Trade Liberalization, Educational Choice, and Income Inequality (joint with Taiji Furusawa at U of Tokyo and Yunfang Hu at Kobe U)

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The Japan Society of International Economics Kansai
March 13, 2021

Motivation

- Does trade increase inequality?
- Trade, inequality, and education. (empirical studies)
  - Trade ⇒ education:

    Blanchard and Olney (2017), Gu et al. (2020)
  - Education ⇒ inequality:

    Martins and Pereira (2004), Gruber and Kosack (2014)
- Traditional theories: between skilled and unskilled (low-skilled).

  Findlay and Kierzkowski (1983), Borsook (1987), Falvey et al. (2010)
- We focus on inequality among (high/middle-) skilled individuals.

Evidence (Trade and Education)

- Exports of agricultural goods ↑
  - secondary education ↓
  - tertiary education ↑

Blanchard and Olney (2017), panel data of 102 countries (1965-2010)

- Exports and imports ↑
  - wage gap between primary and secondary education ↓
  - wage gap between secondary and tertiary education ↑

$\Rightarrow$ skill polarization (SD of years of education ↑)

Gu et al. (2020), data of Denmark (1995–2011)

Evidence (Education and Inequality)

- $\underbrace{\text{high-skilled individuals (high wage)}}_{\text{assumed to have high ability}} \Rightarrow$ high returns to schooling

  Education increases the role of ability on wage inequality.

  Martins and Pereira (2004), data of 16 developed countries for the mid-1990s

- Education spending toward tertiary education $\Rightarrow$ inequality $\uparrow$

  Gruber and Kosack (2014), data of developing countries (1965–2007)

Literature

- Between skilled and unskilled: Heckscher-Ohlin-Samuelson model.

  Trade based on comparative advantage $\Rightarrow$ income inequality

  Findlay and Kierzkowski (1983), Borsook (1987) Falvey et al. (2010)

- Among skilled individuals: Melitz model.

  Trade induces only high productivity firms (managers) to export.

  $\Rightarrow$ income inequality among managers (skilled individuals) $\uparrow$

  Egger and Kreickemeier (2012), Furusawa et al. (2020), Kohl (2020)

Our Paper

We analyze income inequality

- between skilled and unskilled
- among skilled individuals

in the framework of comparative advantage.

- Why comparative advantage? $\Rightarrow$ Blanchard and Olney (2017)
- How analyze? $\Rightarrow$ Consider length of education.
  - short education: secondary education.
  - long education: secondary and tertiary education.

What We Do

Trade liberalization: price of low-tech (agricultural) goods $\uparrow$

- Two effects on income inequality among skilled labor:
  - static: capital shifts from high-tech to low-tech sector.

    $\Rightarrow$ return of long education $\downarrow$ $\Rightarrow$ inequality $\downarrow$
  - dynamic: capital is well accumulated.

    $\Rightarrow$ return of long education $\uparrow$ $\Rightarrow$ inequality $\uparrow$
- The impacts of trade on income inequality:
  - between skilled and unskilled labor $\downarrow$ for all generations
  - among skilled labor $\downarrow$ for generations born before liberalization

