Search, Matching and Training

Chris Flinn[1] Ahu Gemici[2] Steven Laufer [3]

[1]NYU [2]Royal Holloway [3]Federal Reserve Board

Human Capital and Inequality Conference
University of Chicago
December 16, 2015

Views expressed are those of the presenter and not necessarily those of the Board of Governors or others within the Federal Reserve System.

Motivation

Fact 1: Wage changes within and across job spells are important for understanding sources of wage inequality.

Annual Wage Growth

	HS	Some College	College or More
Change in log wages between NLSY Interview Dates			
stayers	0.08	0.08	0.09
job switchers	0.11	0.15	0.20
..... job switchers with nonemployment spell	0.06	0.06	0.23
..... job switchers with no nonemployment spell	0.12	0.17	0.20

Job Transition Probabilities

Motivation

Fact 2: Employed workers build human capital by training on the job.

Incidence of Training

	All	HS	Some College	College or More
% who got training at least once	15%	18 %	13 %	13%
% who got training at the start of job spell	6%	10 %	5 %	3%

Types of Training

This Paper

- We analyze the role of on-the-job training in human capital accumulation, productivty and wage growth in a noncompetitive setting.
- Build model of search and matching and training
  - Start with standard search model with on-the-job search.
  - Allow for heterogenity in worker ability and quality of match with employers.
  - Workers can improve either general ability or match quality by engaing in on-the-job training, which takes time away from production.
- Estimate model using data on wages, employment transitions and training from NLSY.
- Policy experiment with a $15 per hour minimum wage. Look at effect on training.

Literature Review

- Earlier studies of human capital investment: Becker (1964), Acemoglu and Pischke (1999)
- Models of on-the-job search without investment: Postel-Vinay and Robin (2002), Dey and Flinn (2005), Cahuc et al. (2006)
- Wasmer (2006): More stylized. Characterizes which states choose general or match-specific training
  - We take model to data. Explicitly model time costs of training.
- Bagger et al (2014): Worker and firm heterogeneity. Deterministic growth of general ability.
  - We have match-specfic heterogenity, stochastic evoution of both woker and match-specific heterogeneity.
- Lentz and Roys (2015): General and specific human capital. Contracts that deliver lifetime welfare.
  - We have much simpler contracts. Match paths of observed wages.

Model

- Model is in continuous time.
- Workers have general ability $a \in \{a_1, ..., a_M\}$ with $0 < a_1 < ... < a_M < \infty$
- Initial value of a for a worker with education e_k drawn from disitribution that approximates

$$\log a \sim N(\mu_a(e_k), \sigma_a^2)$$

- Worker meets firm at rate λ_u, she draws $\theta \in \{\theta_1, ..., \theta_K\}$ with $0 < \theta_1 < ... < \theta_K < \infty$
- Distribution $g(\theta)$ approximates

$$log\theta \sim N(\mu_\theta, \sigma_\theta^2)$$

- The flow productivity of the match:

$$y(a_i, \theta_j) = a_i\theta_j - \zeta$$

Model: Training

General ability and match quality can be changed through investment on the job.

- For a worker with $a_i < a_N$ who spends a fraction τ_a of her time in general training, her ability level increases at rate

$$\varphi_a^+(a_i, \tau_a) = \delta_a^0 \cdot (a_i)^{\delta_a^1} \cdot (\tau_a)^{\delta_a^2}$$

- For a worker with $\theta_i < \theta_M$ who spends a fraction τ_θ of her time in match-specific training, the value of the match increases at rate

$$\varphi_\theta^+(\theta_j, \tau_\theta) = \delta_\theta^0 \cdot (\theta_j)^{\delta_\theta^1} \cdot (\tau_\theta)^{\delta_\theta^2}$$

- Training time results in less output: $y(a_i, \theta_j, \tau_a, \tau_\theta) = a_i \theta_j (1 - \tau_a - \tau_\theta) - \zeta$
- Constant depreciation rates. a and θ decrease at rates φ_a^- and φ_θ^-.
- Employed workers receice new offers at rate λ_e with $\theta \sim G$

Model: Unemployed Worker

- Unemployed workers receive flow value ba_i and receive offers at rate λ_u
- Value of continued search for unemployed worker is $V_U(a_i)$, and the value of an unfilled vacancy is 0 to the firm.
- Write value of employed worker as $V_E(a_i, \theta_j)$ or just $V_E(i,j)$
- Value of unemployed worker is

$$V_U(a_i) = \frac{ba_i + \lambda_U \sum_{j=r^*(a_i)+1} p_j V_E(a_i, \theta_j)}{\rho + \lambda_E \tilde{G}(\theta_{r^*(a_i)})}$$

where the critical (index) value $r^*(a_i)$ is defined by

$$\begin{aligned} V_U(a_i) &\geq V_E(a_i, \theta_{r^*(a_i)}) \\ V_U(a_i) &< V_E(a_i, \theta_{r^*(a_i)+1}). \end{aligned}$$

Model: Employed Worker

An employed worker in state (a_i, θ_j) faces the following shocks

1. Increase in ability to state (a_{i+1}, θ_j) at rate $\varphi_a^+(a_i, \tau_a)$
2. Increase in match-quality to state (a_i, θ_{j+1}) at rate $\varphi_\theta^+(\theta_j, \tau_\theta)$
3. Decrease in ability to state (a_{i-1}, θ_j) at rate φ_a^-
4. Decrease in match quality to state (a_i, θ_{j-1}) at rate φ_θ^-
5. Exogenous separation at rate η
6. Receive better outside offer at rate $\lambda_e \cdot \tilde{G}(\theta_{j+1})$

Some shocks may cause worker to separate if unemployment has higher value.

Model: Employed Worker

$$\tilde{V}_E(i,j;w,\tau_a,\tau_\theta) = \frac{N_E(w,\tau_a,\tau_\theta;i,j)}{D(\tau_a,\tau_\theta;i,j)},$$

with numerator

$$N_E(w,\tau_a,\tau_\theta;i,j) = w + \lambda_E \sum_{s=j+1} p_s V_E(i,s) +$$
$$\varphi_a^+(i,\tau_a) Q(i+1,j) + \varphi_\theta^+(j,\tau_\theta) V_E(i,j+1) + \phi_a^-(i) Q(i-1,j) +$$
$$\phi_\theta^-(j) Q(i,j-1) + \eta V_U(a_i)$$

and denominator

$$D(\tau_a,\tau_\theta;i,j) = \rho + \lambda_E \tilde{G}(\theta_j) + \varphi_a^+(i,\tau_a) + \varphi_\theta^+(j,\tau_\theta)$$
$$+\phi_a^-(i) + \phi_\theta^-(j) + \eta$$

where

$$Q(i,j) = \max\{V(i,j), V_U(i)\}$$

Model: Bargaining Problem

Division of the match surplus determined by:

$$\begin{aligned}(w^*(a_i,\theta_j),\tau_a^*(a_i,\theta_j),\tau_\theta^*(a_i,\theta_j)) &= \arg\max_{w,\tau_a,\tau_\theta}\left(V_E - V_U(a_i)\right)^\alpha \times V_F^{1-\alpha} \\ V_E(a_i,\theta_j) &= V_E(a_i,\theta_j; w^*(a_i,\theta_j),\tau_a^*(a_i,\theta_j),\tau_\theta^*(a_i,\theta_j)) \\ V_F(a_i,\theta_j) &= V_F(a_i,\theta_j; w^*(a_i,\theta_j),\tau^*(a_i,\theta_j),\tau_\theta^*(a_i,\theta_j)).\end{aligned}$$

subject to time flow constraints

$$\begin{aligned}1 &\geq \tau_a + \tau_b, \\ \tau_a &\geq 0 \\ \tau_\theta &\geq 0.\end{aligned}$$

- The worker's outside option is unemployment, not best previous job offer.

Data

Data from NLSY 1997

- Sample: Nationally representative sample, males, no military serive, at least HS graduate, after last school enrollment. 1,994 individuals.
- Education: 37% HS graduates, 30% some college, 33% BA or higher
- Employment transitions from weeky employment roster, wage observations from annual interviews
- Training roster to identify workers engaged in training while employed.
- Individuals aged 18-32.

