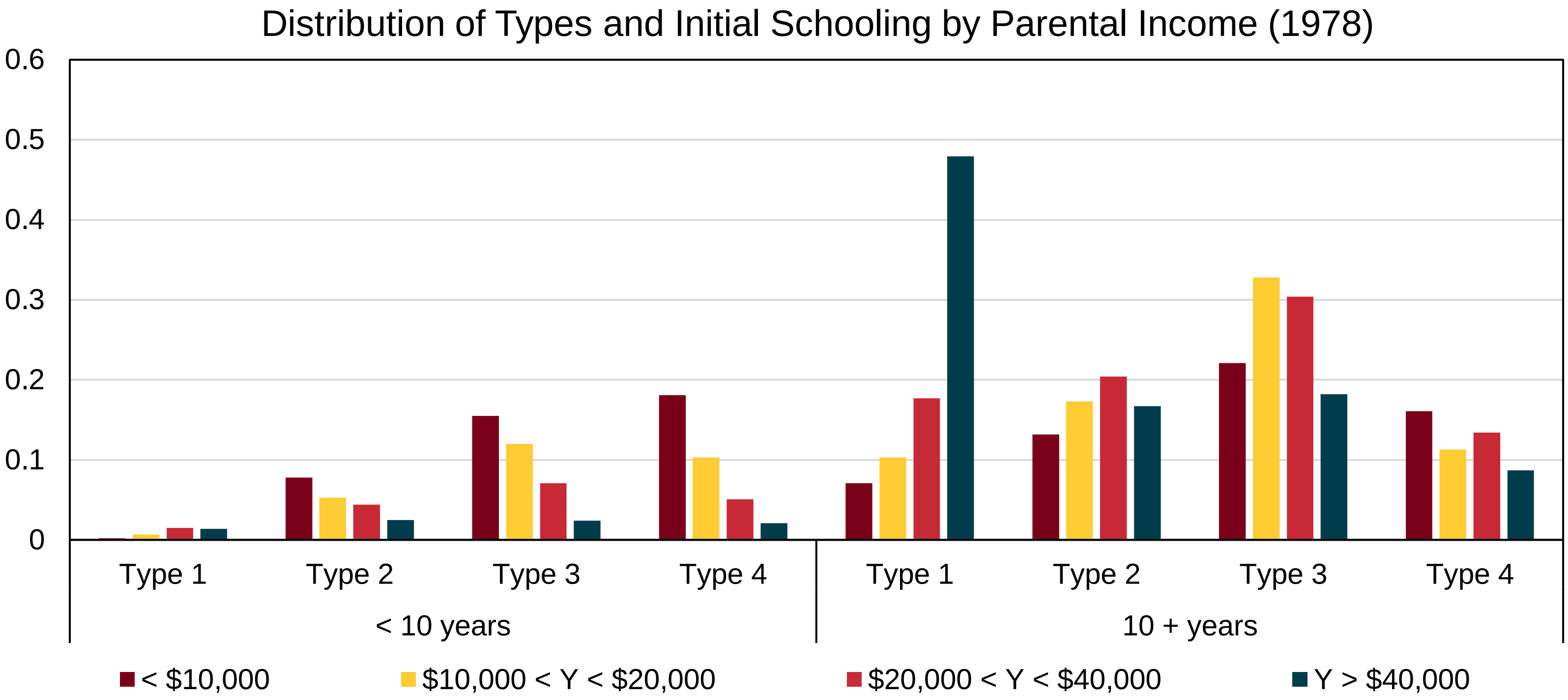
Discussion: Unobserved Skill Heterogeneity

- Between-type variance accounts for 90 percent of total variance
  - Unobserved heterogeneity is important!
  - Need to open “black box”
- **Issue:** Cannot observe actual type
- **Fix:** Use Bayes rule to find probability distribution (conditional on choice, wages, initial schooling)
- Find correlates of type among family characteristics

Discussion: Unobserved Skill Heterogeneity



Discussion: Unobserved Skill Heterogeneity



Discussion: Unobserved Skill Heterogeneity

- Lower maternal education $\rightarrow$ lower lifetime utility
- Living with both parents at age 14 $\rightarrow$ higher lifetime utility
- More siblings $\rightarrow$ lower lifetime utility
  - One sibling is ideal
- Lifetime utility increasing in parent incomes
- **BUT!** Only explain 10 percent of welfare variance
  - Poor proxies
  - Track parental investments (Nix and Daruich)

Discussion: Impact of Tuition Subsidy

Policy Experiment:

- Introduce $2,000 per year direct college tuition subsidy
  - 50 percent cost reduction
- Increases college graduation rate (31.3 percent vs. 24.2 percent)
  - Graduation rates double for Type 2 and 3
- Increases high-school graduation rate (74.8 percent vs. 78.3 percent)
  - Agents are forward looking

Discussion: Impact of Tuition Subsidy

- Private gains are small
- Policy is regressive
  - Benefits Type 1 the most
    - Attend college regardless
  - Under equal per-capita cost sharing, other types worse off
- If types observable, subsidy could be targeted
  - Only marginally lowers inequality
- Family background could serve as imperfect proxy.

