

Earning Functions and Rates of Return

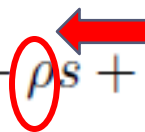
by James J. Heckman, Lance J. Lochner and Petra Todd

What do we mean by returns to education?

- Monetary, private rates of return to schooling which guide investments decisions in human capital (Becker 1964)
- In finance, IRR = discount rate that equates the present value of two potential income streams
- As for human capital: if the marginal IRR exceeds the opportunity cost of funds, an income maximizing individual will prefer to take additional schooling rather than work

Why earning functions?

- IRR are not easily calculated, since they require data on life-long educational expenditures and wages of individuals, so they are usually estimated
- Estimates most commonly rely on **Mincer's regression** of earnings on years of schooling and years of post-school work experience:

$$\ln w(s, x) = \alpha_0 + \rho s + \beta_0 x + \beta_1 x^2 + \varepsilon,$$


where $w(s, x)$ = wage income at experience level x for schooling level s

In order to observe both choices of schooling and working in a population, at the margins they must offer the same returns

i.e.:

$$\text{Earning profile of uneducated} \quad \sum_{t=1}^n \frac{w_t}{(1+\rho)^{t-1}} = \sum_{t=s+1}^{n+s} \frac{w_t^s}{(1+\rho)^{t-1}} \quad \text{Earning profile of educated}$$

Assumptions of Mincer's model

- **No direct or psychic costs of schooling**
 - Identical individuals (they differ only in terms of s and x)
 - **No income taxes**
 - **Length of working life = for everyone**
 - Multiplicative separability between schooling and experience components of earnings
 - Marginal returns = average returns
 - Perfect certainty about future returns of schooling levels
 - **Stationarity of economic environment** (so, of earnings) over time
 - Schooling is exogenous
- Log-linear relation
between
earnings and years of education

