

Evidence on Learning-by-doing vs. On-the-job Training:

Using variation induced by the EITC to test between models of skill formation

From James Heckman, Lance Lochner and Ricardo Cossa, in Edmund S. Phelps (ed.), *Designing Inclusion : Tools to Raise Low-end Pay and Employment in Private Enterprise*. Cambridge University Press, 2003, ch. 3.

Econ 350, Winter 2023

Earned Income Tax Credit

- Introduced in 1975.
- Major expansions in 1986, 1990, 1993.
- In 1994, EITC outlays equaled \$21.6 billion and covered about 19.1 million workers.
- From 1990-94, outlays grew by 150% and number of recipients grew by 50%.
- Schedule depends on number of dependent children and wage earnings.

Figure 1
Earned Income Tax Credit

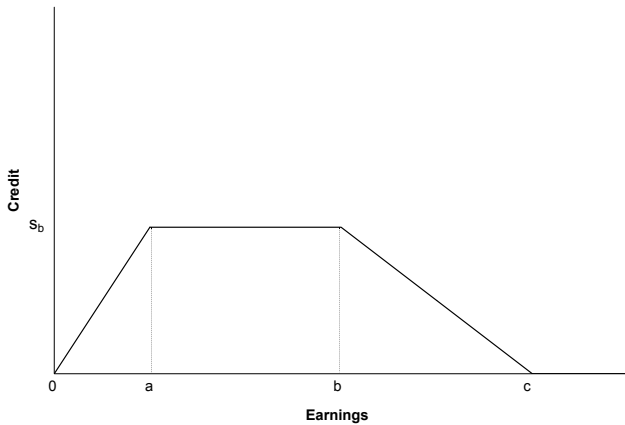


Table 1: Earned Income Tax Credit for 1994

	Families with One Child	Families with Two or More Children	Childless Adults
Phase-in			
Income Range	\$1 - \$7,749	\$1 - \$8,424	\$1 - \$3,999
Phase-in Rate	26.3%	30.0%	7.64%
Plateau			
Income Range	\$7,750 - \$10,999	\$8,425 - \$10,999	\$4,000 - \$4,999
Maximum Credit	\$2,038	\$2,528	\$306
Phase-out			
Income Range	\$11,000 - \$23,754	\$11,000 - \$25,295	\$5,000 - \$8,999
Phase-out Rate	15.98%	17.68%	7.65%

Distribution of Women over the EITC Schedule

- Most qualifying women did not attend college.
- Most qualifying mothers are in the phase-in or phase-out regions.
- Many mothers with high school diplomas do not qualify for the EITC (especially at later ages).
- Single mothers are substantially more likely to be in the phase-in region.
- Women are most likely to be in the phase-in region while young

Table 2: Distribution of Households Qualifying for the EITC

	Percentage by Education Level:				
	<10 yrs	11-12 yrs	HS grad	Some College	College Grad
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No Qualifying Children					
Single Women (36.1%)	9.40	6.98	33.97	33.16	16.48
Single Men (29.8%)	10.05	8.21	32.23	31.25	18.26
Married (34.1%)	18.76	9.11	37.19	18.33	16.61
<hr/>					
One Qualifying Child					
Single Women (36.4%)	5.74	8.38	42.09	36.72	7.06
Single Men (8.2%)	9.21	10.04	47.70	26.36	6.69
Married (55.4%)	15.21	10.20	39.95	22.94	11.69
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Two or More Qualifying Children					
Single Women (23.3%)	8.06	11.65	38.25	33.69	8.35
Single Men (3.5%)	11.54	12.82	42.31	25.00	8.33
Married (73.1%)	17.79	9.14	38.02	23.77	11.28

**Table 5: Estimated Life-Cycle Progression Through the EITC Schedule
(OJT Simulations Based on 1994 EITC Schedule for Two Children)**

	Initial EITC Region	Final EITC Region
Whites		
< 10 Years of School	phase-in/plateau kink	plateau
10-11 Years of School	phase-in	phase-out
12 Years of School	plateau	plateau/phase-out kink
Non-Whites		
< 10 Years of School	phase-in	phase-in/plateau kink
10-11 Years of School	phase-in	plateau
12 Years of School	plateau	phase-out

