Returns to Education

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I heavily draw on the material presented in:

- Heckman, J. J., Lochner, L. J., and Todd, P. E. (2006a). Earnings functions, rates of return and treatment effects: The mincer equation and beyond. In Hanushek, E. A. and Welch, F., editors, *Handbook of the Economics of Education*, volume 1, pages 307–458. North-Holland Publishing Company

We will look at two papers that explore reduced-form estimations of the returns to education .

- Carneiro, P. and Heckman, J. J. (2002). The evidence on credit constraints in post-secondary schooling. *The Economic Journal*, 112(482):705–734
- Bhuller, M., Mogstad, M., and Salvanes, K. G. (2017). Life cycle earnings, education premiums and internal rates of return. *Journal of Labor Economics*, 35(4):993–1030

We will look at two papers that explore structural estimations of the returns to education .

- Cunha, F., Heckman, J. J., and Navarro, S. (2005). Separating uncertainty from heterogeneity in life cycle earnings. *Oxford Economic Papers*, 57(2):191–261
- Eisenhauer, P., Heckman, J. J., and Mosso, S. (2015). Estimation of dynamic discrete choice models by maximum likelihood and the simulated method of moments. *International Economic Review*, 56(2):331–357

Why are returns to education important?

- help explain wage inequality
- judge relative profitability of investment in education?
- ...

Mincer Equation

$$\ln Y(s,x) = \alpha + \rho_s s + \beta_0 x + \beta_1 x^2 + \epsilon$$

$\Rightarrow$ How to interpret the *Mincer Coefficient* ρ_s?

Conceptual Frameworks

- compensating differences model
- accounting-identity model

Compensating Differences Model

$$V(s) = Y(s)\int_s^T e^{-rt}dt = \frac{Y(s)}{r}(e^{-rs} - e^{-rT})$$

Equalizing present value of earnings across schooling levels:

$$\ln Y(s) = \ln Y(0) + rs + \ln\left(\frac{1 - e^{-rs}}{1 - e^{-r(T-s)}}\right)$$

$\Rightarrow \rho_s$ equals the market interest rate and the internal rate of return to schooling by construction.

Model Features:

- identical abilities and opportunities
- no credit constraints
- perfect certainty
- no direct cost of schooling
- no nonpecuniary benefits of school and work

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Accounting-Identity Model

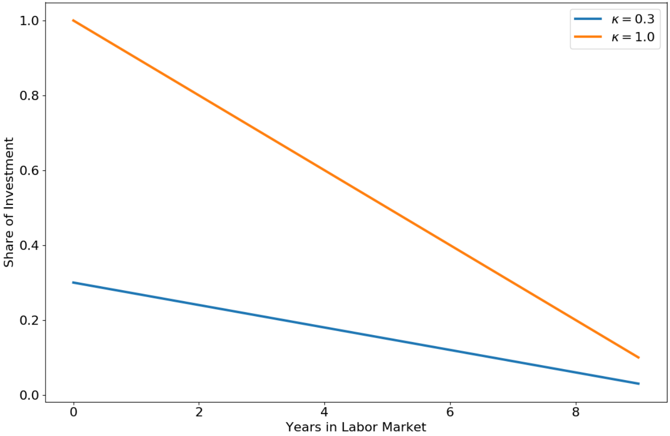
$$P_t \equiv P_{t-1}(1 + k_{t-1}\rho_{t-1}) \equiv \prod_{j=0}^{t-1}(1 + \rho_j k_j)P_0$$

$$\begin{aligned}\ln P_t &\equiv \ln P_0 + s\ln(1+\rho_s) + \sum_{j=s}^{t-1}\ln(1+\rho_0 k_j)\\ &\approx \ln P_0 + s\rho_s + \rho_0\sum_{j=s}^{t-1}k_j\end{aligned}$$

