DCDP Models as a Framework for Policy Evaluation
Part II: Applications

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Applications

- Labor supply
- Human capital

Female labor supply

- A key feature of female labor supply is that a large percentage of women (particularly married women) do not work during significant portions of their life cycle.
- The central role of the decision of whether or not to work has made the DCDP approach more common in the study of female labor supply than in the literature on males.
- The literature on women has also emphasized the relationship between participation and human capital accumulation, while tending to ignore saving.
- The literature has also striven to model how fertility, marriage and participation decisions interact.

The first paper to adopt a full solution approach to modeling female labor supply was Eckstein and Wolpin (1989).

The main focus of the paper is on how the decision to work today affects wages and tastes for work in the future.

Thus, the paper focuses on three of the four issues central to the female labor supply literature:

(i) fixed costs of working,
(ii) human capital accumulation, and
(iii) state dependence in tastes for work.

To make estimation feasible (given 1989 computing technology) Eckstein and Wolpin (1989) make some key simplifying assumptions.

- Ignore savings and assume a static budget constraint.
- Ignore the choice of hours of work and treat labor supply as a discrete work/no-work decision.
- Do not model fertility (focus on woman age 39 or older in 1967)
- Take marriage as exogenous

Eckstein and Wolpin (1989) model

Assume a utility function for married woman i at age t given by:

$$U_{it} = C_{it} + \alpha_1 p_{it} + \alpha_2 C_{it} p_{it} + \alpha_3 X_{it} p_{it} + \alpha_4 N_{it} p_{it} + \alpha_5 S_i p_{it} \quad (1)$$

where p_{it} is an indicator for labor force participation, X_{it} is work experience (the sum of the lagged p_{it}'s), N_{it} is a vector of numbers of children in various age ranges (0-5 and 6-17) and S_i is the woman's completed schooling.

Budget constraint is

$$C_{it} = w_{it} p_{it} + y_t^H - cN_{it} - bp_t \tag{2}$$

where w_{it} the wife's wage (annual earnings) if she works and y_t^H is the annual income of the husband (assumed exogenous).

The assumption that utility is linear in consumption has some important consequences:

- Substitution of (2) into (1) makes clear that we cannot separately identify the fixed cost of work b and the monetary costs of children c from the disutility of work α_1 and the effect of children on the disutility of work α_4. Thus, b and c are normalized to zero.

- The model will exhibit no income effects on labor supply unless consumption and participation interact in the utility function.

- If $\alpha_2 = 0$, then husband's income will have no impact on the wife's labor supply.

- A clear pattern in the data is that women with higher income husbands are less likely to work, which would imply that $\alpha_2 < 0$.

- Eckstein and Wolpin (1989) assume a standard log earnings function (linear in schooling, quadratic in work experience) with both a stochastic productivity shock and measurement error.
- No shocks to tastes for work.
- Husband's earnings is a deterministic function of husband's age, a fixed effect, and a schooling/age interaction.
- The decision rule for participation is to work if the offer wage exceeds the reservation wage, a deterministic function of the state.
- Measurement error accounts for cases where women are observed to make decisions that violate this condition.

- Eckstein and Wolpin (1989) estimate the model by maximum likelihood using data on 318 white married women from the NLS Mature Women's cohort.
- The data set contained 3020 total observations, 53% of which were for working years.
- The discount factor is fixed at 0.952.
- The estimates show substantial selection bias in OLS wage equation estimates. The OLS schooling coefficient is 0.08, while the model estimate (which corrects for selection) is 0.05.
- The measurement error in wages cannot be estimated using wage data alone. Joint estimation of a wage equation and a labor supply model does allow measurement error to estimated, as true wage variation affects behavior while measurement error does not.

- Eckstein and Wolpin (1989) find that $\alpha_2 < 0$; as expected, husband income reduces the wife's participation rate.
- Consider a woman age 39 with 15 years of work experience, 12 years of schooling, no children and a husband with \$10,000 in annual earnings (which is close to the mean in the data).
- The baseline prediction of the model is that she will work 5.9 years out of the 21 years through age 59, or 28% of the time.
- If husband's earnings increase 50% the model predicts her participation rate will drop by half, to 14%.

Van der Klaauw (1996)

- Extends Eckstein and Wolpin (1989) to include marriage as a choice
- Single women get prob of a marriage offer. Start model at age when woman leaves school (as young as age 14).
- Children arrive by a stochastic process that depends on state variables (marital status, education, age, race)
- Separate taste shock for each mutually exclusive choices (working X marriage = 4 choices)

- Not a search model of marriage - no match component and no incentive to reject a marriage offer in the hopes of receiving a better one.
- Woman's wage includes a lagged participation indicator
- Wage specified in levels, not logs, and iid extreme value assumed.
- Uses the model to simulate the impact of an exogenous $1000 increase in annual wages
    - leads to 25% increase in work experience by age 35
    - leads to a one year increase in average years to marriage

Francesconi (2002)

- Extends Eckstein and Wolpin (1989) by making fertility a choice and allowing full-time and part-time work.
- 6 choices (no work, work part-time, work full-time and have a child or not)
- Marriage exogenous - model begins when woman gets married.
- Husband's income a function of wife's characteristics
- Error term in wage offer equation and taste shock for children joint normally distributed.
- Additional measurement error in wages

- Uses simulation methods to evaluate integrals.
- Assumes only number of children and not ages enter the state space (but can distinguish newborns)
- Estimated using NLS Young Women's Survey (765 white women)
- Find re to education 8.5% in the full-time offer wage, 7.6% in the part-time offer wage
- Simulates how a permanent change in wages would affect labor supply.