Data: Wage Growth

Annual Log Wage Growth for Job Stayers

	HS	Some College	College or More
2-year job spells	0.08	0.11	0.10
3-year job spells	0.12	0.08	0.08
>3-year job spells	0.10	0.09	0.09

Data: Training and Wage Changes

Annual Log Wage Growth by Training

	No Training	Got Training
stayers	0.08	0.08
job switchers	0.14	0.10
with intervening nonemployment spell	0.08	0.15
with no nonemployment spell	0.15	0.09

Model Estimation

- Method of Simulated Moments
  - Transition rates: E-to-E, E-to-U, U-to-E
  - Distribution of wages by education, years in labor force
  - Distribution of job spell lengths
  - Wages by tenure, job spell length and education
  - Training by education
- Worker who spends fraction of time τ in training is observed to have received training with probability $\Phi(\beta_0 + \beta_1 \tau)$.

Parameter Estimates

$$\varphi_a^+(a_i,\tau_a) = \delta_a^0 \cdot a^{\delta_a^1} \cdot (\tau_a)^{\delta_a^2} \qquad \varphi_\theta^+(a_i,\tau_a) = \delta_\theta^0 \cdot a^{\delta_\theta^1} \cdot (\tau_\theta)^{\delta_\theta^2}$$

PARAMETERS FOR EMPLOYMENT TRANSITIONS		
flow value of unemployment	b	4.93
job offer rate - unemployed	λ_u	0.145
job offer rate - employed	λ_e	0.074
exogenous job separation rate	η	.0033
PARAMETERS OF INVESTMENT FUNCTIONS		
General ability investment TFP	δ_a^0	.0150
Firm-specific investment TFP	δ_θ^0	.0151
State-dependence of general ability investment	δ_a^1	-.050
State-dependence of firm-specific investment	δ_θ^1	.702
Curvature of general ability investment	δ_a^2	.354
Curvature of firm-specific investment	δ_θ^2	.493
Rate of decrease in general ability	$\tilde{\varphi}_a^-$	.0011
Rate of decrease in match quality	$\tilde{\varphi}_\theta^-$	.0144
Employment cost	ζ	4.51

Model Fit

Incidence of Training

	HS	Some College	College or More
% who got training at least once			
..... Data	18 %	13 %	13%
..... Model	20 %	15 %	13%
% who got training at the start of job spell			
..... Data	10 %	5 %	3%
..... Model	5 %	4 %	4%

Model Fit

Annual Log Wage Growth for Job Stayers

	HS	Some College	College or More
2-year job spells			
..... Data	0.08	0.11	0.10
..... Model	0.09	0.09	0.08
3-year job spells			
..... Data	0.12	0.08	0.08
..... Model	0.10	0.08	0.09
$>$ 3-year job spells			
..... Data	0.10	0.09	0.09
..... Model	0.11	0.10	0.10

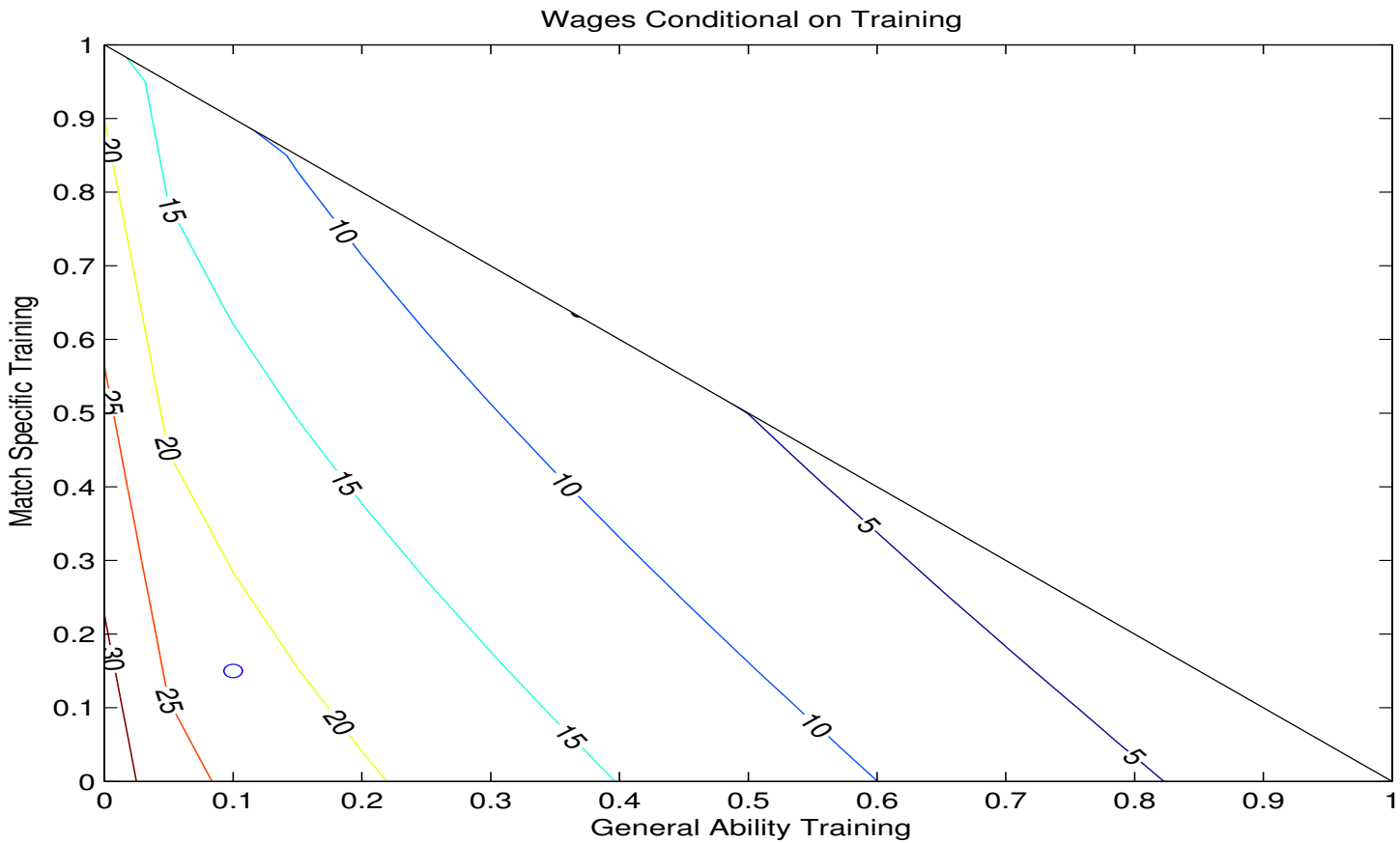
Model Fit

Annual Log Wage Growth for Job Switchers

	HS	Some College	College or More
All switchers			
..... Data	0.11	0.15	0.20
..... Model	0.07	0.11	0.12
with intervening nonemployment spell			
..... Data	0.06	0.06	0.23
..... Model	-0.17	-0.12	-0.08
with no nonemployment spell			
..... Data	0.12	0.17	0.20
..... Model	0.21	0.22	0.22