    among skilled labor $\uparrow$ for generations born after liberalization

Setup

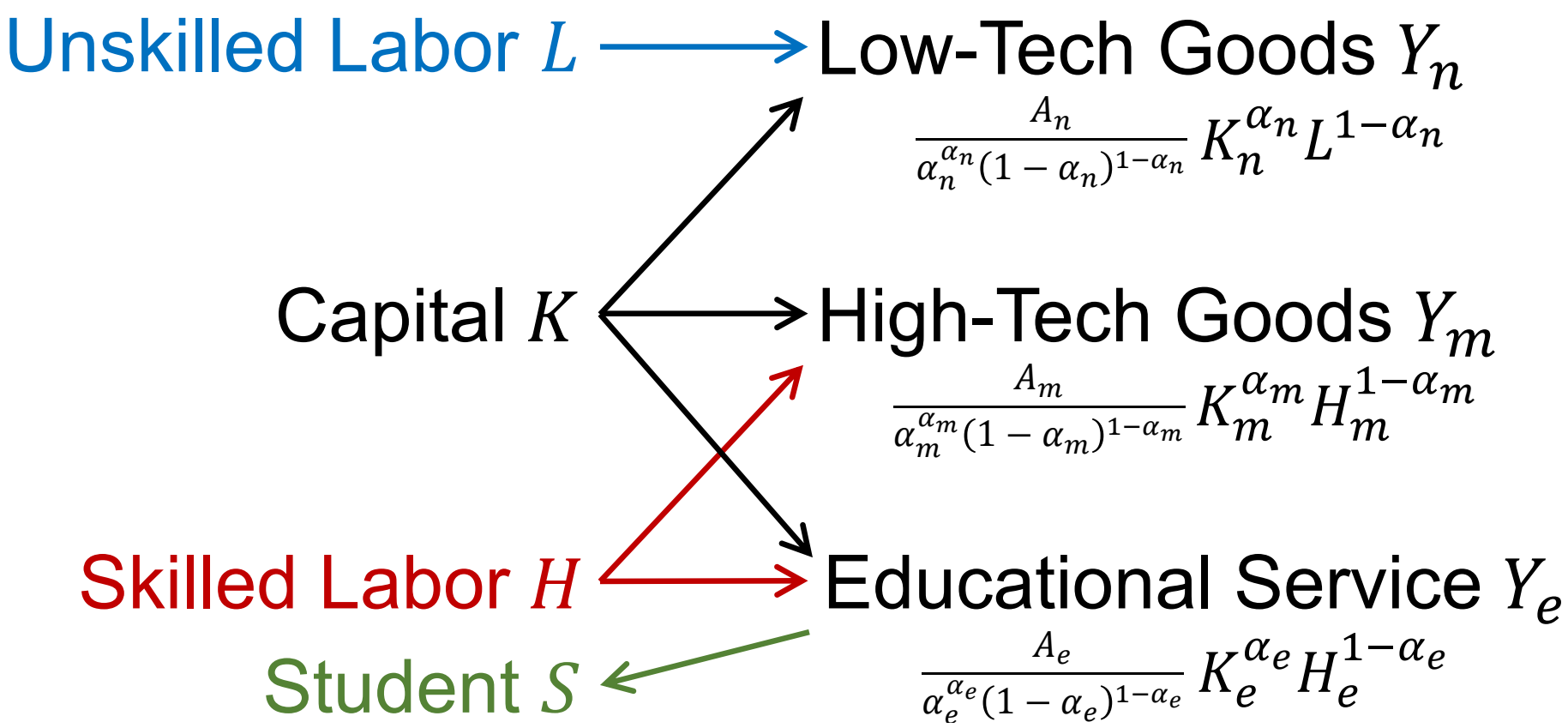
Individuals (T-generation OLG model)

- Heterogeneity: ability $a \in (0, \infty)$. (productivity as the skilled)
- Ability distribution: $F(a)$, time-invariant.
- Population: 1 for each generation.

Production

- Goods and educational services (price, unit cost):
  - low-tech goods Y_n (p_n, χ_n) for pure consumption.
  - high-tech goods Y_m (1, χ_m) for consumable capital.
  - educational service Y_e (p_e, χ_e).
- Production factors (price):
  - unskilled labor L (w_l).
  - skilled labor H (w_h).
  - capital K ($r + \delta$).

Production Structure



Individuals (Ability a and Birth Time $t = \tau$)

- Lifetime utility:

$$\sum_{t=\tau}^{\tau+T-1} \left(\frac{1}{1+\rho}\right)^{t-\tau} \left[\beta \ln c_{n,t}(a,\tau) + (1-\beta) \ln c_{m,t}(a,\tau)\right].$$