Keane and Wolpin (2010)

- Marriage and fertility treated as choices.
- Full-time and Part-time work options.
- Schooling is a choice
- Welfare participation is a choice
- 30 options per period during fertile years.
- Prob of coresidence with parents and of receiving parental income support is stochastic (not a choice)
- Marriage is a search process
    - Marriage offer = mean wage of husband, marriage quality draw (fixed that becomes part of state space)
    - Gives woman an incentive to reject offers to wait for a better one.

- Model is non stationary because welfare rules change over time and differ by state.
- Need assumption on how women forecast changes in rules.
- Develop a five parameter function to characterize welfare rues and assume state-specific VAR used to forecast future rules.

- Women receive utility/disutility from children, pregnancy, marriage, school attendance, welfare participation, and "non-leisure" time.
- Five taste shocks that imply a non-zero probability of observing any choice outcome.
- Incorporate six unobserved types.
- Estimate using NLSY-79 data and using California, Michigan, New York, North Carolina and Ohio
- Use model to predict Texas (hold-out state)

- Do simulations where they increase wage offers by 5% for each type. They find a lot of heterogeneity in responses. Find an increase in schooling and a decrease in teen pregnancy.
- Find wage elasticities of low skill women are much higher than for high skill women.
- Find black women face a worse marriage market (lower husband mean wage offers)
- Find black women have a greater preference for children.

- Equalizing marriage opportunities for black and white women or equalizing labor market opportunities would both reduce welfare participation gaps.
- Equalizing marriage market opportunities also reduces employment of black women.
- Welfare stigma effects accounts for very little of the difference in black-white behavior.
- Eliminating welfare would eliminate employment gap and increase black marriage rates.

Male labor supply

- The literature on males has emphasized the continuous choice of hours of work and savings, with participation usually taken as given.
- Given an assumption of interior solutions, most papers on dynamics of male labor supply have worked with the first order conditions of agents' optimization problems, rather than using the DCDP approach.
- Imai and Keane (2004)) that adapts the DCDP approach to the case of continuous choices of labor supply and consumption.

Human Capital

Keane and Wolpin (1997)

- A dynamic model of schooling, work and occupational choice.
- Extends the framework of Heckman and Sedlacek (1985) by making the choice of schooling and the accumulation of experience endogenous.
- Also extends the Rosen and Willis (1979) frameworks by distinguishing the choice of schooling from the choice of occupational sector, introducing true dynamics and uncertainty.
- Investigate how school attainment and occupation-specific work experience affect the production of occupation specific skills.
- Also examine how altering incentives to attend college, such as tuition subsidies, affects behavior.

Model

- Assumes that individuals have five choices in every time period:

  (i) attend school
  (ii) work in a white-collar occupation
  (iii) work in a blue-collar occupation
  (iv) work in the military
  (v) engage in home production.

- There is a finite horizon, from age 16 to age A during which individuals accumulate schooling and occupation-specific experience which affects future wages.
- People differ in paths over their lifecycle because of differences in endowments and differences in stochastic shocks.

Notation

- Assume that there are m alternatives, where $m \in \{1, 2, 3, 4, 5\}$.
- $d_m(a) = 1$ if alternative m is chosen at date t.
- $R_m(a)$ represent the reward from choosing alternative m, which captures all benefits and costs associated with that alternative.
- The first three alternatives $\{1, 2, 3\}$ are work alternatives and the reward is the wage.
- r_m denote the rental price for skill occupational sector m and let $e_m(a)$ denote the occupation-specific skill units.

The reward is given by:

$$R_m(a) = w_m(a) = r_m e_m(a).$$

The technology for skill production depends on the number of years of schooling accumulated, $g(a)$, and on occupation-specific work experience, $x_m(a)$.

Assume that the production function takes the form:

$$e_m(a) = \exp[e_m(16) + e_{m_1} g(a) + e_{m2} x_m(a) - e_{m3} x_m^2(a) + \varepsilon_m(a)].$$

The term $e_m(16)$ represents the endowment of skill at age 16.

The log wage equation is then given by:

$$\ln w_m(a) = \ln r_m + e_m(16) + e_{m_1} g(a) + e_{m2} x_m(a) - e_{m3} x_m^2(a) + \varepsilon_m(a)$$

Note that the wage equation has the Mincer (1958, 1972) form of being linear in years of education and quadratic in experience, but it has the Ben-Porath (1967) interpretation.

If a person goes to school, the per period reward is:

$R_4(a) = e_4(16) + \varepsilon_4(a) - t_{c1}1(\text{attend college})\text{-}t_{c2}1(\text{attend graduate school})$

where $1(\cdot)$ is an indicator function that equals one if the event in paretheses is true. t_{c1} and t_{c2} are tuition costs (estimated), $e_4(16)$ is endowed skill at age 16 and $\varepsilon_4(a)$ is a random component.

Alternative 5 is to stay home and the associated reward is given by:

$$R_5(a) = e_5(16) + \varepsilon_5(a),$$

where $e_5(16)$ is the skill endowment and $\varepsilon_5(a)$ the random error component.

- The initial conditions in the model are:

$$g(16) - \text{ the highest grade completed at age 16}$$

along with the unobserved endowments.