Model Solution - Policy Functions

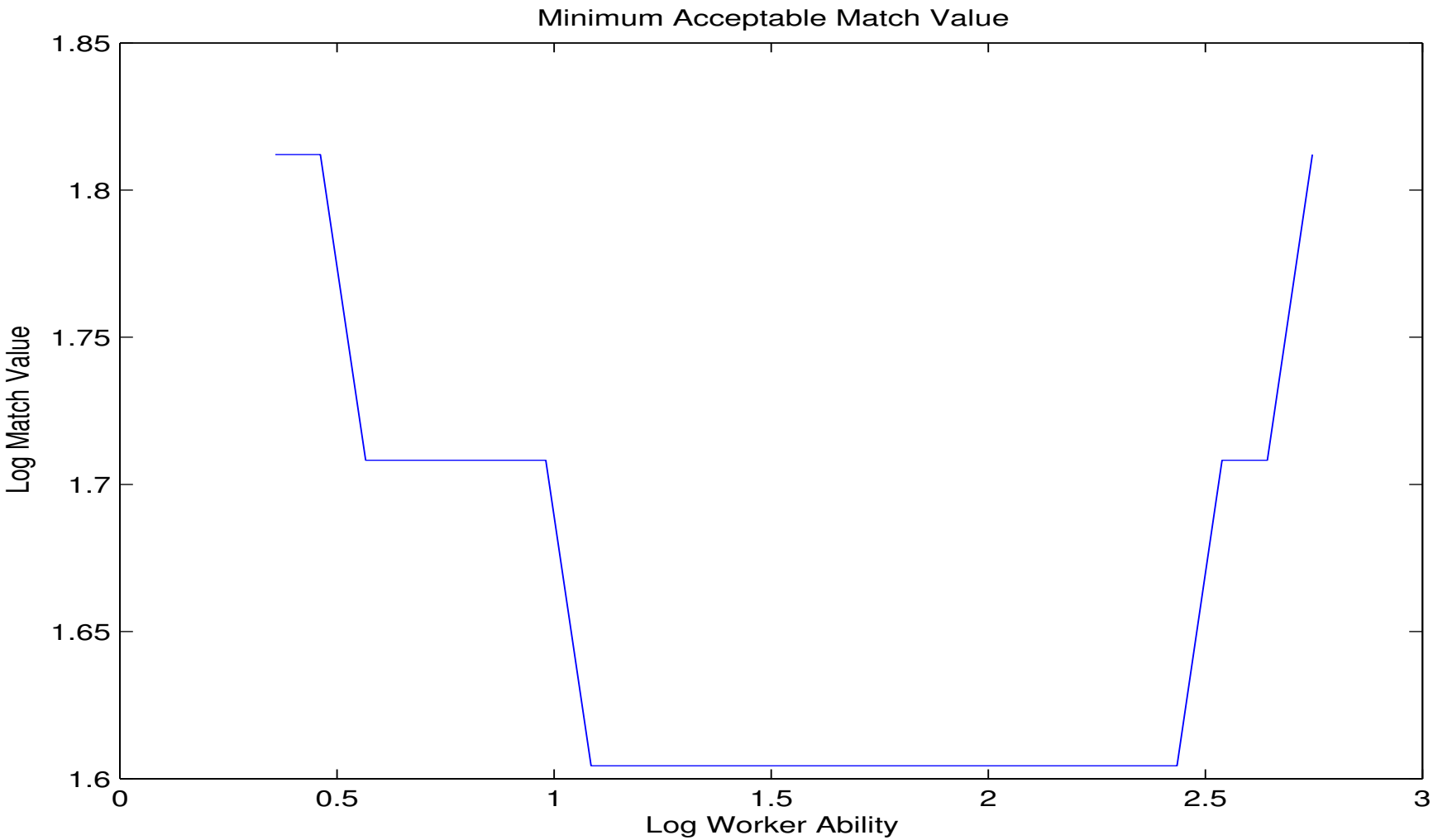
Combinations of training and wages that solve the bargaining problem



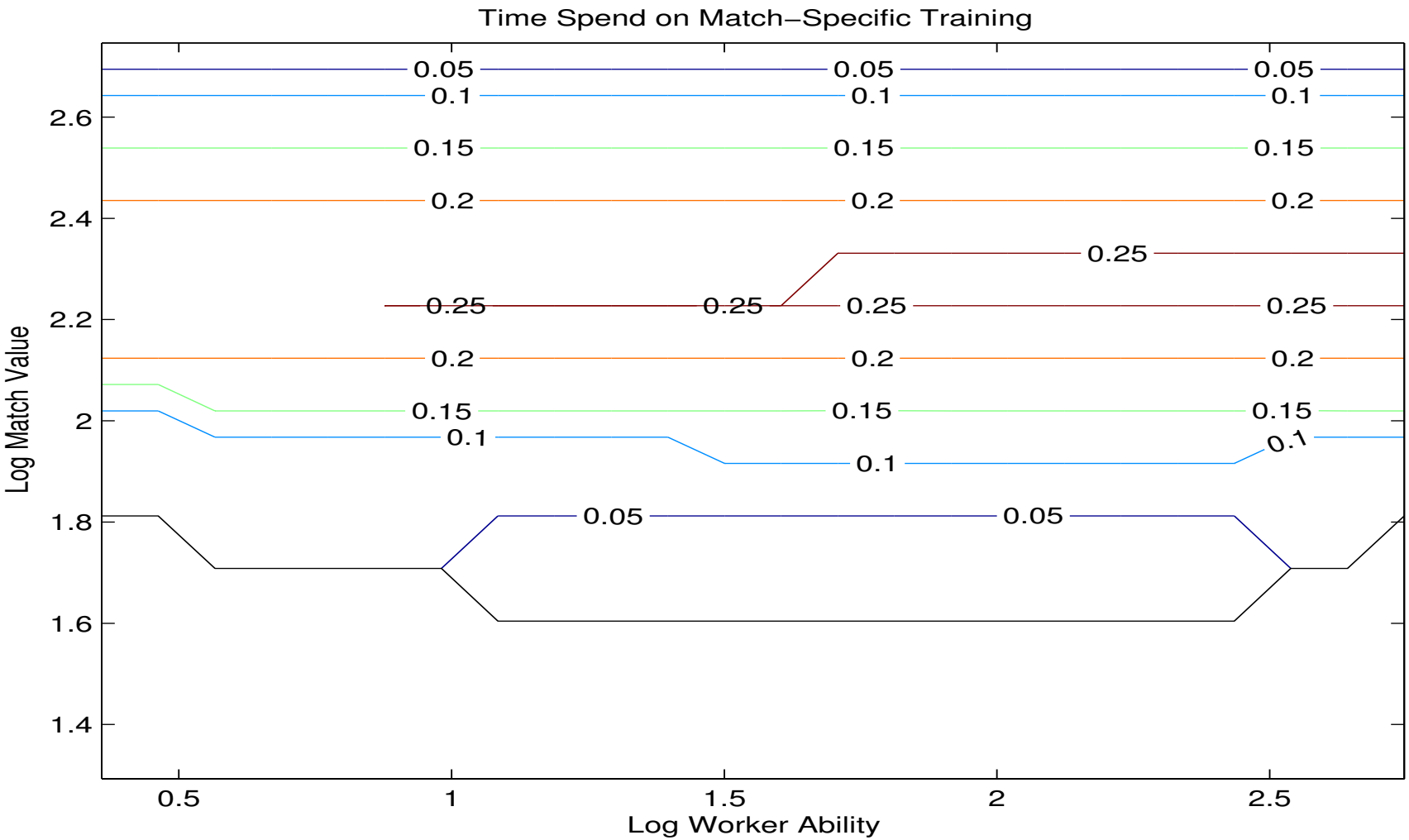
Model Solution - Training

- General Training
  - Increases productivity at current and future jobs.
  - Increases flow value of unemployment.
  - Worker receives most of benefit, bears most of cost.
- Match-specific training
  - Increases productivety at current job.
  - Value increases with expected duration of current job.
  - Decreases probability of better outside offer: benefits employer.
  - Employer bears most of the cost.