Parameterizing the Model

- Individuals live for 10 periods (5 years each corresponding to ages 18-67)
- Perfect credit markets with interest rate r
- Preferences:

$$V(H, K) = \max_{C, L} \left\{ \frac{C^{\gamma+1}}{\gamma+1} + \psi \frac{L^{\sigma+1}}{\sigma+1} + \delta V'(H', K') \right\}$$

- OJT technology: $H_{t+1} = H_t + B(I_t H_t)^\alpha$
- LBD technology: $H_{t+1} = H_0 + \beta_0 X + \beta_1 X^2$ where $X = \sum_{s=1}^{t-1} (1 - L_s)$ represents total experience

- Estimate leisure preference and human capital production parameters, Θ , using synthetic cohorts from CPS in 1980 (pre-EITC) assuming $r = 0.61, \gamma = -0.9, \delta = 0.62$
- For each type of worker, choose Θ to minimize

$$\sum_{i=1}^n \sum_{t=1}^{10} [W_t^w (w_{i,t} - w_t(\Theta))^2 + W_t^h (h_{i,t} - h_t(\Theta))^2]$$

Difficulties in Empirical Estimation

- Child requirements: individuals typically covered for only 20-30 years. Alters marginal returns depending on whether individuals are on phase-out or phase-in region of the schedule when children become too old to qualify.
- Consider tax schedule, TANF, and food stamps and changes over time.
- Full schedule can be regressive in some regions (non-convex budget set).
- More recent data on earnings and hours worked must account for these schedules.

Table D-1: Parameter Values for the OJT Model

	ψ	σ	B	α	H_0
Whites					
< 10 Years of School	0.8901	-5.3879	0.8558	0.6015	3.4585
10-11 Years of School	0.8971	-6.4344	0.7270	0.3122	3.1871
12 Years of School	0.8947	-5.0882	1.8262	0.8473	4.1736
Non-Whites					
< 10 Years of School	0.7751	-6.4974	0.9285	0.6098	3.2512
10-11 Years of School	0.8907	-6.0751	0.9656	0.5064	2.9811
12 Years of School	0.5194	-6.3269	1.3129	0.6186	3.9263

Table D-2: Parameter Values for the LBD Model

	ψ	σ	H_0	β_0	β_1
Whites					
< 10 Years of School	0.9555	-5.1475	3.0491	1.2586	-0.4397
10-11 Years of School	3.0723	-1.3047	3.6451	1.2862	-0.3928
12 Years of School	1.9320	-2.5976	3.8051	1.5468	-0.4592
Non-Whites					
< 10 Years of School	1.5521	-4.8080	2.8516	1.0161	-0.3479
10-11 Years of School	2.8638	-1.1183	3.4269	1.0245	-0.3375
12 Years of School	2.8248	-1.3371	3.6644	1.7231	-0.5218

Table D-3: Goodness of Fit (OJT Model)
Weighted Sum of Squared Differences

	Wages	Hours	Total
Whites			
< 10 Years of School	16.34	74.86	91.20
10-11 Years of School	63.97	201.01	264.98
12 Years of School	150.16	134.43	284.59
Non-Whites			
< 10 Years of School	8.92	24.92	33.84
10-11 Years of School	46.11	93.95	140.06
12 Years of School	49.00	96.13	145.13

**Table D-4: Goodness of Fit (LBD Model)
Weighted Sum of Squared Differences**

	Wages	Hours	Total
Whites			
< 10 Years of School	18.04	78.06	96.10
10-11 Years of School	118.15	178.90	297.05
12 Years of School	52.91	91.14	144.05
Non-Whites			
< 10 Years of School	12.13	36.98	49.11
10-11 Years of School	64.02	114.98	179.00
12 Years of School	19.66	19.93	39.59

Effects of the EITC on Skills

The Intensive Margin

- OJT: Reduces investment for all but the most skilled.
- LBD: Reduces learning for all but the least skilled.

The Extensive Margin

- Encourages employment and, therefore, skills in both models.

Balancing Intensive and Extensive Margin

- Generally observe declines at the intensive margin.
- Increase in skills at extensive margin.
- OJT predicts net declines in potential (H) and utilized skills ($H(1 - I - L)$).
- LBD predicts net increases in potential (H) and declines in utilized skills ($H(1 - L)$).