- Budget constraint: $(t = \tau, \tau+1, ..., \tau+T-1)$

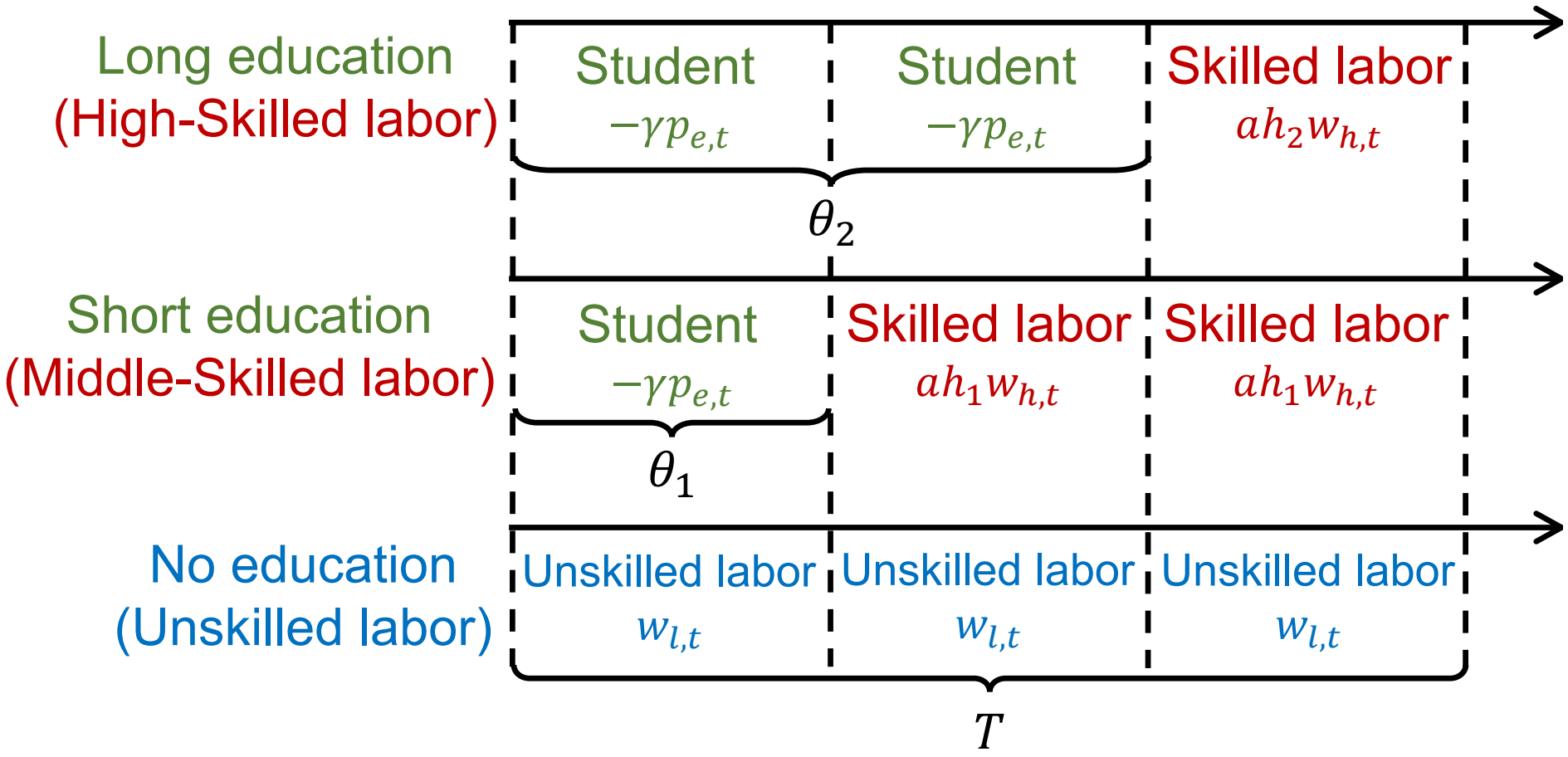
$$\begin{aligned} k_{t+1}(a,\tau) &= w_t(a,\tau) + (1+r_t)k_t(a,\tau) - c_t(a,\tau), \\ c_t(a,\tau) &\equiv p_{n,t}c_{n,t}(a,\tau) + c_{m,t}(a,\tau), \\ k_\tau(a,\tau) &= 0. \end{aligned} \tag{1}$$

w is wage or educational cost, depending educational choice.