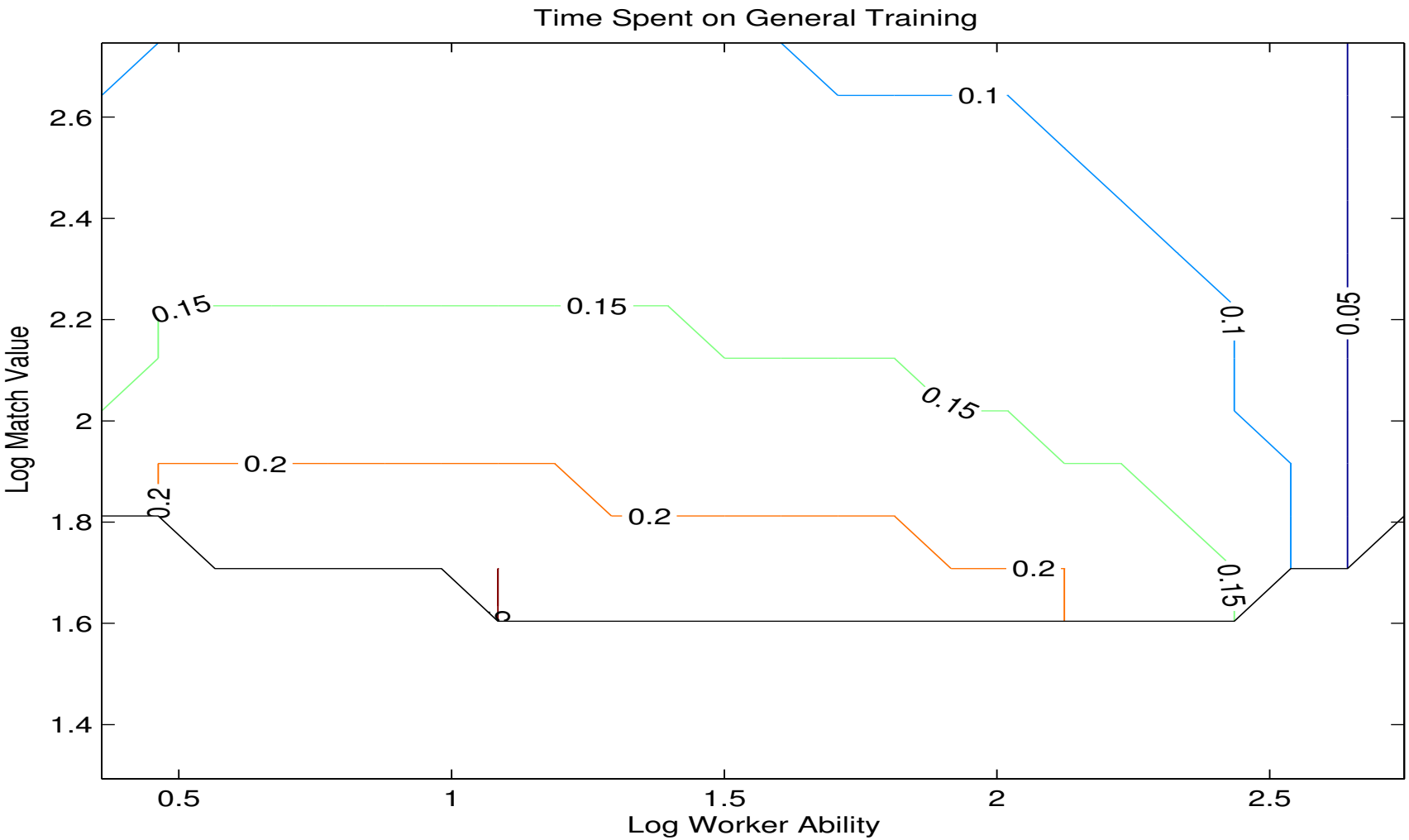
Model Solution - Policy Functions



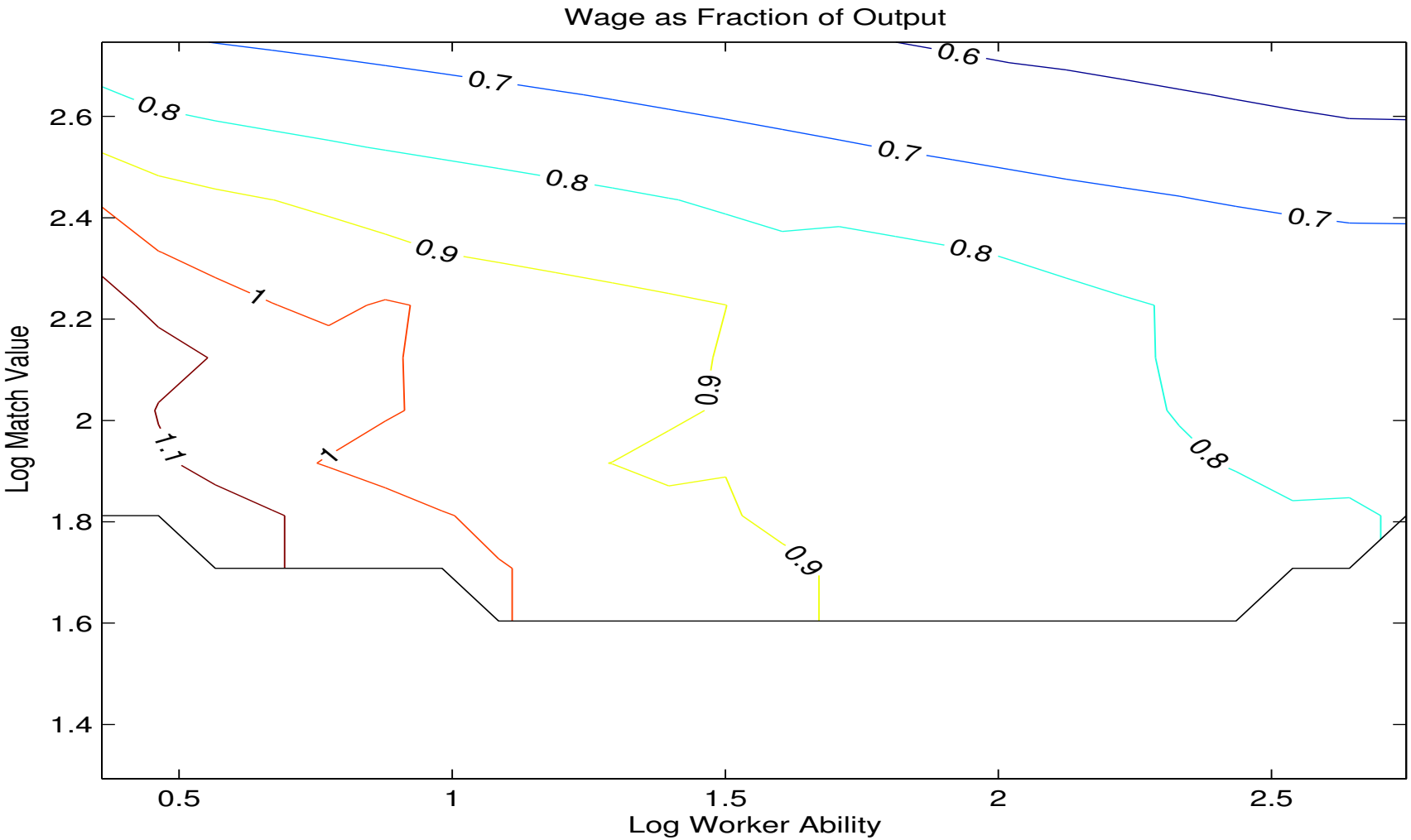
Model Solution - Policy Functions



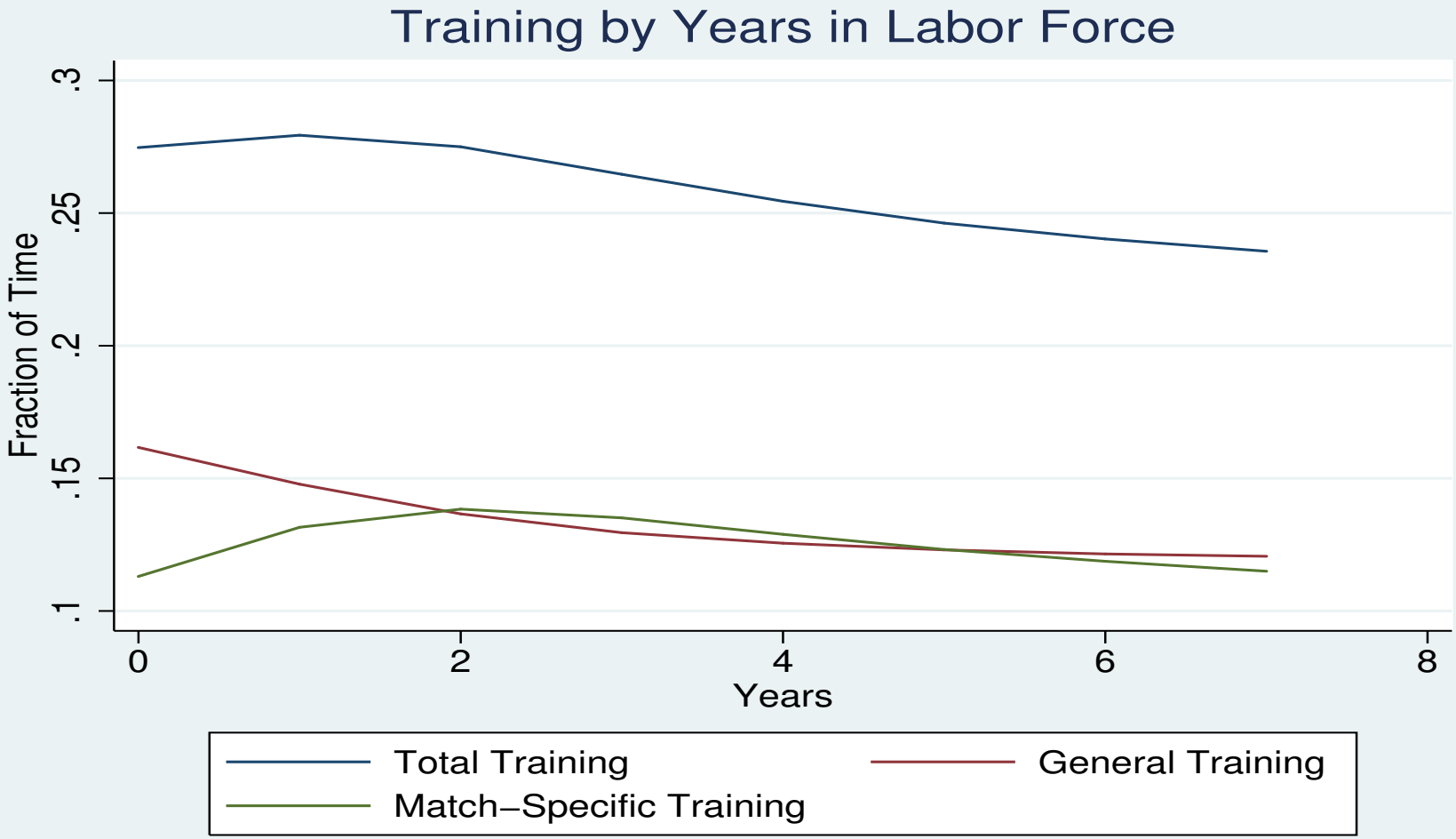
Model Solution - Policy Functions



Model Solution - Policy Functions



Model Simulations - Training



Model Simulations - Wage Growth

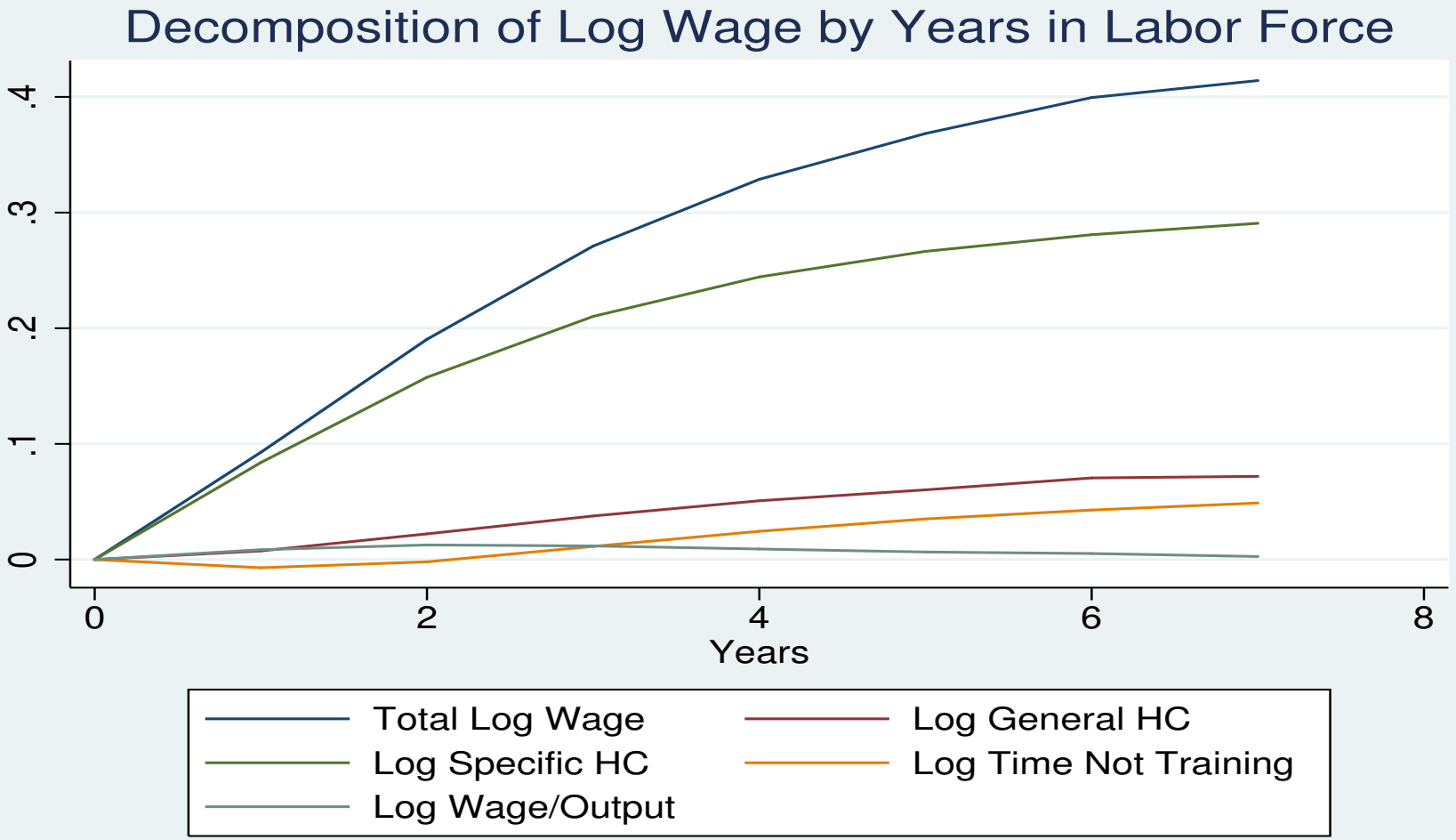
In the absence of employment costs, $y = a \cdot \theta \cdot (1 - \tau_a - \tau_\theta)$ and we could write:

$$w = a \cdot \theta \cdot (1 - \tau_a - \tau_\theta) \cdot (w/y),$$

or in logs,

$$\log(w) = \log(a) + log(\theta) + \log(1 - \tau_a - \tau_\theta) + \log(w/y)$$

Model Simulations - Wage Growth



General and Match-specific Training

- Do we need both general and match-specfic training?
- Estimate model with only general training (a is fixed for each worker)
  - All wage growth comes from changes in θ.
  - Because θ increases more within job spell, less wage growth from job-to-job transitions.
  - Harder to match wage growth across job transitions.
- Estimate model with only match-specific training (θ fixed for each match)
  - All wage growth within job spell comes from changes in a.
  - Current match value doesn't affect productivity of training.
  - Harder to match changes in wage growth and transition rates by length of job spell.