Only under these conditions, $\rho = \hat{\text{IRR}}$

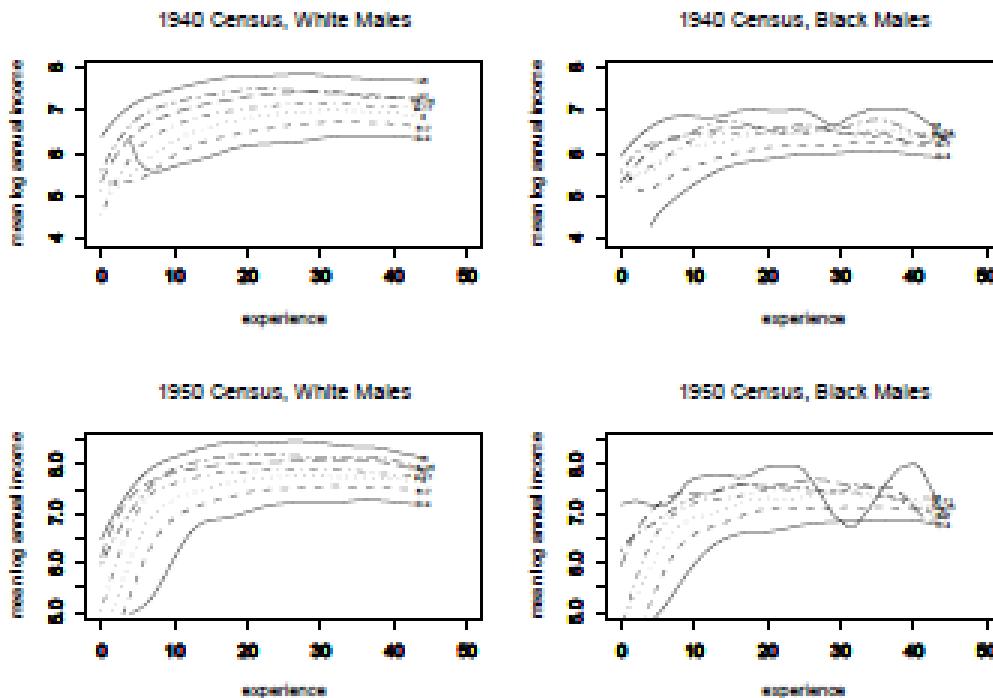
Aim of the paper

- Test the empirical foundations of the Mincerian model in recent decades in the US, in particular:
 - 1) Linearity of log earnings in schoolings
 - 2) Absence of taxes and tuition fees
 - 3) No loss of working life with additional schooling
 - 4) Stationarity of earnings over time
- Offer alternative methods to estimate marginal IRRs for different schooling levels

Linearity in log earnings?

If log wages increased linearly with schooling, we would observe parallelism in log earnings - experience profiles

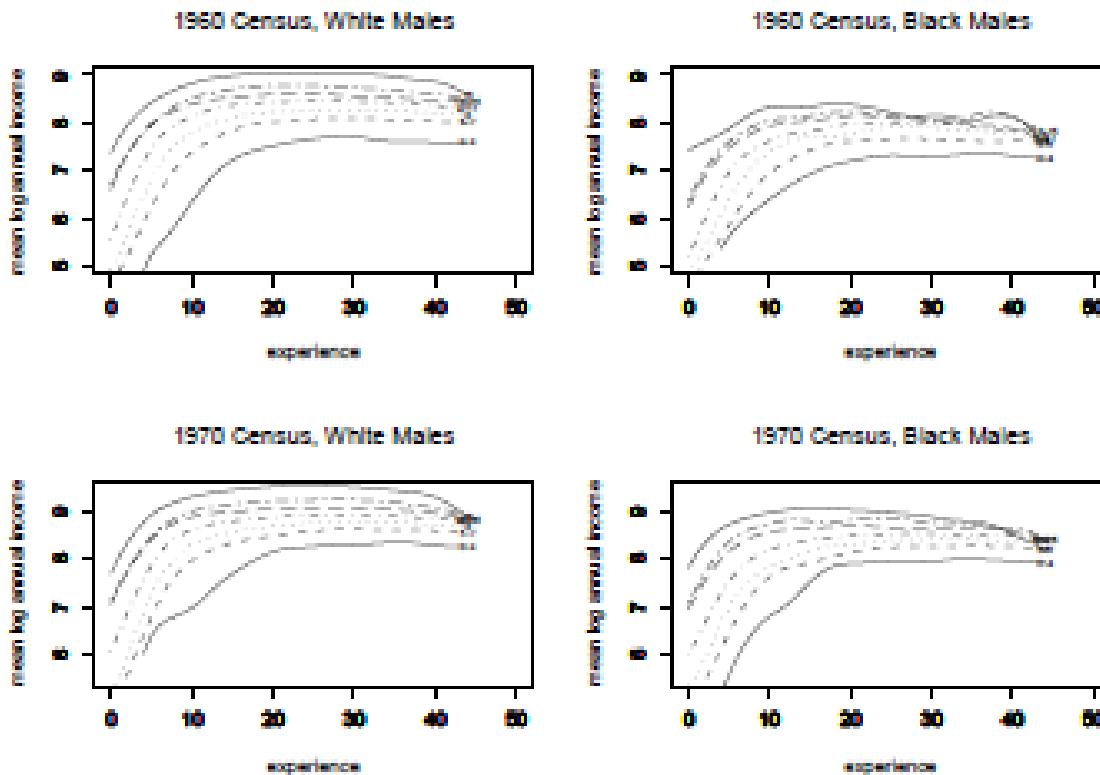
Using 1940-2000 US Census data, non parametric estimates for several groups:



Data from the 40s and 50s provide **support** for parallelism

Formal non parametric tests accept the hp of parallelism for both white and black males