- It is assumed that experience is zero for all alternatives in the first period.
- The shock components are assumed to be joint normally distributed and serially independent (conditional on the unobserved endowments):

$$\begin{pmatrix} \varepsilon_1(a) \\ \varepsilon_2(a) \\ \varepsilon_3(a) \\ \varepsilon_4(a) \\ \varepsilon_5(a) \end{pmatrix} \tilde{} N(0, \Omega).$$

Define a vector of age 16 endowments:

$$e(16) = [e_1(16), e_2(16), e_3(16), e_4(16), e_5(16)].$$

Define a vector of work experience accumulated in the different sectors:

$$x(a) = [x_1(a), x_2(a), x_3(a), x_4(a), x_5(a)].$$

The shock vector is

$$\varepsilon(a) = [\varepsilon_1(a), \varepsilon_2(a), \ldots, \varepsilon_5(a)].$$

The state space at any given age is:

$$s(a) = \{e(16), g(a), x(a), \varepsilon(a)\},$$

which contains all the relevant history.

Let $d_m(a) = 1$ if alternative m is chosen at age a.

The value function at age a is the maximum over all possible sequences of future choices.

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

The problem can be written in Bellman equation form.
The alternative specific value function is

$$V_m(s(a), a) = R_m(s(a), a) + \delta E\left[V(s(a+1), a+1) | s(a), d_m(a) = 1\right]$$

for $a < A$, and

$$V_m(s(A), A) = R_m(S(A), A)$$

in the last time period. The expectation is taken over wage and preference shocks.

The value function is the max over the alternative specific value functions:

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

The state variables that evolve in the model are the accumulated sector-specific experience and the completed schooling:

$$x_m(a+1) = x_m(a) + d_m(a) \qquad m = 1,2,3$$
$$g(a+1) = g(a) + d_4(a) \qquad g(a) \leq \bar{g}$$

Decision Process

- At age 16, given initial conditions $e(16)$ and $g(16)$, the individual draws random shocks $\varepsilon(16)$.
- He calculates the alternative specific value functions and chooses the one with the highest value.
- This step is repeated at each age until age A.
- The solution to the model is the set of regions of $\varepsilon(a)$ over which each choice is optimal.
- There is no closed form, so the solution has to be obtained numerically.

- The observed data are the sector choices that people make and their observed wages (for the sectors with pecuniary rewards):

$$[d_{nm}(a), w_{nm}(a)d_{nm}(a) : m \in \{1,2,3\}]$$
$$[d_{nm}(a) : m \in \{4,5\}]$$

- In the dataset, we only observe wages and choices for part of the life time.
- It is assumed that individuals observe contemporaneous shocks $\varepsilon(a)$ but we do not.

The state space that we observe (exclusive of the shocks) is:

$$\bar{s}(a) = s(a) \text{ net of shocks}=[e(16), g(a), x(a)].$$

The likelihood is

$$\Pr[c(16), ..., c(a) | g(16), e(16)] = \Pi_{a=16}^{\bar{a}} \Pr[c(a)|\bar{s}(a)].$$

Estimation

The estimation proceeds by
(i) choosing an initial set of parameters,
(ii) solving numerically the solution to the dynamic programming problem (starting with the last period to the first),
(iii) computing the likelihood, and
(iv) iterating to maximize the likelihood until convergence.

- An extended version of the model in the paper allows for the possibility that individuals do not have the same age 16 endowments.
- Assume that there are k types with heterogeneous age 16 endowments.

$$e_k(16) = \{e_{mk}(16) : m = 1, ..5\}$$

- Then the likelihood is given by

$$\Pi_{n=1}^{N} \Sigma_{k=1}^{L} \pi_k L_{nk},$$

  where π_k is the probability of an individual being a certain type and L_{nk} is the likelihood conditional on being that type.
- The π_k are additional model parameters to be estimated.
- The probability of being a certain type can depend on initial conditions

Initial conditions

- One of the initial conditions is the schooling attained at age 16, $g(16)$.
- If the shocks were serially correlated, then it would be problematic to condition on $g(16)$, because $g(16)$ reflects prior schooling decisions that would be affected by earlier shocks. The distribution of later shocks would not be invariant to conditioning on $g(16)$.
- If the shocks are iid, then conditioning on $g(16)$ is not problematic.
- The assumption is that $g(16)$ is exogenous with respect to the shocks conditional on the unobserved type.

- Taking into account the initial condition, the likelihood is:

$$\Pi_{n=1}^{N}\Sigma_{k=1}^{L}\pi_{k|g_{n(16)}}\Pr[c_n(a)|g_n(16), type = k]$$

- The type probability is estimated as a function of the initial conditions.

Empirical Results

- The model is estimated on data from the NLSY79.
- Analyses subsample consists of 1373 observations on white males who were age 16 or less as of Oct. 1, 1977 and who are following through 1988.
- Each time period corresponds to one year.
- Wages are measured as full-time-equivalent wages, which correspond to the average weekly wage*50.
- Estimation assumes that $A = 65$ and that there are four types.
- Occupational classifications are blue collar, white collar and military.

- Table 1 shows the choice distributions by age.
- After age 22, participation in blue collar work remains unchanged but white collar work doubles, reflecting the connection between leaving school and going to a white collar job.