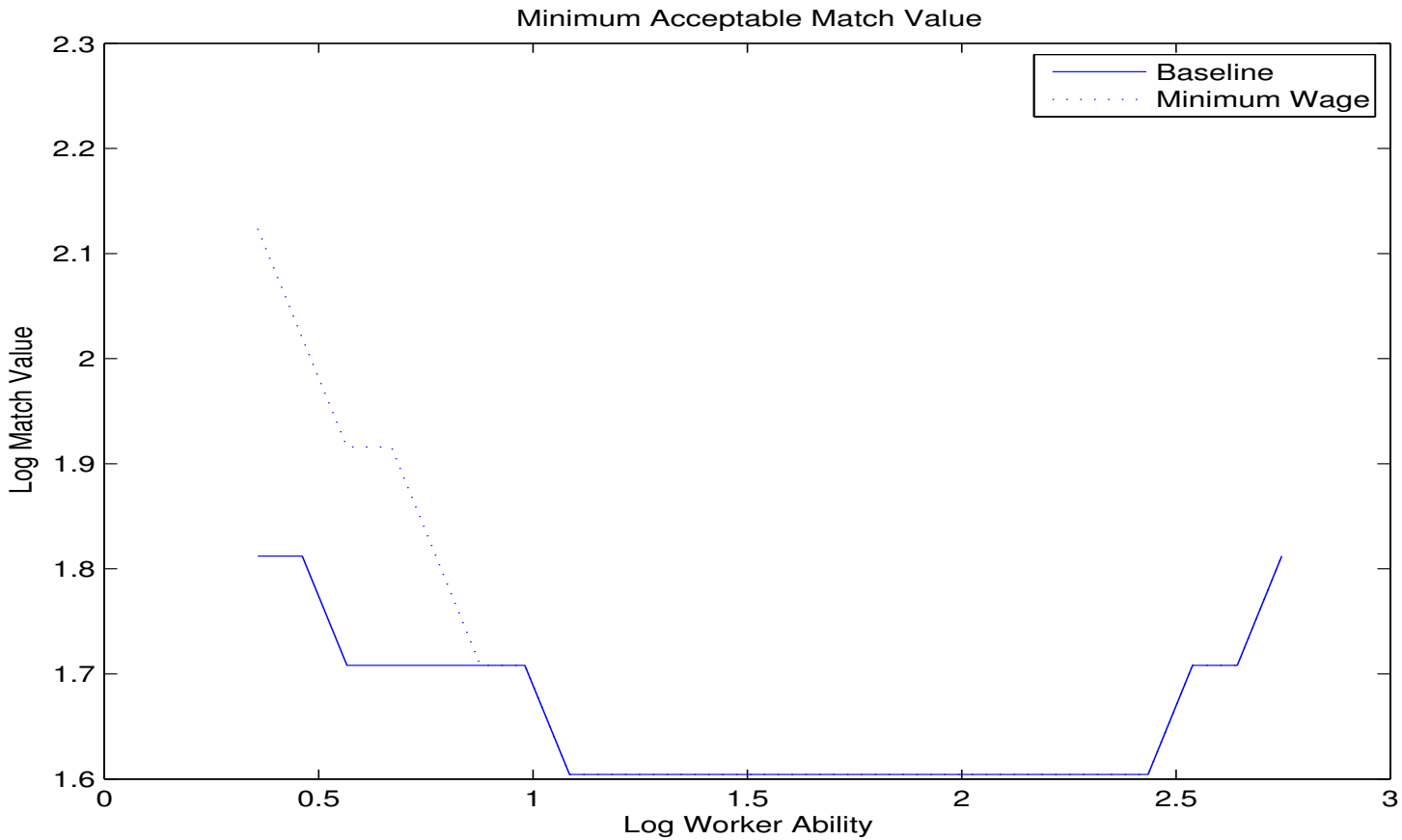
Policy Experiment - Minimum Wage

Impose minimum wage of $ 10.17 (equal to $15 per hour in 2014 dollars).

Policy Experiment - Minimum Wage

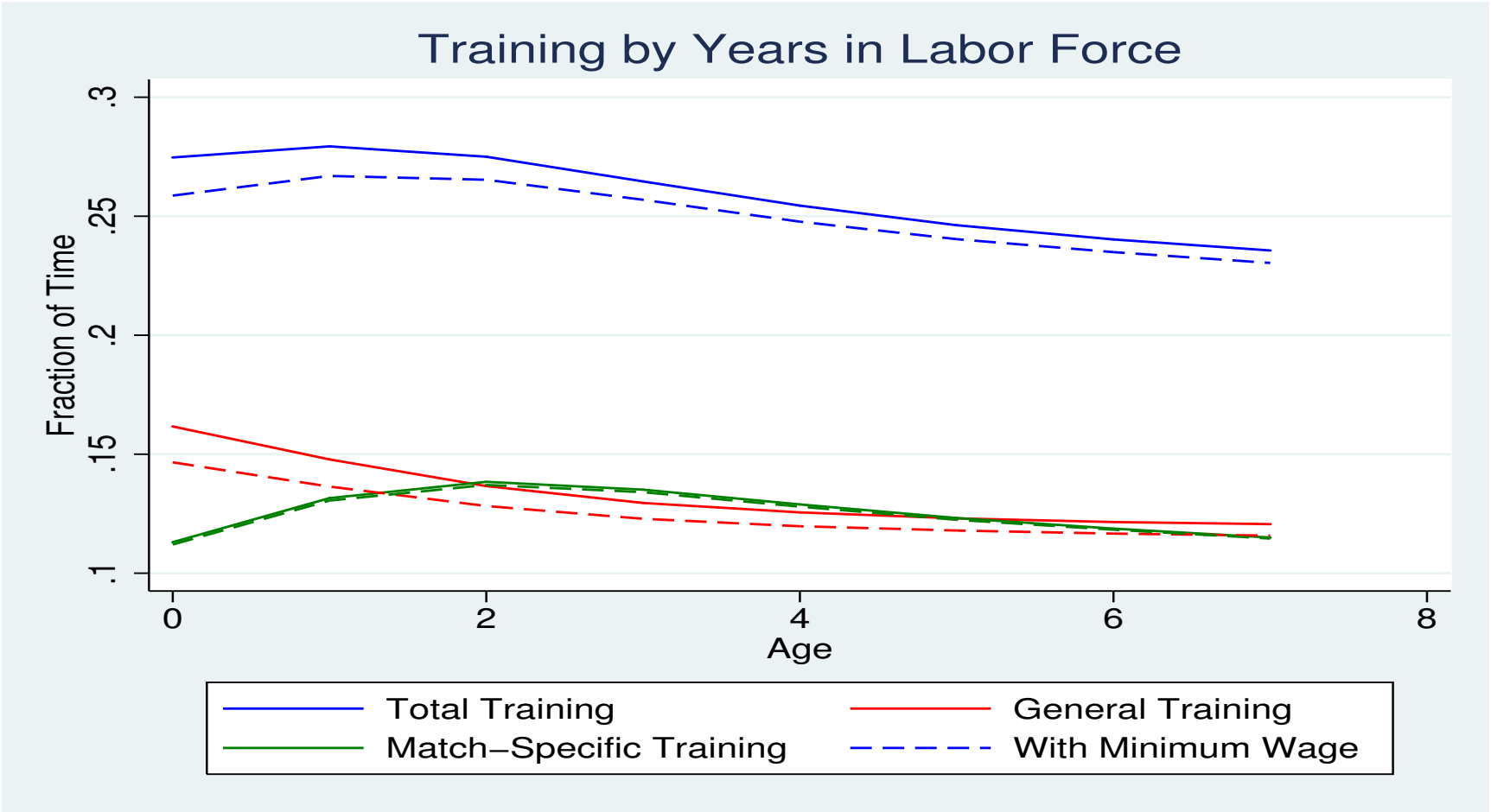
Impose minimum wage of \$ 10.17 (equal to \$15 per hour in 2014 dollars).

- Higher $r^*(a)$ for low a. Higher unemployment.



Policy Experiment - Minimum Wage

- Higher wages substitute for some general training.



Policy Experiment - Minimum Wage

- Wages are 6 percent higher for new workers, 1 1/2 percent higher several years out.
  - Selection into higher match quality
  - Less time training, more output
  - Higher fraction of output given to workers to meet minimum wage.
- Small welfare losses for less educated workers.

Conclusion

- Model needs both general and match-specific training to match observed patterns of wage growth.
- Improvements in match quality important for understading wage growth. Firm has strong incentives to provide match-specific training but firm-specific capital is lost when match disolves.
- Minimum wage increases unemployment, reduces investment in worker ability.