Effects at the Intensive Margin

OJT Model:

- Large declines in l .
- Small initial hours effects, but greater long-term declines.
- Wage profiles flatten considerably.
- Sizeable increases in net lifetime earnings from EITC supplement.

Table 6: Effects of EITC (OJT Model)

	% Change in PV of Earnings	Change in PV of Earnings (thousands of dollars)	PV of received subsidies
Whites			
< 10 Years of School	-6.32	-4.68	20.61
10-11 Years of School	-1.97	-1.29	18.91
12 Years of School	-9.25	-8.65	20.61
Non-Whites			
< 10 Years of School	-0.13	-0.09	19.69
10-11 Years of School	-0.79	-0.49	18.26
12 Years of School	-8.68	-8.29	20.30

Figure 2: Simulated Effects of EITC on Investment (OJT model)

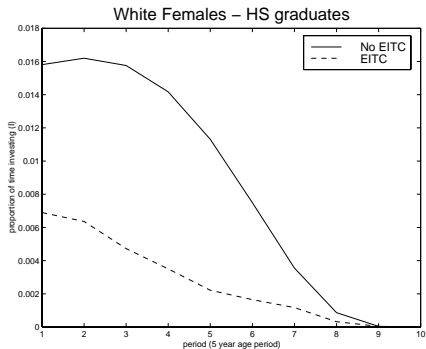
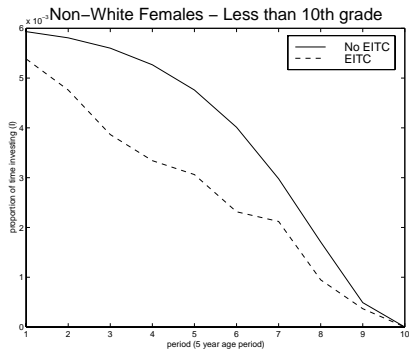


Figure 3: Simulated Effects of EITC on Hours Worked (OJT model)

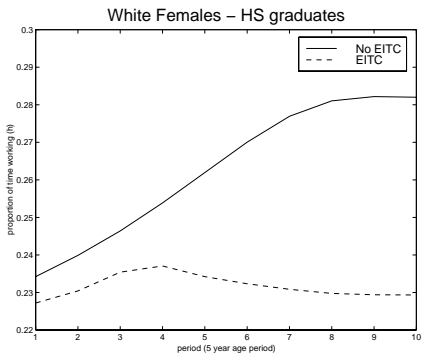
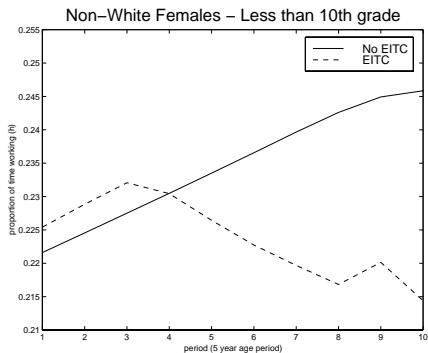


Figure 4: Simulated Effects of EITC on Human Capital (OJT model)

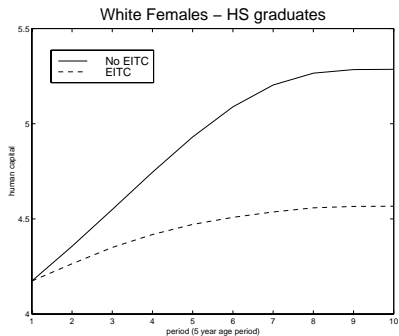
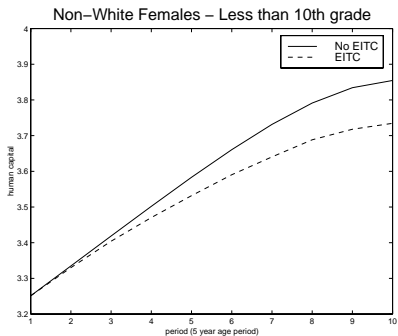


Figure 5: Simulated Effects of EITC on Wage Rates (OJT model)