TABLE 1

CHOICE DISTRIBUTION: WHITE MALES AGED 16–26

AGE	CHOICE: School	Home	White-Collar	Blue-Collar	Military	TOTAL
16	1,178	145	4	45	1	1,373
	85.8	10.6	.3	3.3	.1	100.0
17	1,014	197	15	113	20	1,359
	74.6	14.5	1.1	8.3	1.5	100.0
18	561	296	92	331	70	1,350
	41.6	21.9	6.8	24.5	5.2	100.0
19	420	293	115	406	107	1,341
	31.3	21.9	8.6	30.3	8.0	100.0
20	341	273	149	454	113	1,330
	25.6	20.5	11.2	34.1	8.5	100.0
21	275	257	170	498	106	1,306
	21.1	19.7	13.0	38.1	8.1	100.0
22	169	212	256	559	90	1,286
	13.1	16.5	19.9	43.5	7.0	100.0
23	105	185	336	546	68	1,240
	8.5	14.9	27.1	44.0	5.5	100.0
24	65	112	284	416	44	921
	7.1	12.2	30.8	45.2	4.8	100.0
25	24	61	215	267	24	591
	4.1	10.3	36.4	45.2	4.1	100.0
26	13	32	88	127	2	262
	5.0	12.2	33.6	48.5	.81	100.0
Total	4,165	2,063	1,724	3,762	645	12,359
	33.7	16.7	14.0	30.4	5.2	100.0

NOTE.—Number of observations and percentages.

Table 2 shows the transition between different sectors, which shows strong persistence. There is also strong state dependence in occupation-specific employment. Transitions from white collar to blue collar occupations fall after age 25.

TABLE 2

TRANSITION MATRIX: WHITE MALES AGED 16–26

	Choice (t)				
Choice ($t-1$)	School	Home	White-Collar	Blue-Collar	Military
School:					
Row %	69.9	12.4	6.5	9.9	1.3
Column %	91.2	32.6	2.5	14.2	11.2
Home:					
Row %	9.8	47.2	8.1	31.3	3.7
Column %	4.4	42.9	8.8	15.6	10.7
White-collar:					
Row %	5.7	6.3	67.4	19.9	.7
Column %	1.8	4.0	51.4	7.0	1.4
Blue-collar:					
Row %	3.4	12.4	9.9	73.4	.9
Column %	2.6	19.0	18.2	61.7	4.3
Military:					
Row %	1.4	5.5	3.1	9.6	80.5
Column %	.2	1.6	1.0	1.5	72.4

Table 3 provides information on how transitions vary with other variables in the model, such as experience and schooling levels.

TABLE 3

SELECTED CHOICE-STATE COMBINATIONS

Highest grade completed	9	10	11	12	13	14	15	16	17
Percentage choosing school	26.9	59.8	49.1	13.5	45.1	44.8	62.5	13.5	42.5
If in school previous period	73.5	91.1	85.0	44.2	72.9	70.6	68.8	23.5	55.6
White-collar experience	0	1	2	3	4	5	6		
Percentage choosing white-collar employment	6.8	38.0	55.3	63.3	76.2	74.6	79.2		
If white-collar previous period	...	57.5	71.7	76.7	78.8	82.0	86.4		
Blue-collar experience	0	1	2	3	4	5	6	7	
Percentage choosing blue-collar employment	15.0	51.6	64.9	74.0	74.9	81.2	77.1	88.3	
If blue-collar previous period	...	62.0	71.4	78.7	81.7	85.3	78.7	85.4	
Military experience	0	1	2	3	4	5			
Percentage choosing military employment	1.5	68.0	56.6	44.6	32.7	61.9			
If military previous period	...	90.7	86.5	74.0	57.1	78.8			

Table 4 tabulates the average real wages by occupation for white males age 16-26. Wages rise with age. White collar and blue collar are similar up to age 21 and then white collar wages are higher. Military wages are the lowest.

TABLE 4

AVERAGE REAL WAGES BY OCCUPATION: WHITE MALES AGED 16–26

	MEAN WAGE			
AGE	All Occupations	White-Collar	Blue-Collar	Military
16	10,217 (28)	...	10,286 (26)	...
17	11,036 (102)	10,049 (14)	11,572 (75)	9,005 (13)
18	12,060 (377)	11,775 (71)	12,603 (246)	10,171 (60)
19	12,246 (507)	12,376 (97)	12,949 (317)	9,714 (93)
20	13,635 (587)	13,824 (128)	14,363 (357)	10,852 (102)
21	14,977 (657)	15,578 (142)	15,313 (419)	12,619 (96)
22	17,561 (764)	20,236 (214)	16,947 (476)	13,771 (74)
23	18,719 (833)	20,745 (299)	17,884 (481)	14,868 (53)
24	20,942 (667)	24,066 (259)	19,245 (373)	15,910 (35)
25	22,754 (479)	24,899 (207)	21,473 (250)	17,134 (22)
26	25,390 (206)	32,756 (79)	20,738 (125)	...

NOTE.—Number of observations is in parentheses. Not reported if fewer than 10 observations.

Parameter values:

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 (···)

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.

Goodness of fit:

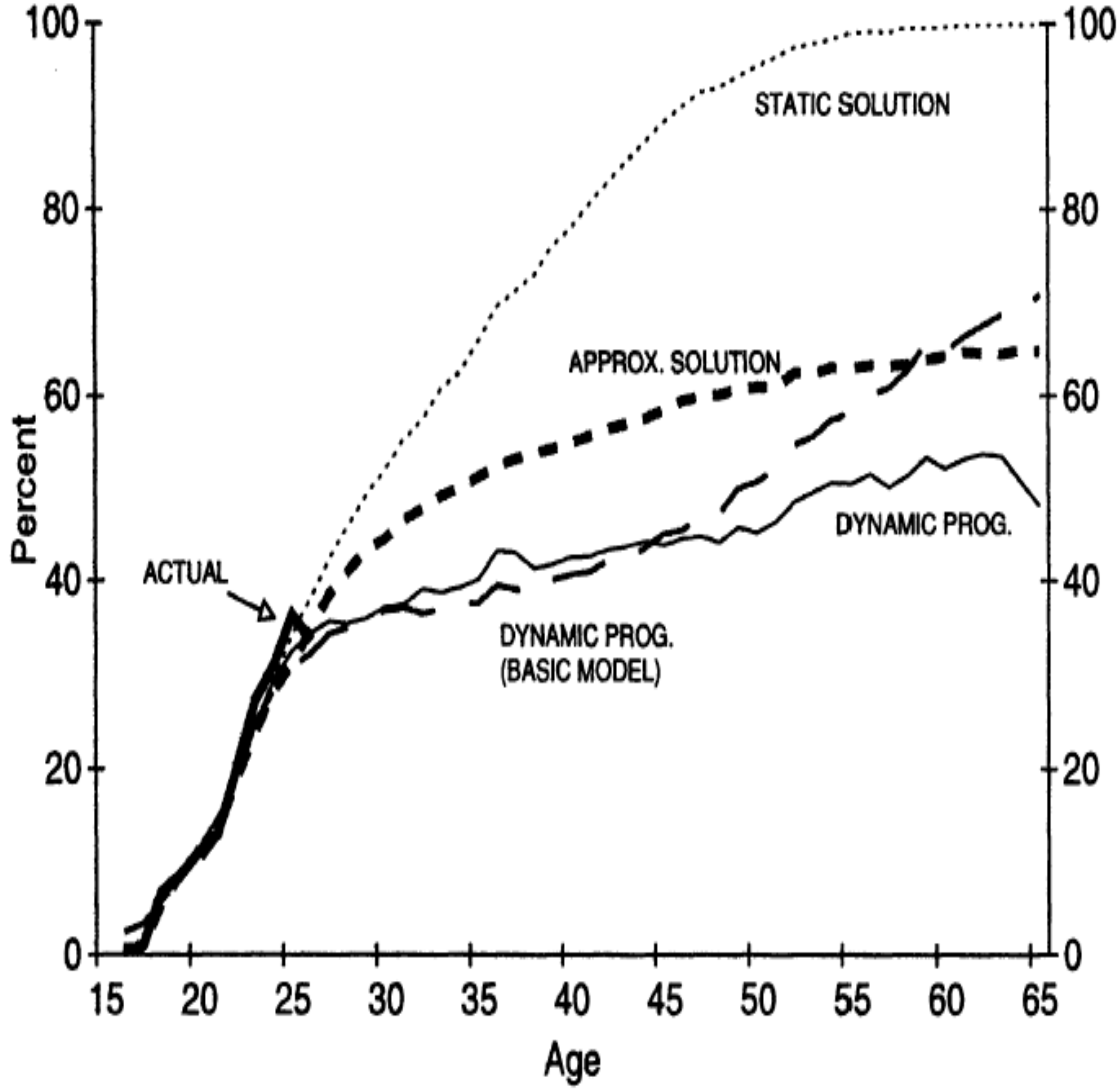

FIG. 1.—Percentage white-collar by age

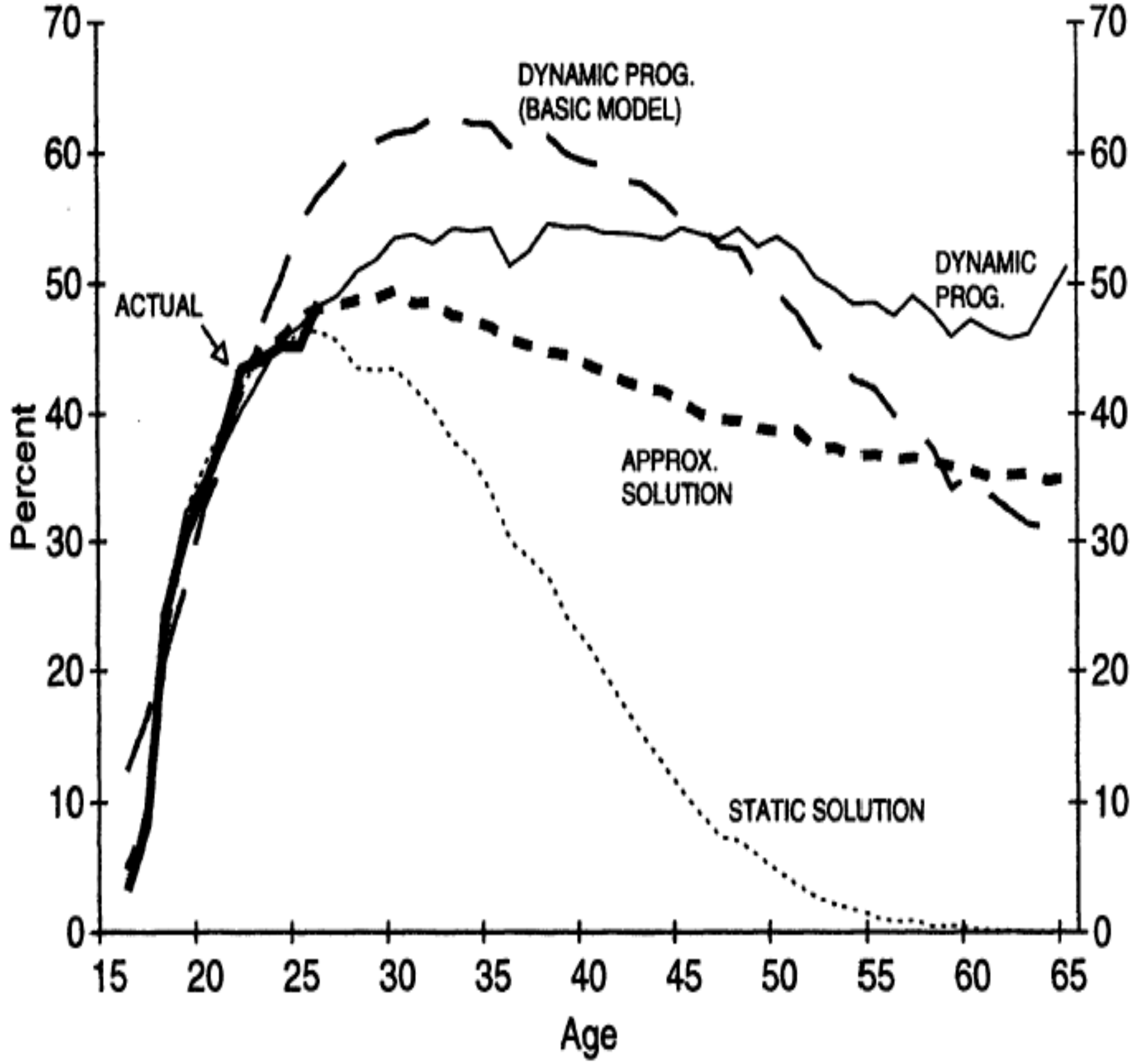

FIG. 2.—Percentage blue-collar by age

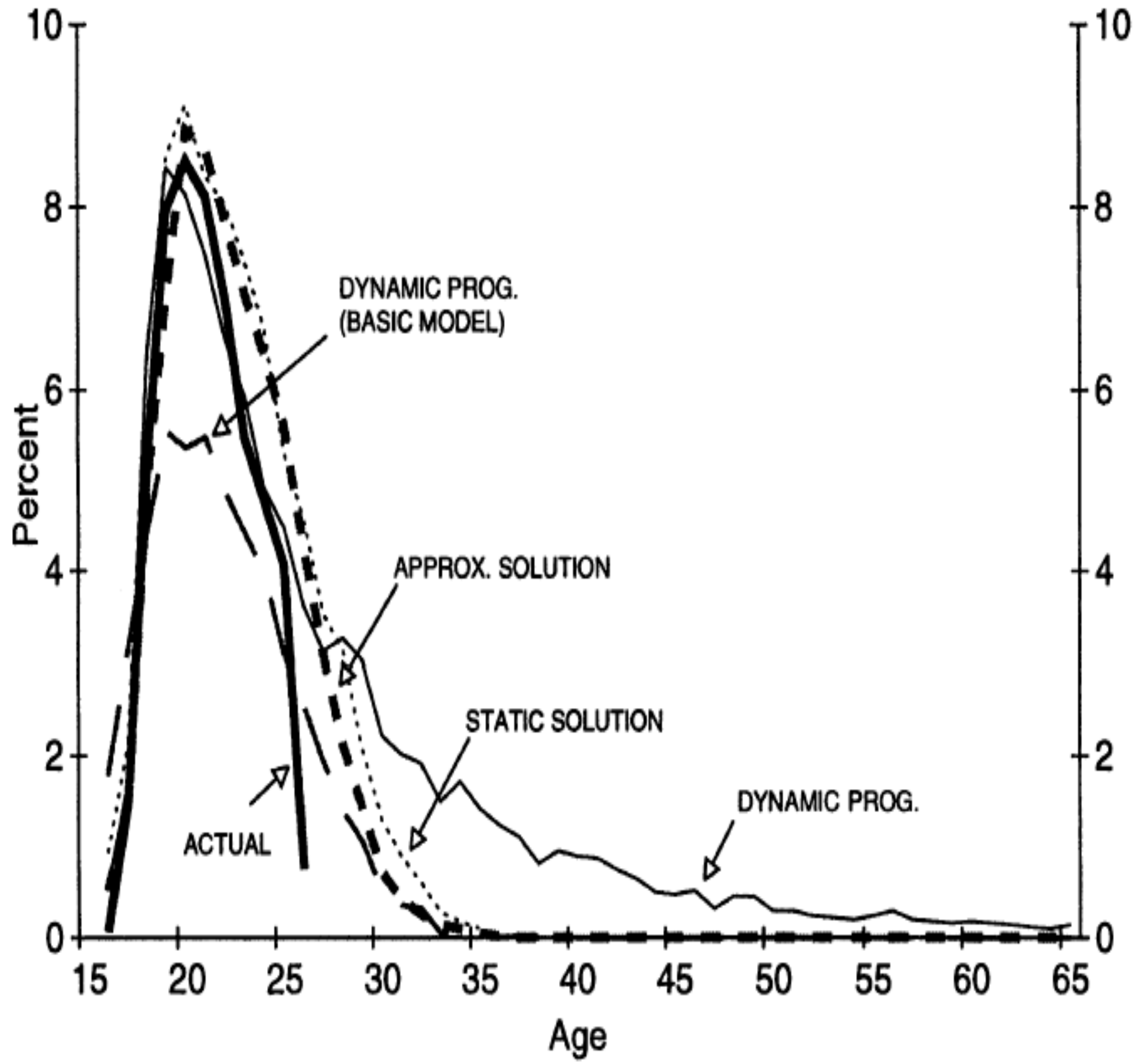

FIG. 3.—Percentage in the military by age

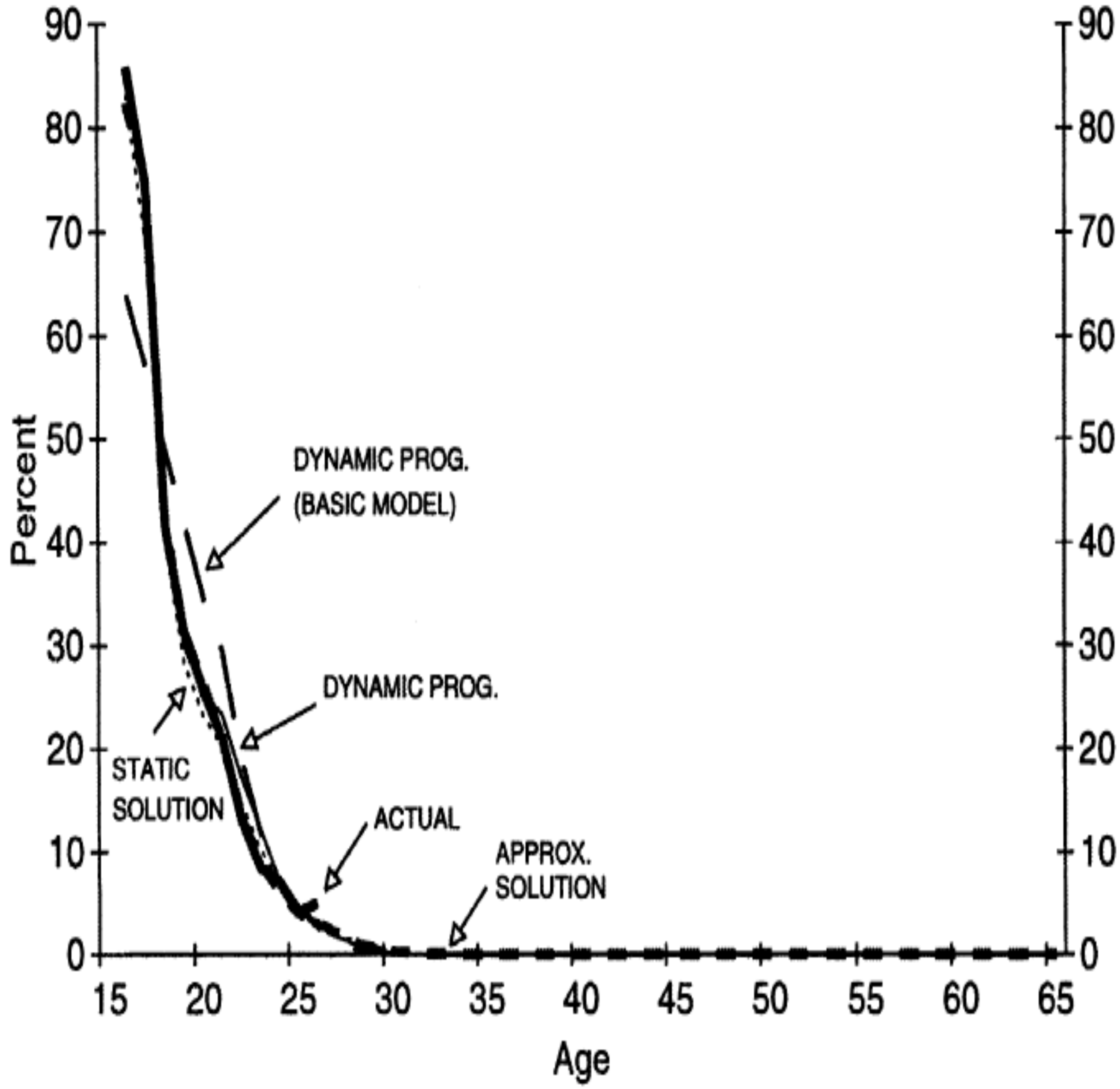

FIG. 4.—Percentage in school by age

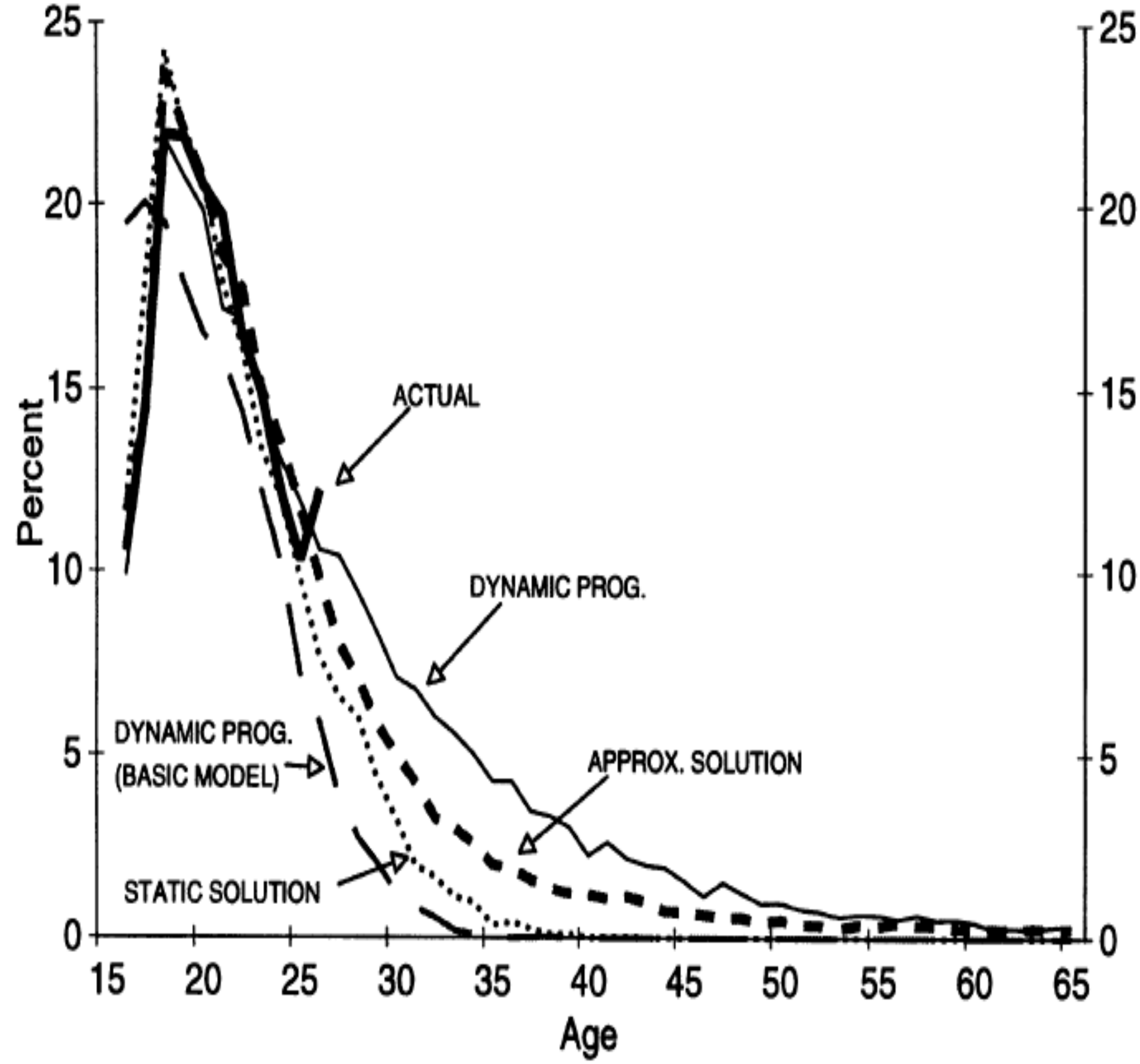

FIG. 5.—Percentage at home by age

TABLE 5

χ^2 GOODNESS-OF-FIT TESTS OF THE WITHIN-SAMPLE CHOICE DISTRIBUTION: DYNAMIC PROGRAMMING MODEL AND MULTINOMIAL PROBIT

Age	School	Home	White-Collar	Blue-Collar	Military	Row
16:						
DP-basic	103.05*	17.10*	†	92.61*	†	213.2*
DP-extended	.00	.07	†	.15	†	.22
APP	2.00	.19	†	7.05*	†	9.24*
17:						