Assuming linearly declining rate of post-school investment:

$$k_{s+x} = \kappa\left(1 - \frac{x}{T}\right), \text{where} \quad x = t - s$$

Figure: Post-School Investment



$$\ln P_{x+s} \approx lnP_0 + s\frac{3}{4_s} + P_0 \sum_{j=1}^{x} \kappa \left(1 - \frac{j}{T}\right) \tag{1}$$

further decomposing experience addition

$$\begin{aligned} P_0 \sum_{j=1}^{x} \kappa \left(1 - \frac{j}{T}\right) &= P_0 \sum_{j=1}^{x} \kappa - P_0 \sum_{j=1}^{x} \left(\frac{j}{T}\right) \\ &= P_0 \kappa x - \frac{P_0}{T} \sum_{j=1}^{x} j \end{aligned}$$

using result on sum of arithmetic series

$$
\begin{aligned}
&= P_0 \kappa x - \frac{P_0}{T} x \left(\frac{1+x}{2} \right) = P_0 \kappa x - \frac{P_0}{2T} x - \frac{P_0}{2T} x^2 \\
&= \left(P_0 \kappa - \frac{P_0}{2T} \right) x - \frac{P_0}{2T} x^2
\end{aligned}
$$

substituting back into (1)

$$
\ln P_{x+s} \approx \ln P_0 + s\rho_s + \left(\rho_0 \kappa + \frac{\rho_0 \kappa}{2T} \right) x - \frac{\rho_0 \kappa}{2T} x^2
$$

Accounting for the difference in potential and observed earnings:

$$\begin{aligned}\ln Y(s,x) &= \ln P_{x+s} - \kappa\left(1-\frac{x}{T}\right)\\ &= [\ln P_0 - \kappa] + \rho_s s + \left(\rho_0\kappa + \frac{\rho_0\kappa}{2T} + \frac{\kappa}{T}\right)x - \frac{\rho_0\kappa}{2T}x^2\end{aligned}$$

$\Rightarrow$ ρ_s is the average earnings increase with schooling

Standard Mincer Equation

$$\ln Y(s,x) = \alpha + \rho_s s + \beta_0 x + \beta_1 x^2,$$

where

$$\begin{aligned}
\alpha &= \ln P_0 - \kappa \\
\beta_0 &= \left(\rho_0 \kappa + \frac{\rho_0 \kappa}{2T} + \frac{\kappa}{T}\right) \\
\beta_1 &= -\frac{\rho_0 \kappa}{2T}
\end{aligned}$$

Random Coefficient Version

$$\ln Y(s_i, x_i) = \alpha_i + \rho_{si} s_i + \beta_{0i} x_i + \beta_{1i} x_i^2$$

and let

$$\bar{\alpha} = \mathrm{E}[\alpha_i] \qquad \bar{\rho}_s = \mathrm{E}[\rho_{si}]$$
$$\bar{\beta}_0 = \mathrm{E}[\beta_{0i}] \qquad \bar{\beta}_1 = \mathrm{E}[\beta_{1i}]$$

Dropping individual subscripts ...

$$
\begin{aligned}
\ln Y(s,x) &= \bar{\alpha} + \bar{\rho}_s s + \bar{\beta}_0 x + \bar{\beta}_1 x^2 \\
&\quad + \underbrace{[(\alpha - \bar{\alpha}) + (\rho_s - \bar{\rho}_s)s + (\beta_0 - \bar{\beta}_0)x + (\beta_1 - \bar{\beta}_1)x^2]}_{\epsilon}
\end{aligned}
$$

$\Rightarrow$ If the schooling decision is determined by individual returns, then we are back in the case of a correlated random coefficient model (Heckman et al., 2006b).

Table 2: Estimated Coefficients from Mincer Log Earnings Regression for Men

		Whites		Blacks	
		Coefficient	Std. Error	Coefficient	Std. Error
1940	Intercept	4.4771	0.0096	4.6711	0.0298
	Education	0.1250	0.0007	0.0871	0.0022
	Experience	0.0904	0.0005	0.0646	0.0018
	Experience-Squared	-0.0013	0.0000	-0.0009	0.0000
1950	Intercept	5.3120	0.0132	5.0716	0.0409
	Education	0.1058	0.0009	0.0998	0.0030
	Experience	0.1074	0.0006	0.0933	0.0023
	Experience-Squared	-0.0017	0.0000	-0.0014	0.0000
1960	Intercept	5.6478	0.0066	5.4107	0.0220
	Education	0.1152	0.0005	0.1034	0.0016
	Experience	0.1156	0.0003	0.1035	0.0011
	Experience-Squared	-0.0018	0.0000	-0.0016	0.0000
1970	Intercept	5.9113	0.0045	5.8938	0.0155
	Education	0.1179	0.0003	0.1100	0.0012
	Experience	0.1323	0.0002	0.1074	0.0007
	Experience-Squared	-0.0022	0.0000	-0.0016	0.0000
1980	Intercept	6.8913	0.0030	6.4448	0.0120
	Education	0.1023	0.0002	0.1176	0.0009
	Experience	0.1255	0.0001	0.1075	0.0005
	Experience-Squared	-0.0022	0.0000	-0.0016	0.0000
1990	Intercept	6.8912	0.0034	6.3474	0.0144
	Education	0.1292	0.0002	0.1524	0.0011
	Experience	0.1301	0.0001	0.1109	0.0006
	Experience-Squared	-0.0023	0.0000	-0.0017	0.0000