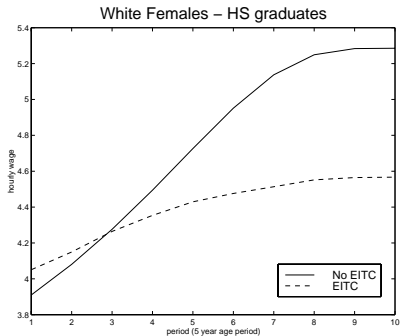
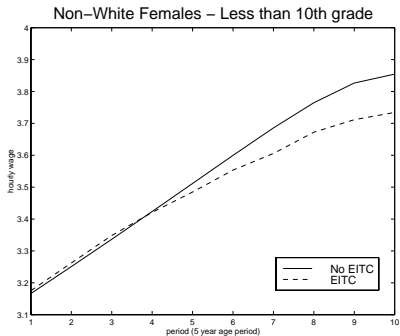


Figure 6: Simulated Effects of EITC on Wage Income (OJT model)

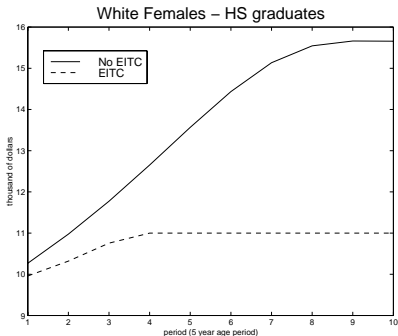
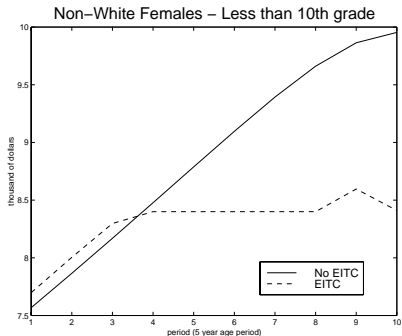


Table 7: Annual Compensation (in thousand of dollars) Necessary to Make People Indifferent between Employment and Unemployment (OJT Simulations Based on 1994 EITC Schedule for Two Children)

	without EITC	with EITC
Whites		
< 10 Years of School	5.40	5.39
10-11 Years of School	4.84	4.79
12 Years of School	6.70	6.69
Non-Whites		
< 10 Years of School	4.95	4.95
10-11 Years of School	4.49	4.47
12 Years of School	7.52	7.48

**Table 8: Employment Rates and Average Human Capital Levels
(OJT Simulations Based on 1994 EITC Schedule for Two Children)**

	% of Population	Employment Rate	Average Human Capital	Average Supplied HC
Whites				
< 10 Years of School	3.27	41.88	1.59	0.40
10-11 Years of School	2.80	54.80	2.32	0.55
12 Years of School	15.86	72.83	3.56	0.94
Non-Whites				
< 10 Years of School	0.74	37.61	1.35	0.32
10-11 Years of School	0.87	45.83	1.71	0.41
12 Years of School	3.01	68.19	3.42	0.96

Note: Human capital averages (both potential and supplied) are lifetime averages of levels obtained in the simulations for each group, assuming an equal distribution of workers across all age groups. They are inclusive of non-workers who we assume have potential skill levels equal to H_0 and supply zero skills to the market.

**Table 9: Effects of EITC on Potential Skill Levels
(OJT Simulations Based on 1994 EITC Schedule for Two Children)**

	Difference in Average HC between Workers and Non-Workers		Change in Average HC Due to Changes in:				
	1%	3%	Extensive Margin (entry) (Increase in Employment)			Intensive Margin (those who work with or without EITC) Unweighted (by employment rate)	
	(1)	(2)	(3)	5% (4)	7% (5)	(6)	Weighted (7)
Whites							
< 10 Years of School	0.2765	0.0028	0.0083	0.0138	0.0194	-0.0518	-0.0217
10-11 Years of School	0.9527	0.0095	0.0286	0.0476	0.0667	-0.0977	-0.0535
12 Years of School	0.2675	0.0027	0.0080	0.0134	0.0187	-0.4471	-0.3256
Non-Whites							
< 10 Years of School	0.2847	0.0028	0.0085	0.0142	0.0199	-0.0603	-0.0227
10-11 Years of School	0.6368	0.0064	0.0191	0.0318	0.0446	-0.1144	-0.0524
12 Years of School	0.7835	0.0078	0.0235	0.0392	0.0548	-0.3095	-0.2110
			Average Human Capital (no EITC)	1%	3%	5%	7%
Net Effects on Average Human Capital for All Less-Educated Women			3.0485	-0.2250	-0.2167	-0.2085	-0.2003

Note: Human capital averages are lifetime averages of levels obtained in the simulations for each group, assuming an equal distribution of workers across all age groups. They are inclusive of non-workers who we assume have potential skill levels equal to H_0 .