DP-basic	74.13*	7.37*	21.14*	54.63*	11.86*	169.15*
DP-extended	.95	.02	.28	3.31	.42	4.98
APP	.02	.00	1.78	.03	.00	1.84
18:						
DP-basic	15.02*	1.60	2.18	6.75*	1.71	27.26*
DP-extended	.03	.00	.93	.01	3.09	4.06
APP	.09	.94	3.03	.42	.17	4.65
19:						
DP-basic	35.83*	5.04*	.26	7.23*	14.41*	62.77*
DP-extended	.83	.51	.07	1.27	.34	3.02
APP	.00	.02	.01	.17	1.53	1.73
20:						
DP-basic	31.10*	6.24*	.14	.92	24.47*	62.86*
DP-extended	.16	.25	.24	.22	.22	.94
APP	.25	.01	.82	.06	.17	1.31
21:						
DP-basic	31.28*	6.54*	.01	1.46	16.61*	55.89*
DP-extended	2.91	3.50	2.45	.23	.72	9.81*
APP	.00	.65	.05	.03	.41	1.14
22:						
DP-basic	23.78*	2.94	1.01	.08	11.84*	39.66*
DP-extended	12.43*	.11	.61	3.04	.38	16.60*
APP	.12	1.49	.72	.64	1.21	4.19
23:						