Strengths and Weaknesses of the Paper

- Takes selection issues seriously in estimating returns to education and wages
  - Uses assumption each individual makes best choice (in expected payoff terms) given alternatives
- Takes heterogeneity seriously

Strengths and Weaknesses of the Paper

Clearly shows its age. Many simplifying assumptions made to simplify computation:

- Small sample of white males
- Category cutoffs are arbitrary; no robustness checks mentioned
- Occupations broad
- Mutually exclusive categories and low data frequency assumptions very strong
- Independence and normality of shocks questionable
- K = 4 arbitrary
- CPS March Supplement data not directly comparable to NLSY
  - Population of NLSY not representative

Elements of the Paper that are Unclear

- No diploma effect on wages.
  - Very surprising result
  - Dramatic differences in undergraduate and graduate tuition rates ($4,168 versus $11,198)
  - Effect even stronger in the basic human capital model
  - Does this ensure enough people quit school after their degree (to match the data)?
  - Effect on degree completion coefficients?

Elements of the Paper that are Unclear

Lack of accurate standard errors makes model difficult to evaluate:

- All variables seem reasonable, but cannot test statistical significance
  - No reason given for including them
  - Seemed to use whatever was available in the NLSY
- Large number of variables; relatively small sample size
  - Overfitting
- Forecasting is suspect

How the paper could be improved/expanded

- Many issues could be fixed with modern computers
- We have more data:
  - Check forecasts
  - Is administrative data better suited?
  - Could increase the frequency of the data (monthly)

Backup Slides

Parameter Estimates – Basic Model

TABLE B1

ESTIMATES OF THE BASIC MODEL

A. OCCUPATION-SPECIFIC PARAMETERS

	White-Collar		Blue-Collar		Military	
Skill functions:						
Schooling	.0938	(.0014)	.0189	(.0014)	.0443	(.0027)
White-collar experience	.1170	(.0015)	.0674	(.0017)	. . .	
Blue-collar experience	.0748	(.0017)	.1424	(.0011)	. . .	
Military experience	.0077	(.0007)	.1021	(.0021)	.3391	(.0122)
"Own" experience squared/100	−.0461	(.0032)	−.1774	(.0041)	−2.9900	(.2156)
Constants:						
Type 1	8.8043	(.0124)	8.9156	(.0126)	8.4704	(.0234)
Deviation of type 2 from type 1	−.0668	(.0047)	.2996	(.0094)	. . .	
Deviation of type 3 from type 1	−.4221	(.0100)	−.1223	(.0079)	. . .	
Deviation of type 4 from type 1	−.4998	(.0176)	.0756	(.0058)	. . .	
True error standard deviation	.3301	(.0077)	.3329	(.0070)	.3308	(.0156)
Measurement error standard deviation	.4133	(.0065)	.3089	(.0055)	.1259	(.0166)
Error correlation matrix:						
White-collar	1.0010	(. . .)				
Blue-collar	−.3806	(.0252)	1.0000	(. . .)		
Military	−.3688	(.0245)	.4120	(.0505)	1.0000	(. . .)

Parameter Estimates – Basic Model

B. School and Home Parameters

	School			Home	
Constants:					
Type 1	43,948	(850)		16,887	(413)
Deviation of type 2 from type 1	−26,352	(757)		215	(377)
Deviation of type 3 from type 1	−30,541	(754)		−16,966	(542)
Deviation of type 4 from type 1	226	(594)		−13,128	(1,000)
Net tuition costs:					
College	2,983	(156)		. . .	
Graduate school	26,357	(737)		. . .	
Error standard deviation	2,312	(105)		13,394	(460)
Discount factor			.7870 (.0048)		

C. Type Proportions by Initial School Level and Type-Specific Endowment Rankings

	Type 1		Type 2		Type 3		Type 4	
Initial schooling:								
Nine years or less	.1751	(· · ·)	.2396	(.0172)	.5015	(.0199)	.0838	(.0125)
10 years or more	.0386	(· · ·)	.4409	(.0344)	.4876	(.0350)	.0329	(.0131)
Rank ordering:								
White-collar	1		2		3		4	
Blue-collar	3		1		4		2	
Schooling	2		3		4		1	
Home	2		1		4		3	

Note.—Standard errors are in parentheses.