The values assumed for increase in employment denote percentage points of increase.

**Table 10: Effects of EITC on Skills Supplied to the Market
(OJT Simulations Based on 1994 EITC Schedule for Two Children)**

	Difference in Avg Supplied HC between Workers and Non-Workers		Change in Average Supplied HC Due to Changes in:				
	(1)	(2)	Extensive Margin (entry) (Increase in Employment)				Intensive Margin (those who work with or without EITC)
1%			3%	5%	7%	Unweighted (by employment rate)	Weighted
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whites							
< 10 Years of School	0.8558	0.0086	0.0257	0.0428	0.0599	-0.0919	-0.0385
10-11 Years of School	0.8893	0.0089	0.0267	0.0445	0.0622	-0.1225	-0.0671
12 Years of School	1.0286	0.0103	0.0309	0.0514	0.0720	-0.2631	-0.1916
Non-Whites							
< 10 Years of School	0.7903	0.0079	0.0237	0.0395	0.0553	-0.0555	-0.0209
10-11 Years of School	0.8105	0.0081	0.0243	0.0405	0.0567	-0.0909	-0.0416
12 Years of School	1.1659	0.0117	0.0350	0.0583	0.0816	-0.2427	-0.1655
			Average Supplied HC (no EITC)		1%	(Increase in Employment)	
					3%	5%	7%
Net Effects on Average Human Capital for All Less-Educated Women			0.8000	-0.1370	-0.1172	-0.0973	-0.0774

Note: Supplied human capital averages are lifetime averages of levels obtained in the simulations for each group, assuming an equal distribution of workers across all age groups. They are inclusive of non-workers who we assume have potential skill levels equal to H_0 and supply zero skills to the market.

The values assumed for increase in employment denote percentage points of increase.

LBD Model:

- Large declines in hours for HS grads, but small increases for non-white dropouts.
- Large decline in skills among HS grads, but negligible changes for dropouts.
- Wage profiles flatten for HS grads.
- Smaller (than with OJT) but sizeable increases in net lifetime earnings from EITC supplement.

**Table 11: Estimated Life-Cycle Progression Through the EITC Schedule
(LBD Simulations Based on 1994 EITC Schedule for Two Children)**

	Initial EITC Region	Final EITC Region
Whites		
< 10 Years of School	phase-in	plateau
10-11 Years of School	phase-in/plateau kink	phase-out
12 Years of School	plateau	phase-out
Non-Whites		
< 10 Years of School	phase-in	phase-in
10-11 Years of School	phase-in/plateau kink	plateau
12 Years of School	phase-in plateau kink	plateau/phase-out kink

Figure 7: Simulated Effects of EITC on Hours Worked (LBD model)

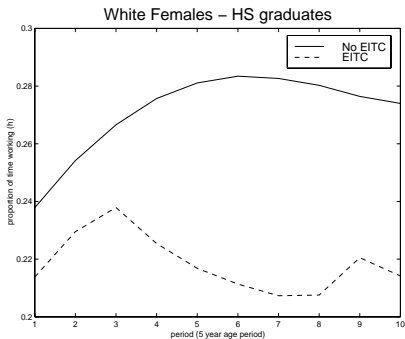
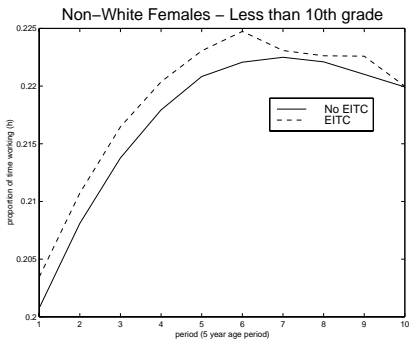