- NPG condition:

$$k_{\tau+T}(a,\tau) \geq 0.$$

Educational Choice and Wage (Educational Cost)



Optimal Consumption

- Optimal consumption (under given expenditure $c_t(a,\tau)$)

$$c_{n,t}(a,\tau) = \beta c_t(a,\tau)/p_{n,t}, \quad c_{m,t}(a,\tau) = (1-\beta)c_t(a,\tau). \tag{2a}$$

- Optimal expenditure (under given wage $w_t(a,\tau)$)

$$c_t(a,\tau) = \frac{R(\tau,t)}{(1+\rho)^{t-\tau}} \frac{I(a,\tau)}{\Gamma}, \tag{2b}$$

$$\text{where} \quad I(a,\tau) \equiv \sum_{t=\tau}^{\tau+T-1} \frac{w_t(a,\tau)}{R(\tau,t)},$$

$$R(\tau,t) \equiv \begin{cases} 1 & \text{if } t \le \tau, \\ \prod_{\nu=\tau+1}^{t}(1+r_\nu) & \text{if } t \ge \tau+1. \end{cases}$$

$$\Gamma \equiv \sum_{t=\tau}^{\tau+T-1} \frac{1}{(1+\rho)^{t-\tau}} = \frac{1-(\frac{1}{1+\rho})^T}{1-\frac{1}{1+\rho}}.$$

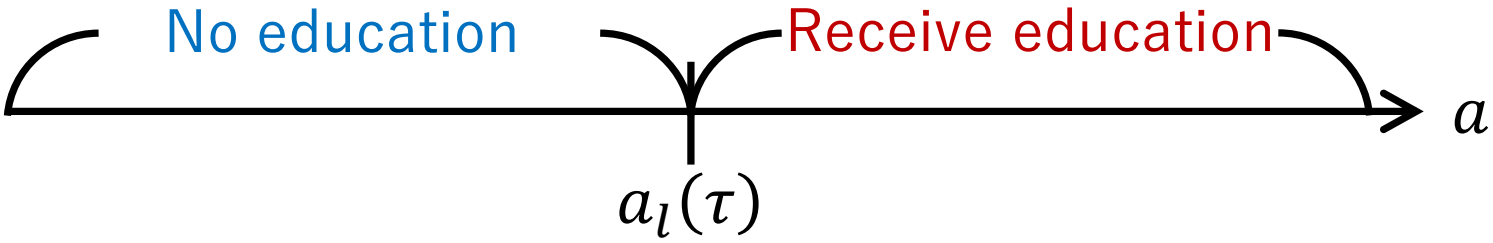
Educational Choice and Cutoff Levels of Ability

Educational choice and lifetime income $I(a, \tau)$ Lifetime Income

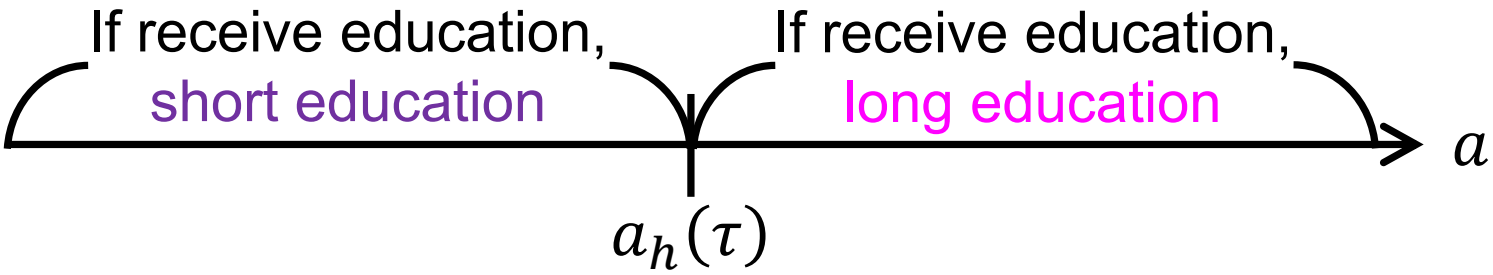
- No education: $I_l(\tau)$.
- Short education: $I_{h1}(a, \tau)$.
- Long education: $I_{h2}(a, \tau)$.