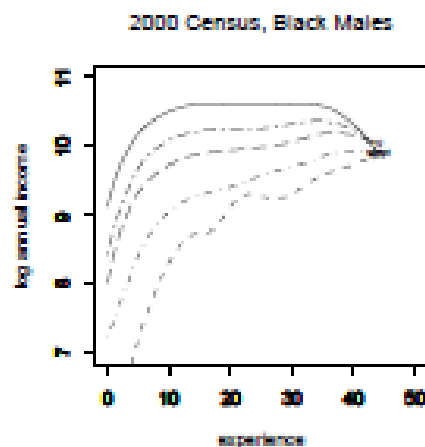
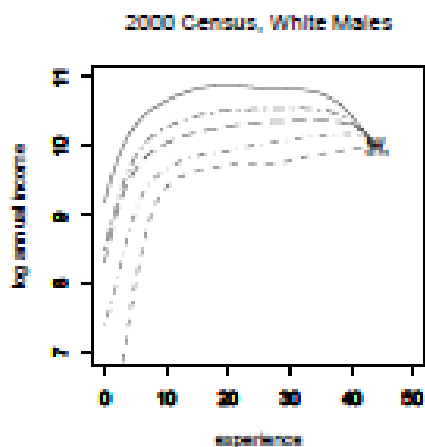
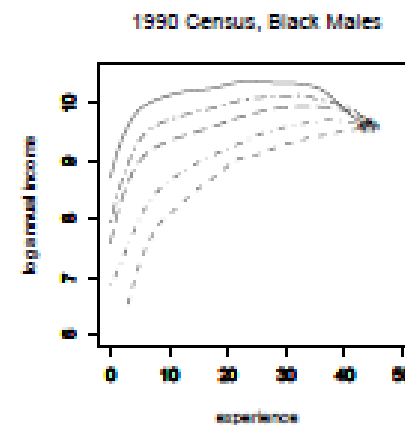
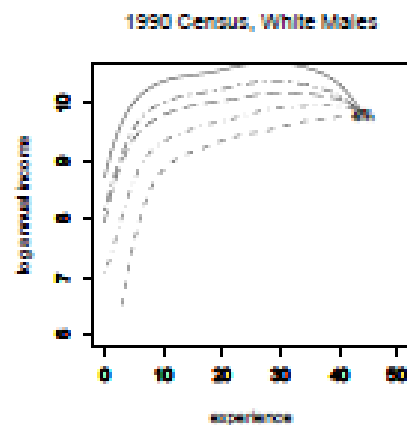
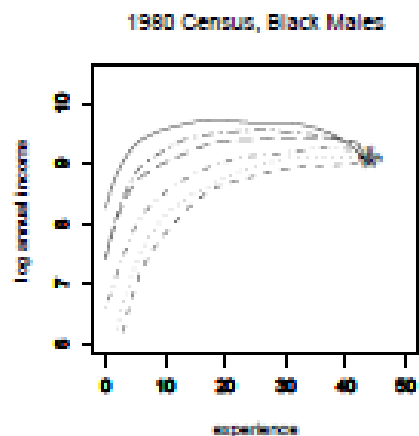
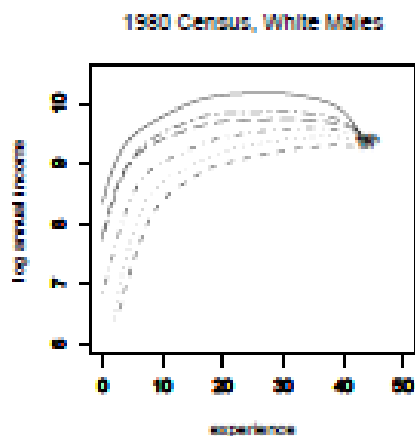
Linearity in log earnings? (2)



Eyeball evidence supports the hp of parallelism in the 60s and 70s

Formal tests reject the hp for the whites and accept it for the blacks (but small sample size)

Linearity in log earnings? (3)



Data from 80s and 90s show convergence with experience in the log earnings profiles across different schooling levels for both whites and blacks

The hp of parallelism is rejected: **recent data from are not supportive for Mincer's model**

Are tuition fees and taxes negligible?