Parameter Estimates – Wages

TABLE 6

WITHIN-SAMPLE WAGE FIT

	White-Collar				Blue-Collar			
	NLSY*	DP-Basic	DP-Extended	Static	NLSY†	DP-Basic	DP-Extended	Static
Wage:								
Mean	19,691	17,456	19,605	19,688	16,224	16,230	15,805	15,914
Standard deviation	12,461	10,324	12,091	13,664	8,631	8,437	8,431	9,837
Wage regression:								
Highest grade completed	.095	.033	.090	.091	.048	.006	.047	.056
	(.007)‡	(.007)	(.006)	(.007)	(.008)	(.006)	(.006)	(.007)
Occupation-specific experience	.103	.017	.080	.123	.096	.082	.078	.108
	(.009)	(.011)	(.012)	(.010)	(.005)	(.004)	(.004)	(.005)
Constant	8.33	9.15	8.44	8.22	8.80	9.25	8.84	8.54
	(.102)	(.087)	(.080)	(.100)	(.096)	(.069)	(.078)	(.082)
R^2	.213	.021	.182	.172	.150	.117	.104	.142
Observations	1,509	1,605	1,685	1,698	3,143	4,013	3,761	3,772

* Three wage outliers of over $250,000 were discarded. The only important effect was to reduce the wage standard deviation significantly.
† Two wage outliers of over $200,000 were discarded. The only important effect was to reduce the wage standard deviation significantly.
‡ Heteroskedasticity-corrected standard errors are in parentheses.

Model — An Extended Model

<u>Extended Model Specification ($k = 1, 2, 3, 4$), Reward Functions:</u>

$$R_{mk} = w_{mk}(a) - c_{ml} \times I[d_m(a-1) = 0] - c_{m2} \times I[x_m(a) = 0] + \alpha_m + \beta_1 \times I[g(a) \geq 12] + \beta_2 \times I[g(a) \geq 16] + \beta_3 I[x_3(a) = 1], m = 1, 2$$

$$R_{3k}(a) = \exp[\alpha_3(a)]\, w_3(a) - c_{32} \times I[x_3(a) = 0] + \beta_1 \times I[g(a) \geq 12] + \beta_2 \times I[g(a) \geq 16]$$

$$R_{4k}(a) = e_{4k}(16) - tc_1 \times I[12 \leq g(a)] - tc_2 \times I[g(a) \geq 16] - rc_1 \times I[d_4(a-1) = 0, g(a) \leq 11] - rc_2 \times I[d_4(a-1) = 0, g(a) \geq 12] + \beta_1 \times I[g(a) \geq 12] + \beta_2 \times I[g(a) \geq 16] + \beta_3 \times I[x_3(a) = 1] + \gamma_{41} \times a + \gamma_{42} \times I(16 \leq a \leq 17) + \epsilon_4(a)$$

$$R_{5k}(a) = e_{5k}(16) + \beta_1 \times I[g(a) \geq 12] + \beta_2 \times I[g(a) \geq 16] + \beta_3 \times I[x_3(a) = 1] + \gamma_{51} \times I[18 \leq a \leq 20] + \gamma_{52} \times I(a \geq 21) + \epsilon_5(a)$$

Model — An Extended Model

Extended Model Specification ($k = 1,2,3,4$), Skill Technology Function:

$$e_{mk}(a) = \exp\{e_{mk}(16) + e_{m11}g(a) + e_{m12} \times I[g(a) \geq 12] + e_{m13} \times I[g(a) \geq 16] + e_{m2}x_m(a) - e_{m3}x_m^2(a) + e_{m4} \times I(x_m > 0) + e_{m5}(a) + e_{m6} \times I(a < 18) + e_{m7}d_m(a - 1) + e_{m8}x_{m' \neq m}(a) + e_{m9}x_3(a)\} \times \exp[\epsilon_m(a)], m, m' = 1,2; a = 16, \ldots, 65$$

$$e_3(a) = \exp[e_3(16) + e_{31}g(a) + e_{32}x_3(a) - e_{33}x_3^2(a) + e_{34} \times I(x_3 > 0) + e_{35}(a) + e_{36} \times I(a < 18)]$$

Discussion: Unobserved Skill Heterogeneity

TABLE 11

SELECTED CHARACTERISTICS AT AGE 24 BY TYPE: NINE OR 10 YEARS INITIAL SCHOOLING

	Initial Schooling 9 Years or Less				Initial Schooling 10 Years or More			
	Type 1	Type 2	Type 3	Type 4	Type 1	Type 2	Type 3	Type 4
Schooling	15.6	10.6	10.9	11.0	16.4	12.5	12.4	13.0
Experience:								
White-collar	.528	.704	.742	.279	1.07	1.06	1.05	.436
Blue-collar	.189	4.05	2.85	1.61	.176	3.65	2.62	1.77
Military	.000	.000	1.35	.038	.000	.000	1.10	.034
Proportion who chose:								
White-collar	.509	.123	.176	.060	.673	.236	.284	.155
Blue-collar	.076	.775	.574	.388	.039	.687	.516	.441
Military	.000	.000	.151	.010	.000	.000	.116	.005
School	.416	.008	.013	.038	.239	.024	.025	.074
Home	.000	.095	.086	.505	.050	.053	.059	.325

NOTE.—Based on a simulation of 5,000 persons.