Educational choice and cutoff levels of ability Cutoff Levels of Ability

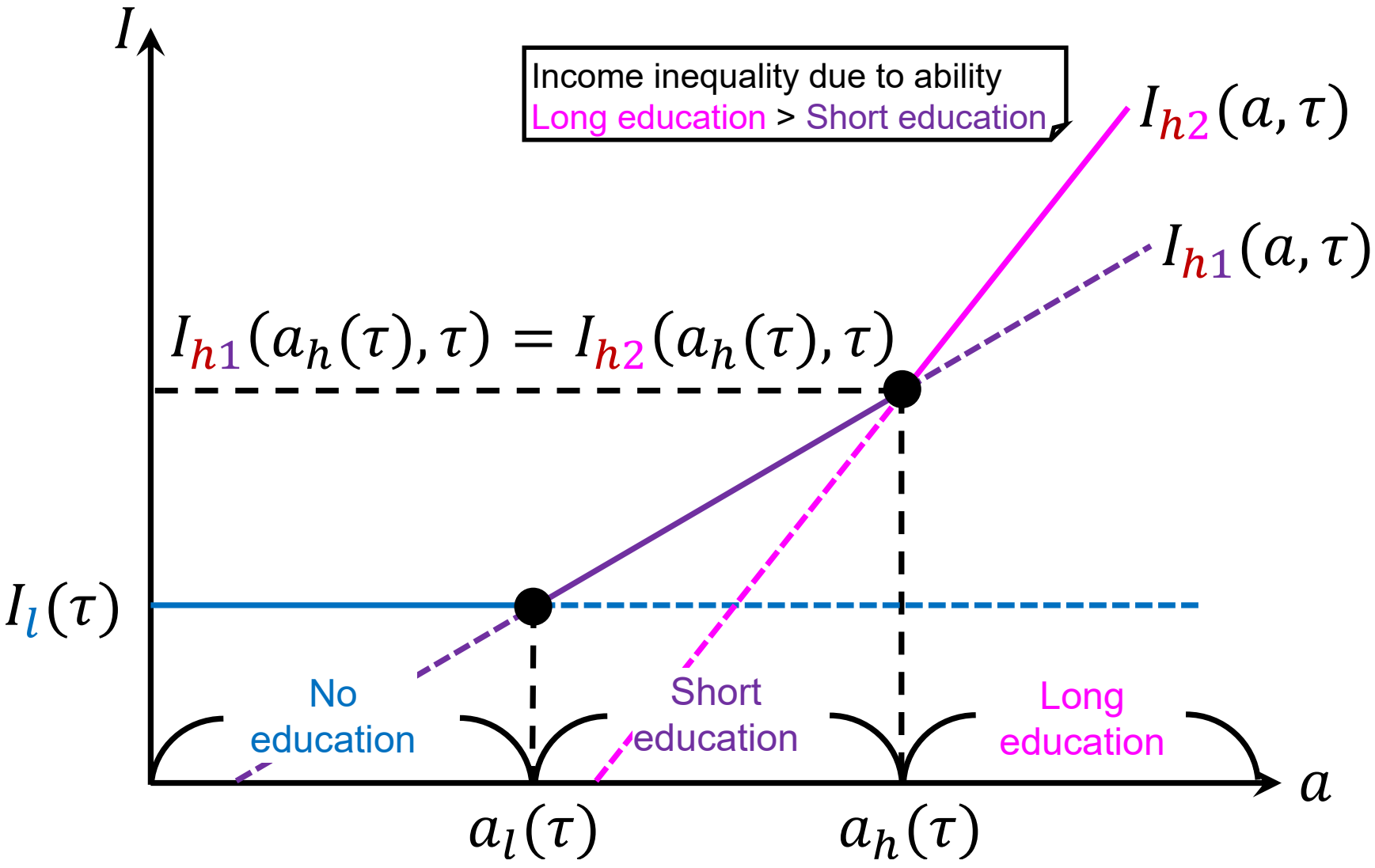
- Education or not: $I_l(\tau) \equiv I_{h1}(a_l, \tau)$ or $I_l(\tau) \equiv I_{h2}(a_l, \tau)$.



- Short or long education: $I_{h1}(a_h, \tau) \equiv I_{h2}(a_h, \tau)$.