Year	Avg. Tuition	Avg. Marginal Tax Rate
1940	\$1,710	5.6%
1950	\$1,336	19.6%
1960	\$1,978	23.4%
1970	\$2,596	24.3%
1980	\$2,380	30.4%
1990	\$3,569	23.3%
2000	\$4,413	25.3%

Data show that in the US both the average college tuition fees and the average marginal income tax rate are **non trivial**, especially in the last decades

Other works (Carneiro, Hansen and Heckman 2003 and Cunha, Heckmann and Navarro 2005) show evidence of substantial **non pecuniary costs** of schooling, far greater than tuition costs e.g. psychic costs

Alternative ways to estimate IRRs

After showing that the empirical evidence disproof two crucial assumptions of the Mincer's model, the authors estimate the IRRs for the same period in the US using alternative strategies

First of all, they allow for:


- Income taxes and college tuitions
- Variable lenght of working life
- Flexible relation between earnings, schooling and experience (non-parametric approach)

Then, they account for:

- Instability of economic environment comparing cross section and cohort estimates

Some non-parametric estimates

Allowing for taxes, tuitions, variable length of working life and a flexible relation between earnings, schooling and experience, they estimate non-parametrically the IRR for s_1 vs s_2 by equating the corresponding earning streams:

$$\int_0^{T(s_1)-s_1} (1-\tau)e^{-rI(x+s_1)} w(s_1, x) dx - \int_0^{s_1} ve^{-rIz} dz$$
$$= \int_0^{T(s_2)-s_2} (1-\tau)e^{-rI(x+s_2)} w(s_2, x) dx - \int_0^{s_2} ve^{-rIz} dz$$


Note that rI will equal the Mincer coefficient on schooling ρ if the assumptions of that model are met

Some non-parametric estimates (2)

Using this equation, IRRs are estimated:

- under the assumptions of Mincer's model
- relaxing linearity in schooling
- relaxing the latter and the quadratic specification for experience
- relaxing the latter and parallelism of log wages

→ Results: **Mincer's estimates are downwards biased**, especially for the return of high school completion and they do **not record the increasing pattern** over the last decades

Table 2a: Internal Rates of Return for White Men: Earnings Function Assumptions

	Schooling Comparisons					
	6-8	8-10	10-12	12-14	12-16	14-16
1940						
Mincer Specification	13	13	13	13	13	13
Relax Linearity in S	16	14	15	10	15	21
Relax Linearity in S & Quad. in Exp.	16	14	17	10	15	20
Relax Lin. in S & Parallelism	12	14	24	11	18	26
1950						
Mincer Specification	11	11	11	11	11	11
Relax Linearity in S	13	13	18	0	8	16
Relax Linearity in S & Quad. in Exp.	14	12	16	3	8	14
Relax Linearity in S & Parallelism	26	28	28	3	8	19
1960						
Mincer Specification	12	12	12	12	12	12
Relax Linearity in S	9	7	22	6	13	21
Relax Linearity in S & Quad. in Exp.	10	9	17	8	12	17
Relax Linearity in S & Parallelism	23	29	33	7	13	25
1970						
Mincer Specification	13	13	13	13	13	13
Relax Linearity in S	2	3	30	6	13	20
Relax Linearity in S & Quad. in Exp.	5	7	20	10	13	17
Relax Linearity in S & Parallelism	17	29	33	7	13	24
1980						
Mincer Specification	11	11	11	11	11	11
Relax Linearity in S	3	-11	36	5	11	18
Relax Linearity in S & Quad. in Exp.	4	-4	28	6	11	16
Relax Linearity in S & Parallelism	16	66	45	5	11	21
1990						
Mincer Specification	*	14	14	14	14	14
Relax Linearity in S	*	-7	39	7	15	24
Relax Linearity in S & Quad. in Exp.	*	-3	30	10	15	20
Relax Linearity in S & Parallelism	*	20	50	10	16	26
2000						
Mincer Specification	*	14	14	14	14	14
Relax Linearity in S	*	-12	44	8	15	23
Relax Linearity in S & Quad. in Exp.	*	-5	33	10	15	20
Relax Linearity in S & Parallelism	*	9	52	11	18	29