Discussion: Unobserved Skill Heterogeneity

TABLE 13

Relationship of Initial Schooling and Type to Selected Family Background Characteristics

	Initial Schooling Nine Years or Less and Person Is of Type				Initial Schooling 10 Years or More and Person Is of Type					Expected Present Value of Lifetime Utility at Age 16
	1 (1)	2 (2)	3 (3)	4 (4)	1 (5)	2 (6)	3 (7)	4 (8)	Observations (9)	(10)
All	.010	.051	.103	.090	.157	.177	.289	.123	1,373	307,673
Mother's schooling:										
Non–high school graduate	.004	.099	.177	.161	.038	.141	.276	.103	333	286,642
High school graduate	.011	.043	.086	.071	.143	.210	.305	.131	685	309,275
Some college	.023	.021	.043	.058	.294	.166	.263	.133	152	328,856
College graduate	.007	.005	.049	.023	.388	.151	.222	.154	142	339,593
Household structure at age 14:										
Live with mother only	.001	.062	.133	.119	.123	.137	.297	.128	178	296,019
Live with father only	.026	.037	.088	.120	.062	.180	.378	.106	44	291,746
Live with both parents	.011	.049	.097	.082	.169	.184	.284	.124	1,123	310,573
Live with neither parent	.0001	.090	.154	.184	.037	.175	.275	.085	28	290,469
Number of siblings:										
0	.002	.041	.086	.092	.142	.227	.285	.126	50	310,833
1	.002	.029	.064	.051	.236	.199	.287	.133	261	320,697
2	.016	.048	.104	.063	.191	.157	.275	.146	364	311,053
3	.013	.056	.119	.090	.147	.182	.288	.104	320	306,395
4+	.009	.067	.117	.141	.081	.171	.303	.111	378	296,089
Parental income in 1978:										
$Y \leq \frac{1}{2}$ median*	.002	.078	.155	.181	.071	.132	.221	.161	214	292,565
$\frac{1}{2}$ median $< Y \leq$ median	.007	.053	.120	.103	.103	.173	.328	.113	382	296,372
Median $\leq Y \leq 2 \cdot$ median	.015	.044	.071	.051	.177	.204	.304	.134	446	314,748
$Y \geq 2 \cdot$ median	.014	.025	.024	.021	.479	.167	.182	.087	83	358,404

* Median income in the sample is $20,000.

Discussion: Impact of Tuition Subsidy

TABLE 14

EFFECT OF A $2,000 COLLEGE TUITION SUBSIDY ON SELECTED CHARACTERISTICS BY TYPE

	All Types	Type 1	Type 2	Type 3	Type 4
Percentage high school graduates:					
No subsidy	74.8	100.0	68.6	70.2	67.0
Subsidy	78.3	100.0	73.2	74.0	72.2
Percentage college graduates:					
No subsidy	28.3	98.7	11.1	8.6	19.5
Subsidy	36.7	99.5	21.0	17.1	32.9
Mean schooling:					
No subsidy	13.0	17.0	12.1	12.0	12.4
Subsidy	13.5	17.0	12.7	12.5	13.0
Mean years in college:					
No subsidy	1.34	3.97	.69	.59	1.05
Subsidy	1.71	3.99	1.14	1.00	1.58

NOTE.—Subsidy of $2,000 each year of attendance. Based on a simulation of 5,000 persons.

TABLE 15

DISTRIBUTIONAL EFFECTS OF A $2,000 COLLEGE TUITION SUBSIDY

	Type 1	Type 2	Type 3	Type 4
Mean expected present value of lifetime utility at age 16:				
No subsidy	413,911	391,162	225,026	286,311
Subsidy	419,628	392,372	226,313	288,109
Gross gain	5,717	1,210	1,287	1,798
Net gain:				
Subsidy to all types*	3,513	−994	−917	−406
Subsidy to types 2, 3, and 4†	−1,134	76	153	664
Subsidy to types 3 and 4‡	−862	−862	425	936

* The per capita cost of the subsidy program is $2,204.
† The per capita cost of the subsidy program is $1,134.
‡ The per capita cost of the subsidy program is $862.