Conclusion

- Model needs both general and match-specific training to match observed patterns of wage growth.
- Improvements in match quality important for understading wage growth. Firm has strong incentives to provide match-specific training but firm-specific capital is lost when match disolves.
- Minimum wage increases unemployment, reduces investment in worker ability.
- Future work:
  - General equilibrium.
  - Explore sensitivty to different definitions of on-the-job training.
  - Include schooling choices together with training in the labor market.

Training Patterns from NLSY 1997

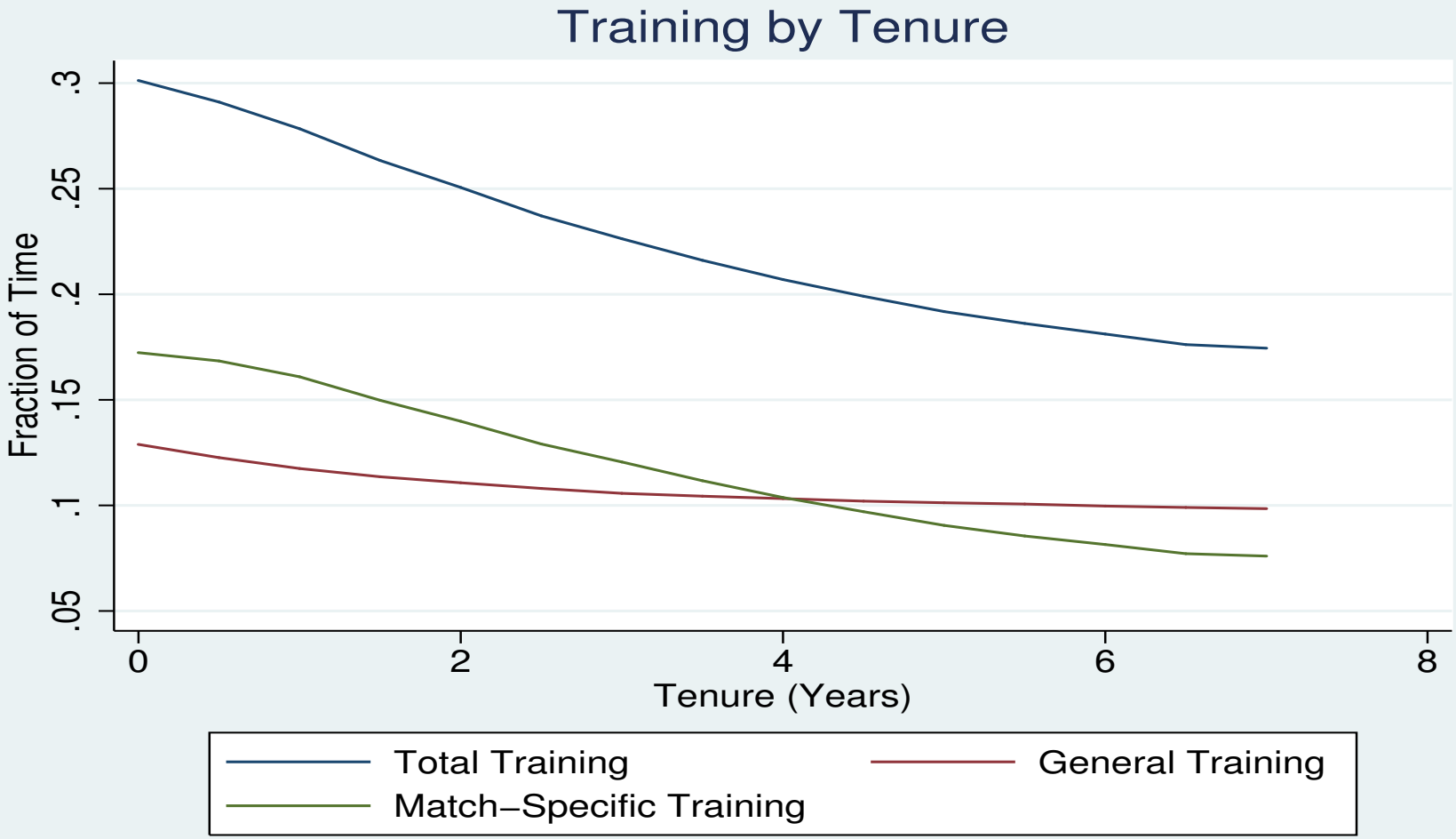
Proportion of Workers in Training by Type of Program

	HS	College
Vocational, technical, or trade	24%	9%
Apprenticeship Program	4%	1%
Formal company training run by employer	32%	44%
Government Training	14%	3%
Seminar or training program at work	6%	14 %
Seminar or training program outside of work	7%	13%