College completion

High school completion

Table 2b: Internal Rates of Return for Black Men: Earnings Function Assumptions

	Schooling Comparisons					
	6-8	8-10	10-12	12-14	12-16	14-16
1960						
Mincer Specification	11	11	11	11	11	11
Relax Linearity in S	13	12	18	5	8	11
Relax Linearity in S & Quad. in Exp.	13	11	18	5	7	10
Relax Linearity in S & Parallelism	22	15	38	5	11	25
1970						
Mincer Specification	12	12	12	12	12	12
Relax Linearity in S	5	11	30	7	10	14
Relax Linearity in S & Quad. in Exp.	6	11	24	10	11	12
Relax Linearity in S & Parallelism	15	27	44	9	14	23
1980						
Mincer Specification	12	12	12	12	12	12
Relax Linearity in S	-4	1	35	10	15	19
Relax Linearity in S & Quad. in Exp.	-4	6	29	11	14	17
Relax Linearity in S & Parallelism	10	44	48	8	16	31
1990						
Mincer Specification	*	16	16	16	16	16
Relax Linearity in S	*	-5	41	15	20	25
Relax Linearity in S & Quad. in Exp.	*	-3	35	17	19	22
Relax Linearity in S & Parallelism	*	16	58	18	25	35
2000						
Mincer Specification	*	18	18	18	18	18
Relax Linearity in S	*	-8	44	15	20	24
Relax Linearity in S & Quad. in Exp.	*	-2	38	16	19	21
Relax Linearity in S & Parallelism	*	31	56	19	24	31

Table 3: Internal Rates of Return for White & Black Men: Accounting for Taxes and Tuition (General Non-Parametric Specification)

		Schooling Comparisons					
		Whites			Blacks		
		12-14	12-16	14-16	12-14	12-16	14-16
1940	No Taxes or Tuition	11	18	26			
	Including Tuition Costs	9	15	21			
	Including Tuition & Flat Taxes	8	15	21			
	Including Tuition & Prog. Taxes	8	15	21			
1950	No Taxes or Tuition	3	8	19			
	Including Tuition Costs	3	8	16			
	Including Tuition & Flat Taxes	3	8	16			
	Including Tuition & Prog. Taxes	3	7	15			
1960	No Taxes or Tuition	7	13	25	5	11	25
	Including Tuition Costs	6	11	21	5	9	18
	Including Tuition & Flat Taxes	6	11	20	4	8	17
	Including Tuition & Prog. Taxes	6	10	19	4	8	15
1970	No Taxes or Tuition	7	13	24	9	14	23
	Including Tuition Costs	6	12	20	7	12	18
	Including Tuition & Flat Taxes	6	11	20	7	11	17
	Including Tuition & Prog. Taxes	5	10	18	7	10	16
1980	No Taxes or Tuition	5	11	21	8	16	31
	Including Tuition Costs	4	10	18	7	13	24
	Including Tuition & Flat Taxes	4	9	17	6	12	21
	Including Tuition & Prog. Taxes	4	8	15	6	11	20
1990	No Taxes or Tuition	10	16	26	18	25	35
	Including Tuition Costs	9	14	20	14	18	25
	Including Tuition & Flat Taxes	8	13	19	13	17	22
	Including Tuition & Prog. Taxes	8	12	18	13	17	22
2000	No Taxes or Tuition	11	18	29	19	24	31
	Including Tuition Costs	9	14	22	14	18	22
	Including Tuition & Flat Taxes	8	14	20	13	16	21
	Including Tuition & Prog. Taxes	8	13	19	12	16	20