DP-basic	12.63*	7.78*	2.99	2.00	3.15	28.56*
DP-extended	14.66*	.12	3.76	.42	.44	19.40*
APP	.23	.14	5.90*	.44	4.38	10.97*
24:						
DP-basic	.18	4.76*	2.28	4.61*	1.40	13.30*
DP-extended	.18	.99	.81	.04	.04	1.89
APP	1.21	2.77	2.20	.05	2.77	10.01*
25:						
DP-basic	.30	12.35*	6.21*	9.31*	1.84	30.01*
DP-extended	.14	3.45	2.71	.29	.23	6.82
APP	.01	2.98	5.00*	.61	2.56	11.16*
26:						
DP-basic	4.96*	38.64*	.17	3.13	†	46.90*
DP-extended	2.61	2.14	.45	.00	†	5.20
APP	2.84	4.95*	.10	.01	†	7.90*

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	

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.

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.

Conclusions

- Augmented human capital investment model does a good job of fitting the data. Inclusion of skill depreciation during periods of nonwork, of mobility or job finding costs, of school reentry costs, and of nonpecuniary components was important.
- Predicted impact of a $2000 college subsidy is that it would increase high school graduation rates by 3.5 percentage points and college graduation rates by 8.4 percentage points. But effect on lifetime utility would be negligible.
- Main beneficiaries of subsidy are those who would have gone to college even without the subsidy.
- Tuition subsidies of this magnitude do little to compensate for utility differences arising from endowments. Inequality in skill endowments (at age 16) explains the bulk of variation in lifetime utility.