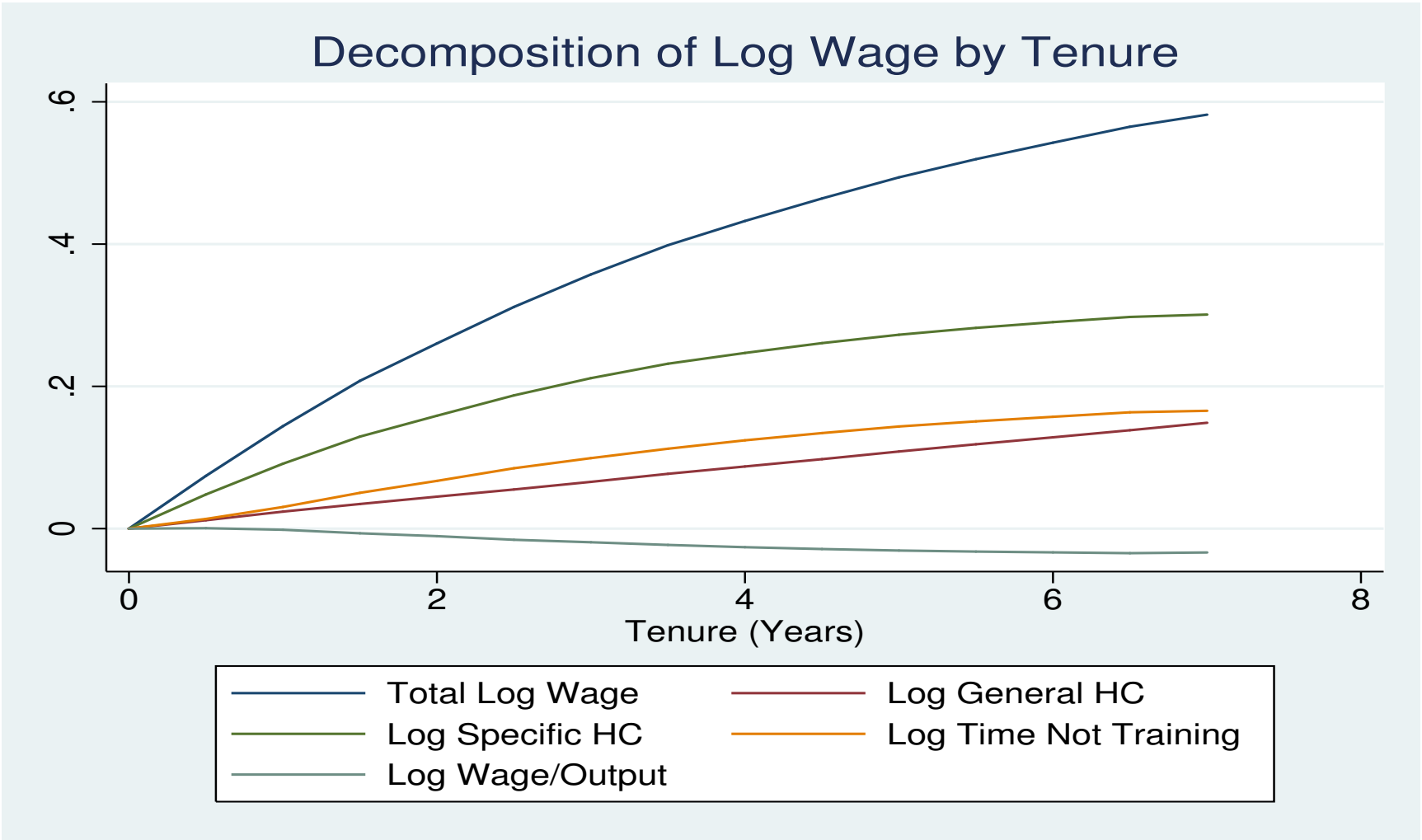
Source: NLSY 1997, Males, Age 18-31

Back to Intro

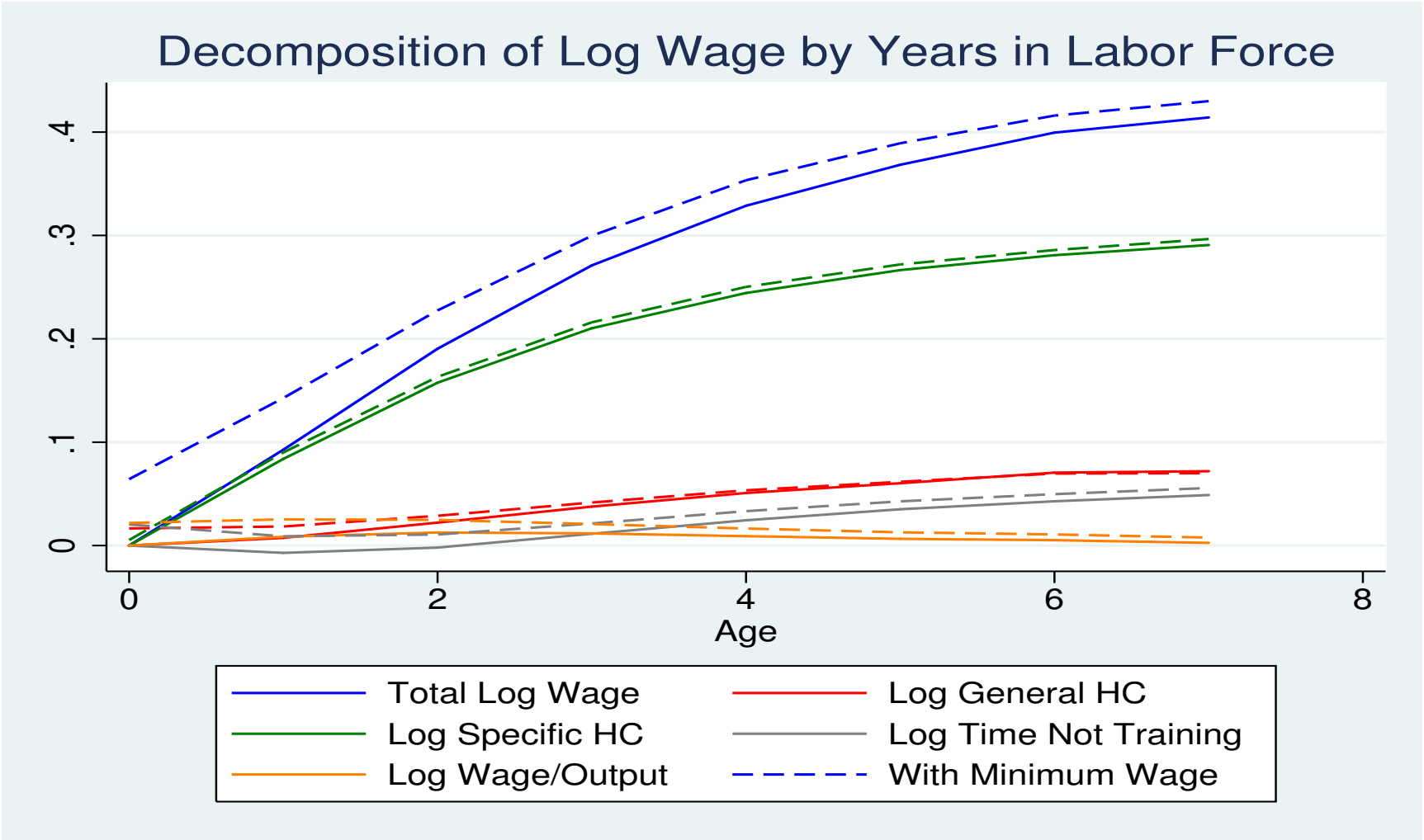
Model Simulations - Training



Model Simulations - Wage Growth



Model Simulations - Wage Growth



How common is on-the-job training?

Table: **Incidence of Training**

HS	College	Some or More	College
% who got training at least once	18 %	13 %	13%
% who got training at the start of job spell	10 %	5 %	3%

Table: **Job Transitions Btw Interview Dates**

	HS	Some College	College or More
% of stayers	81 %	85 %	88%
% of job switchers	19 %	15 %	12%
..... % of job switchers with unemployment spell	4 %	3%	2%
..... % of job switchers with no unemployment spell	15%	12%	10%

Back to Intro

Table: **Avg. of $logw_t - logw_{t-1}$ Btw Interview Dates**

	HS	Some College	College or More
stayers	0.08	0.08	0.09
job switchers	0.11	0.15	0.20
..... job switchers with unemployment spell	0.06	0.06	0.23
..... job switchers with no unemployment spell	0.12	0.17	0.20

Table: **Proportion of $logw_t - logw_{t-1} \leq 0$ Btw Interview Dates**

	HS	Some College	College or More
stayers	17 %	20 %	23%
job switchers	21 %	22 %	15%
..... job switchers with unemployment spell	30 %	36%	18%
..... job switchers with no unnemployment spell	18%	18%	14%

Table: **Avg. of $logw_t - logw_{t-1}$ By Training Status**

	No Training	Got Training
stayers	0.08	0.08
job switchers	0.14	0.10
job switchers with unemployment spell	0.08	0.15
job switchers with no unemployment spell	0.15	0.09

Table: **Incidence of Training**

HS	College	Some or More	College	
% who got training at least once				
..... Data	18 %	13 %	13%	
..... Model	20 %	15 %	13%	
% who got training at the start of job spell				
..... Data	6%	10 %	5 %	3%
..... Model	4%	5 %	4 %	4%

Table: **Job Transitions Btw Interview Dates**

	HS	Some College	College or More
% of stayers			
..... Data	81 %	85 %	88%
..... Model	78 %	75 %	73%
% of job switchers			
..... Data	19 %	15 %	12%
..... Model	22 %	25 %	27%

Table: **Job Transitions Btw Interview Dates**

	HS	Some College	College or More
% of job switchers with unemployment spell			
..... Data	4 %	3%	2%
..... Model	8 %	8%	9%
% of job switchers with no unemployment spell			
..... Data	15%	12%	10%
..... Model	14%	16%	18%

Estimated Model - Key Features

What aspects of the estimated model give rise to the decreasing proportion of training with education?

1. Mean of initial general ability differs by education:

Table: Parameters of Initial Ability Distributions

Mean of initial general ability - High School	$\mu_a(e_i = 1)$	1.07	(.024)
Mean of initial general ability - Some College	$\mu_a(e_i = 2)$	1.28	(.020)
Mean of initial general ability - BA or higher	$\mu_a(e_i = 3)$	1.53	(.051)

2. Workers with higher general ability endowments get less training in the model. Why?

Table: Parameters of Investment Functions

General ability investment TFP	δ_a^0	.0150	(.0003)
Firm-specific investment TFP	δ_θ^0	.0151	(.0003)
State-dependence of general ability investment	δ_a^1	-.050	(.010)
State-dependence of firm-specific investment	δ_θ^1	.702	(.006)

- $\delta_1^a < 0$:
  1. General training becomes less productive with values of a.
  2. More difficult and costly to change general ability once schooling is over.
- $\delta_1^a < 0$, $\delta_1^a < \delta_1^\theta$ and $\delta_1^\theta > 0$:
  1. At high values of the (θ, a) pair, general training has a high opportunity cost since productivity of θ investment increases with values of θ.
  2. Increasing opportunity cost of general training with values of (θ, a) vs. complementarity between a and θ: These are two countervailing forces that offset each other in equilibrium.