Accounting for college tuitions in the more flexible model makes fall the returns to college by some points, but does not affect trends over time

Further accounting for effects of flat and/or progressive taxes has a little impact on the estimates

Overall, **failure to account for tuitions and taxes leads to an overstatement** of the levels of returns to college but even so, these numbers are higher than the Mincer's estimates

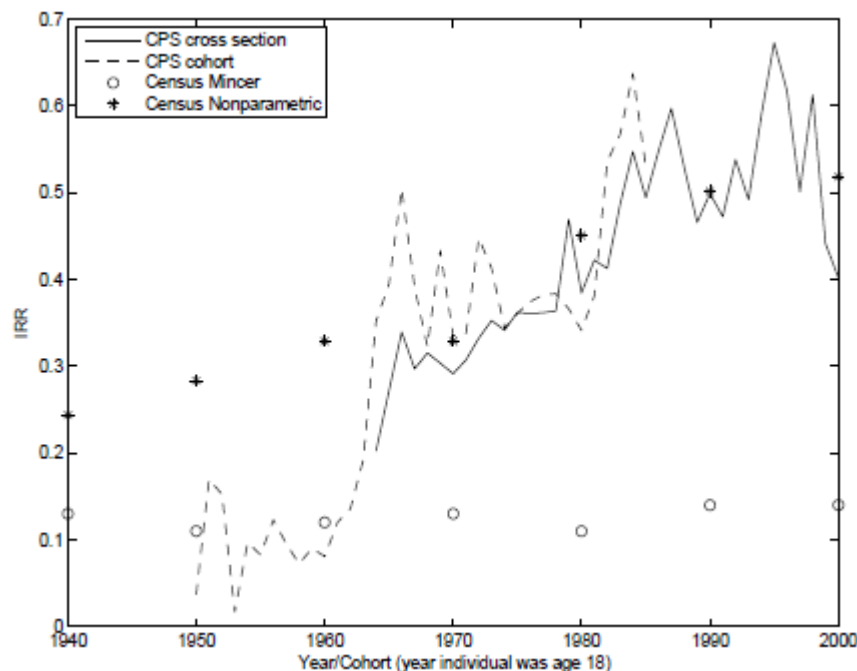
Non stationarity of earnings

- Several studies show that wage patterns have changed dramatically across cohorts so that cross sections no longer approximate life cycle change (MaCurdy and Mroz 1995; Card and Lemieux 2001)
- The authors combined repeated cross section data from the 1964-2006 CPS and the results of their analysis on Census data to **compare IRR estimates for cohorts and cross-sections**, which they expect to be different
- Earning regressions are estimated separately allowing the intercept and the coefficients to vary for each year or for each cohort:

$$\log(w(s, x)) = \alpha_s + \beta_{0s}x + \beta_{1s}x^2 + \varepsilon_s$$

Non stationarity of earnings (2)