Figure 8: Simulated Effects of EITC on Human Capital (LBD model)

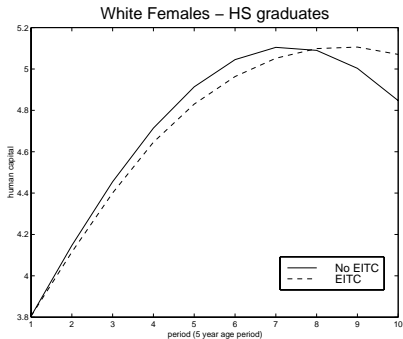
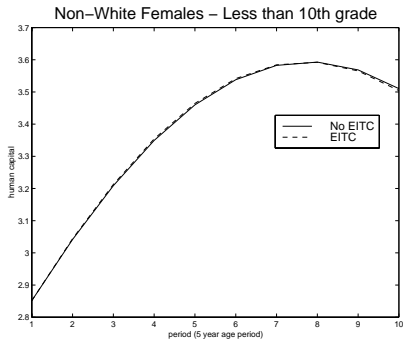


Figure 10: Simulated Effects of EITC on Wage Income (LBD model)

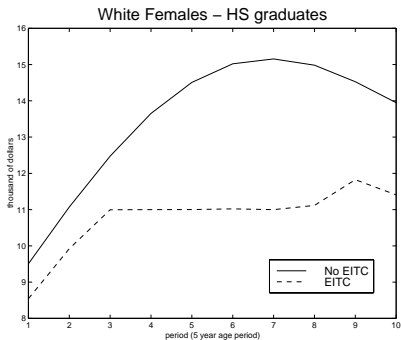
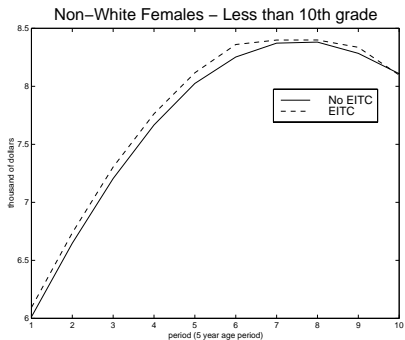


Table 12: Effects of EITC when Imposed (LBD Model)

	% Change in PV of Earnings	Change in PV of Earnings (thousands of dollars)	PV of received subsidies
Whites			
< 10 Years of School	-4.34	-3.12	20.18
10-11 Years of School	-12.71	-10.38	20.59
12 Years of School	-14.20	-13.25	20.60
Non-Whites			
< 10 Years of School	1.26	0.70	16.90
10-11 Years of School	-13.30	-10.91	20.61
12 Years of School	-15.26	-13.87	20.58

Table 13: Annual Compensation (in thousand of dollars) Necessary to Make People Indifferent between Employment and Unemployment (LBD Simulations Based on 1994 EITC Schedule for Two Children)

	without EITC	with EITC
<hr/>		
Whites		
< 10 Years of School	5.10	5.08
10-11 Years of School	4.01	3.98
12 Years of School	5.39	5.36
Non-Whites		
< 10 Years of School	3.61	3.59
10-11 Years of School	4.03	4.02
12 Years of School	4.50	4.45

**Table 14: Employment Rates and Average Human Capital Levels
(LBD Simulations Based on 1994 EITC Schedule for Two Children)**

	% of Population	Employment Rate	Average Human Capital	Average Supplied HC
Whites				
< 10 Years of School	3.27	41.88	1.54	0.39
10-11 Years of School	2.80	54.80	2.39	0.64
12 Years of School	15.86	72.83	3.43	0.94
Non-Whites				
< 10 Years of School	0.74	37.61	1.27	0.28
10-11 Years of School	0.87	45.83	1.81	0.50
12 Years of School	3.01	68.19	3.16	0.90

Note: Human capital averages (both potential and supplied) are lifetime averages of levels obtained in the simulations for each group, assuming an equal distribution of workers across all age groups. They are inclusive of non-workers who we assume have potential skill levels equal to H_0 and supply zero skills to the market.