Notes: Data taken from 1940-90 Decennial Censuses. See Appendix B for data description.

Implications

- Log-earnings profiles are parallel across schooling levels.

$$\frac{\partial \ln Y(s,x)}{\partial s \partial x} = 0$$

- Log-earnings age profiles diverge with age across schooling levels.

$$\frac{\partial \ln Y(s,x)}{\partial s \partial t} = \frac{\rho_0 \kappa}{T} > 0$$

- The variance of earnings over the life cycle has a U-shaped pattern.

Figure: Mincerian Experience Profiles

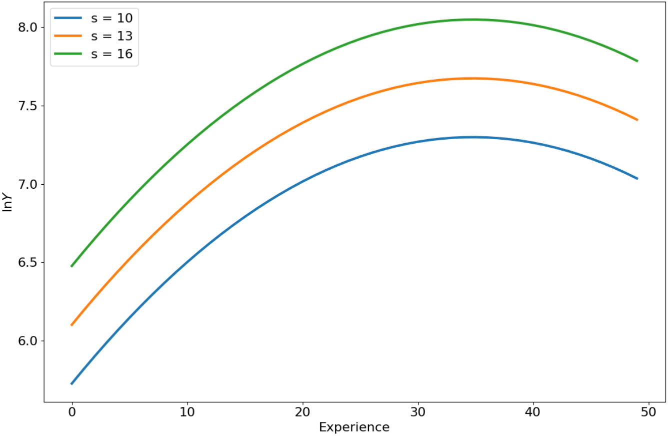


Figure: Mincerian Age Profiles

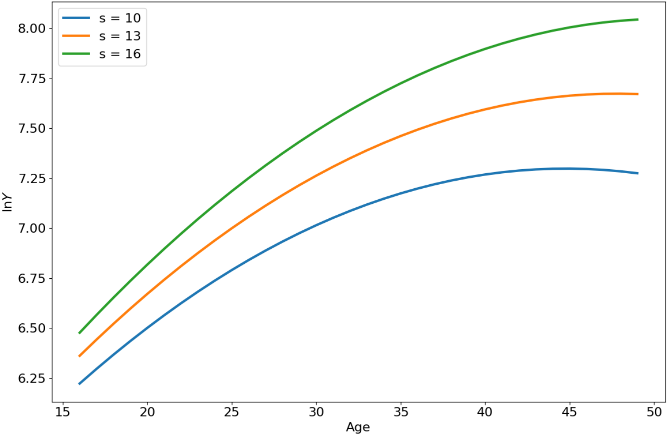
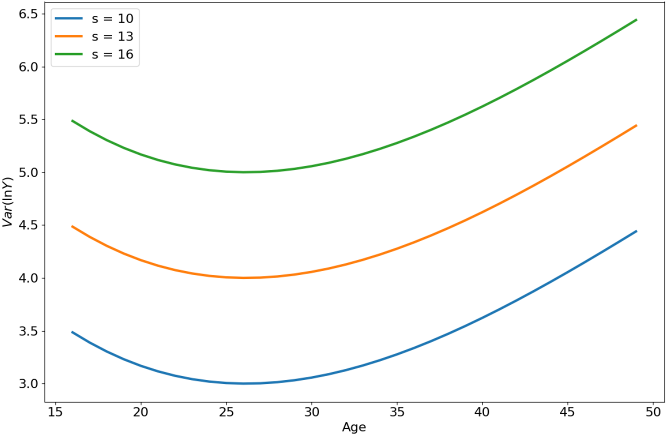
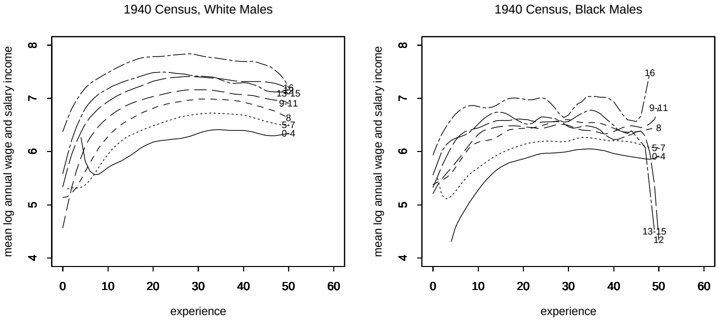