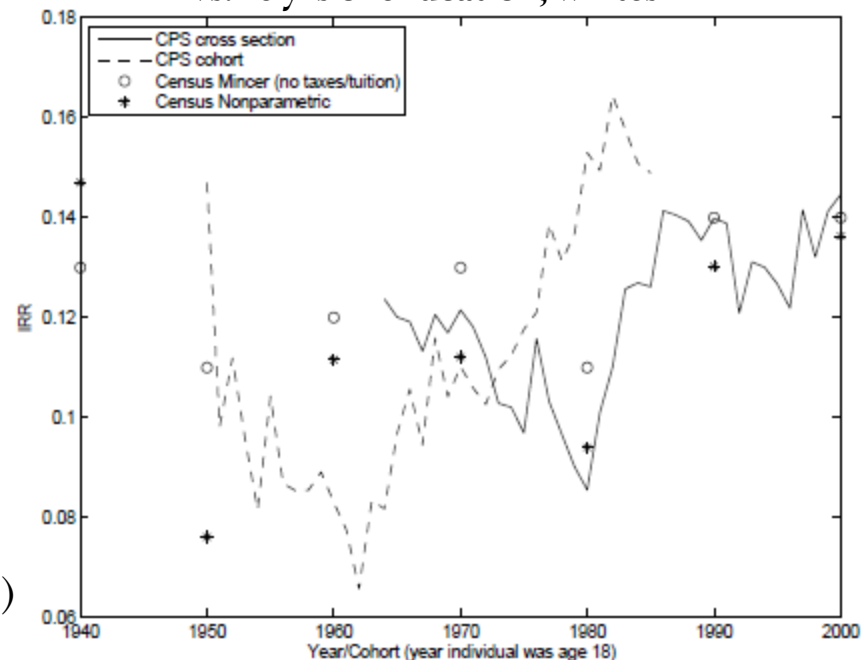
10 vs. 12 yrs of education, whites



Cohort based estimated IRRs for **college** completion continually increase from the 60s til the 80s (severe **cross section bias**)

Cohort and cross section estimated IRRs for **high school** completion are fairly **similar** over most years

12 vs. 16 yrs of education, whites



Perfect certainty on future wages?

- We have mentioned that another key assumption of the Mincer's model is perfect certainty about future earnings streams associated with different educational levels at the time schooling decisions are made
- In a previous paper, the same authors relax this assumption and find out substantially reduced estimates of IRR (see Heckman Lochner and Todd 2003)
- They also propose another estimation strategy allowing for the **sequential resolution of uncertainty** (eg completing high school generates the option to attend college and attending college generates the option to complete it)
- Accounting for **option values** does not allow anymore to compare IRR with the interest rate as a rule for education decisions (a major empirical tool in human capital theory)

Interpreting the results

- The standard representative agent income maximizing model suggests that marginal rates of return should equal the real interest rate faced by students. Yet, non-parametric **estimates of the IRR** to high school and college completion for recent decades are substantially **larger than real interest rates** typically observed. Why?
- Psychic costs of schooling
- Uncertainty about future earnings for risk-adverse agents
 - ➔ *ex ante* \neq *ex post* average rates of return:
the previous govern schooling choices but only the latter are typically estimated
- Time inconsistent preferences, heavy discounting of future utility and credit market constraints may also explain why some individuals drop out before completing a high school degree despite a high internal rate of return

Summary

- Internal rates of return to education are a key concept of economic literature on human capital and are typically estimated as the coefficient to schooling in a Mincerian earning function
- This paper reports empirical evidence against some of the assumptions of this model, i.e. linearity in the earning-education-experience relationship, negligibility of taxes and tuitions, equal length of working life and stability of earnings over time
- The authors do not discuss other assumptions, such as the exogeneity of schooling
- The paper offers an alternative to the Mincer's framework for measuring the returns to schooling
- Both the levels and trends of IRRs estimated via non-parametric methods differ substantially from those obtained by Mincer's model

Conclusions

- The Mincer's model relies on many strong assumptions, which were valid in the period when the model was proposed but do not hold anymore
- Economic literature on human capital has not questioned the validity of these assumptions: as a result, the widely used Mincer's model applied to more recent data led to invalid estimates of returns to schooling
- In particular, the literature has failed to see the increase in the return to graduating from high school and has focused wrongly on documenting and explaining the (far more modest) increase in the returns to college graduation (see Katz and Murphy 1992)
- One possible explanation of the estimates is the failure of the income maximizing concept for schooling decisions (uncertainty environment and option values)

References

Becker G. (1964) *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, New York, Columbia University Press

Mincer J. (1974) *Schooling, Experience and Earnings*, New York, Columbia University Press

Heckman J., Lochner L., Todd P., *Fifty Years of Mincer Earnings Regressions*, IZA DP no. 775, May 2003