Table 15: Effects of EITC on Potential Skill Levels
(LBD Simulations Based on 1994 EITC Schedule for Two Children)

	Difference in Average HC between Workers and Non-Workers		Change in Average HC Due to Changes in:				
	1%	3%	Extensive Margin (entry) (Increase in Employment)		Intensive Margin (those who work with or without EITC) Unweighted Weighted (by employment rate)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whites							
< 10 Years of School	0.6441	0.0064	0.0193	0.0322	0.0451	0.0186	0.0078
10-11 Years of School	0.7197	0.0072	0.0216	0.0360	0.0504	-0.0015	-0.0008
12 Years of School	0.9035	0.0090	0.0271	0.0452	0.0632	-0.0039	-0.0028
Non-Whites							
< 10 Years of School	0.5198	0.0052	0.0156	0.0260	0.0364	0.0011	0.0004
10-11 Years of School	0.5485	0.0055	0.0165	0.0274	0.0384	0.0219	0.0100
12 Years of School	0.9857	0.0099	0.0296	0.0493	0.0690	0.0194	0.0132
			Average Human Capital (no EITC)		Average (Increase in Employment)		
				1%	3%	5%	7%
Net Effects on Average Human Capital for All Less-Educated Women			2.9436	0.0094	0.0262	0.0430	0.0598

Note: Human capital averages are lifetime averages of levels obtained in the simulations for each group, assuming an equal distribution of workers across all age groups. They are inclusive of non-workers who we assume have potential skill levels equal to H_0 .

The values assumed for increase in employment denote percentage points of increase.

**Table 16: Effects of EITC on Skills Supplied to the Market
(LBD Simulations Based on 1994 EITC Schedule for Two Children)**

	Difference in Avg Supplied HC between Workers and Non-Workers (1)	Change in Average Supplied HC Due to Changes in:					
		Extensive Margin (entry) (Increase in Employment)				Intensive Margin (those who work with or without EITC)	
		1%	3%	5%	7%	Unweighted (by employment rate)	Weighted (by employment rate)
		(2)	(3)	(4)	(5)	(6)	(7)
Whites							
< 10 Years of School	0.8558	0.0086	0.0257	0.0428	0.0599	-0.0762	-0.0319
10-11 Years of School	0.9450	0.0094	0.0283	0.0472	0.0661	-0.2183	-0.1196
12 Years of School	1.0266	0.0103	0.0308	0.0513	0.0719	-0.2572	-0.1874
Non-Whites							
< 10 Years of School	0.7389	0.0074	0.0222	0.0369	0.0517	0.0062	0.0023
10-11 Years of School	0.9109	0.0091	0.0273	0.0455	0.0638	-0.1762	-0.0807
12 Years of School	1.0186	0.0102	0.0306	0.0509	0.0713	-0.3025	-0.2063
		Average Supplied HC (no EITC)		(Increase in Employment)			
			1%	3%	5%	7%	
Net Effects on Average Human Capital for All Less-Educated Women			0.8033	-0.1446	-0.1249	-0.1052	-0.0855

Note: Supplied human capital averages are lifetime averages of levels obtained in the simulations for each group, assuming an equal distribution of workers across all age groups. They are inclusive of non-workers who we assume have potential skill levels equal to H_0 and supply zero skills to the market.

The values assumed for increase in employment denote percentage points of increase.

Summary

- Standard models of skill formation yield similar lifecycle patterns for wages and hours.
- Those models yield quite different predictions of individual responses to wage subsidy policies among workers.
- Responses differ based on worker skill levels and age.
- Small average effects can mask greater individual effects.
- Both models predict increases in skills from increased employment.
- Effects on skills at intensive and extensive margin are of the same order of magnitude, but on net, reductions at intensive margin tend to dominate.

Determining the True Skill Formation Process

- In steady state, cannot identify true model from lifecycle wage and hours worked profiles.
- Can we use individual responses to changes in the EITC to determine the dominant method of skill formation?

- Consider a difference in differences approach comparing women with and without children before and after an EITC expansion:
 - Similar trends?
 - Interaction of child constraints and schedule
 - Heterogeneous responses expected depending on skill level and age
 - Other tax/welfare changes?
 - Changes are relatively recent have responses kicked in?
 - Changes at extensive margin need to be accounted for (heterogeneity)