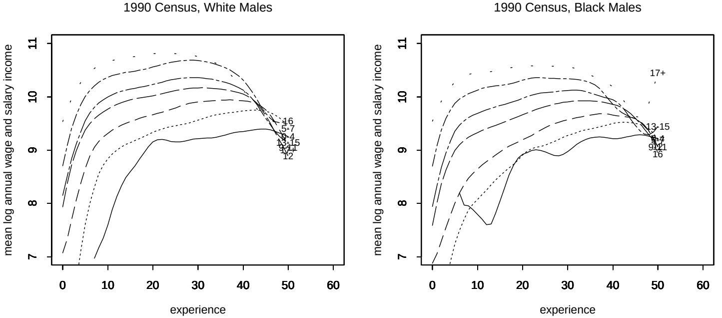
Figure: Minncerian Variance Profiles



Empirical Evidence

Figure 1a: Experience-Earnings Profiles, 1940-1960





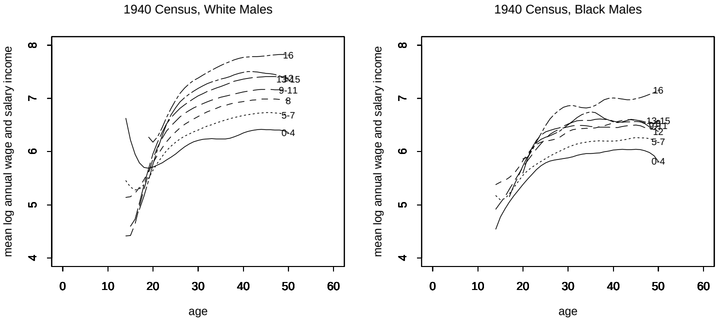
1990 Census, White Males
mean log annual wage and salary income
experience
16
5-7
0-4
13-15
9-11
12
1990 Census, Black Males
17+
13-15
9-11
16

Table 1: Tests of Parallelism in Log Earnings Experience Profiles for Men

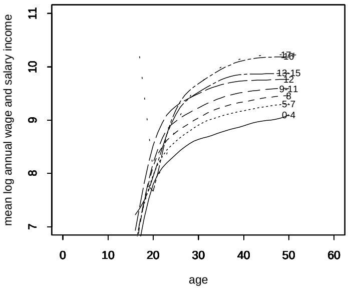
Sample	Experience Level	Estimated Difference Between College and High School Log Earnings at Different Experience Levels 1940	1950	1960	1970	1980	1990
Whites	10	0.54	0.30	0.46	0.41	0.37	0.59
	20	0.40	0.40	0.43	0.49	0.45	0.54
	30	0.54	0.27	0.46	0.48	0.43	0.52
	40	0.58	0.21	0.50	0.45	0.27	0.30
	p-value	0.32	0.70	<0.001	<0.001	<0.001	<0.001
Blacks	10	0.20	0.58	0.48	0.38	0.70	0.77
	20	0.38	0.05	0.25	0.22	0.48	0.69
	30	-0.11	0.24	0.08	0.33	0.36	0.53
	40	-0.20	0.00	0.73	0.26	0.22	-0.04
	p-value	0.46	0.55	0.58	0.91	<0.001	<0.001

Notes: Data taken from 1940-90 Decennial Censuses without adjustment for inflation. Because there are very few blacks in the 1940 and 1950 samples with college degrees, especially at higher experience levels, the test results for blacks in those years refer to a test of the difference between earnings for high school graduates and persons with 8 years of education. See Appendix B for data description. See Appendix C for the formulae used for the test statistics.

Figure 2: Age-Earnings Profiles, 1940,1960,1980



1980 Census, White Males



1980 Census, Black Males

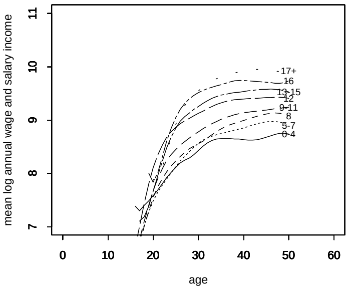
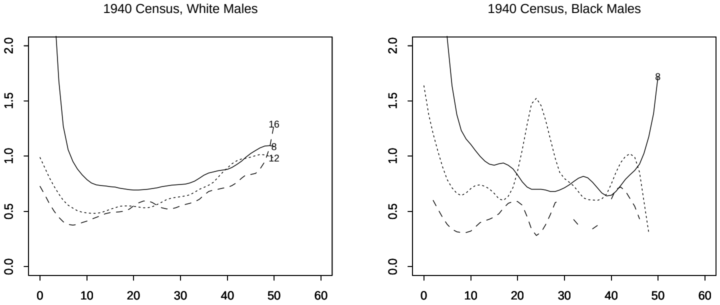
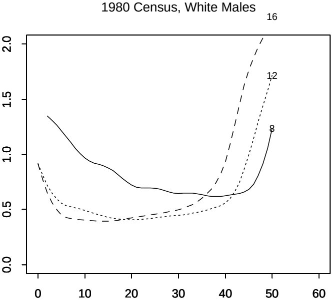
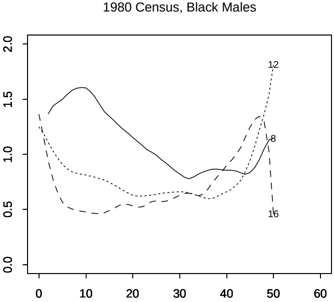


Figure 3: Experience-Variance Log Earnings




1980 Census, White Males
16
12
8
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60


1980 Census, Black Males
12
8
16
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60

In the end, Heckman et al. (2006a) conclude:

> *In common usage, the coefficient on schooling in a regression of log earnings on years of schooling is often called a rate of return. In fact, it is a price of schooling from a hedonic market wage equation. It is a growth rate of market earnings with years of schooling and not an internal rate of return measure, except under stringent conditions which we specify, test and reject in this chapter.*

Appendix

References

Bhuller, M., Mogstad, M., and Salvanes, K. G. (2017). Life cycle earnings, education premiums and internal rates of return. *Journal of Labor Economics*, 35(4):993–1030.

Carneiro, P. and Heckman, J. J. (2002). The evidence on credit constraints in post-secondary schooling. *The Economic Journal*, 112(482):705–734.

Carneiro, P., Heckman, J. J., and Vytlacil, E. J. (2011). Estimating marginal returns to education. *American Economic Review*, 101(6):2754–2781.

Cunha, F., Heckman, J. J., and Navarro, S. (2005). Separating uncertainty from heterogeneity in life cycle earnings. *Oxford Economic Papers*, 57(2):191–261.

Eisenhauer, P., Heckman, J. J., and Mosso, S. (2015). Estimation of dynamic discrete choice models by maximum likelihood and the simulated method of moments. *International Economic Review*, 56(2):331–357.

Heckman, J. J., Lochner, L. J., and Todd, P. E. (2006a). Earnings functions, rates of return and treatment effects: The mincer equation and beyond. In Hanushek, E. A. and Welch, F., editors, *Handbook of the Economics of Education*, volume 1, pages 307–458. North-Holland Publishing Company.

Heckman, J. J., Urzua, S., and Vytlacil, E. J. (2006b). Understanding instrumental variables in models with essential heterogeneity. *The Review of Economics and Statistics*, 88(3):389–432.

Mincer, J. (1974). *Schooling, Experience and Earnings*. National Bureau of Economic Research, New York, NY.

Mincer, J. A. (1958). Investment in human capital and personal income distribution. *Journal of Political Economy*, 66(4):281–302.