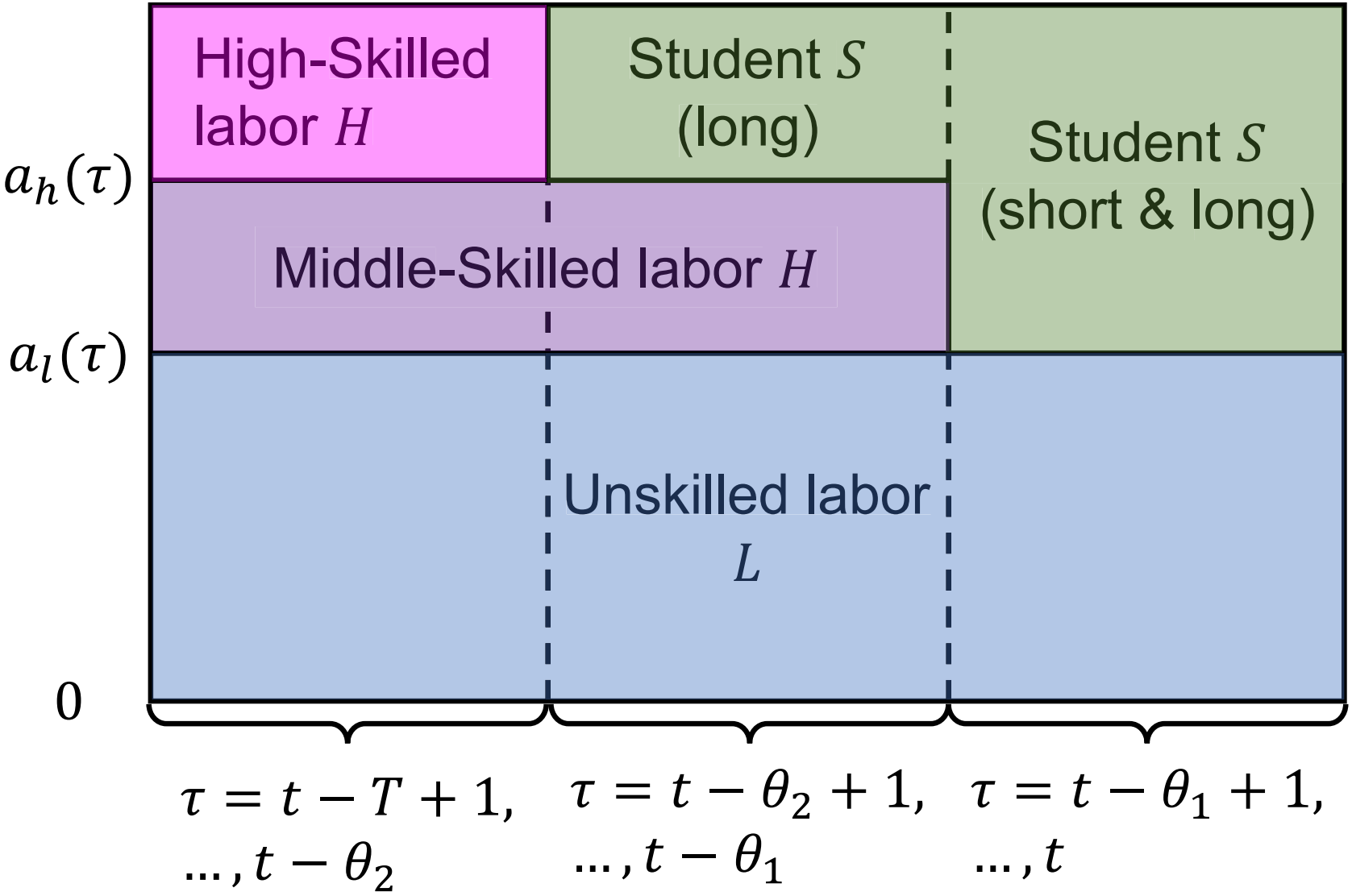


Educational Choice (Short and Long Education)



Labor Supplies (Short and Long Education)

The Other Cases



Aggregation (Labor Supplies and Students)

- Unskilled labor:

$$L_t = \sum_{\tau=t-T+1}^{t} F\big(a_l(\tau)\big). \tag{3a}$$

- Skilled labor:

$$H_t = h_1 \sum_{\tau=t-T+1}^{t-\theta_1} \int_{a_l(\tau)}^{a_e(\tau)} a \; dF(a) + h_2 \sum_{\tau=t-T+1}^{t-\theta_2} \int_{a_e(\tau)}^{\infty} a \; dF(a), \tag{3b}$$

- Students:

$$S_t = \sum_{\tau=t-\theta_1+1}^{t} \left[F\big(a_e(\tau)\big) - F\big(a_l(\tau)\big)\right] + \sum_{\tau=t-\theta_2+1}^{t} \left[1 - F\big(a_e(\tau)\big)\right], \tag{3c}$$

where $a_e(\tau) \equiv \max\big\{a_l(\tau), a_h(\tau)\big\}$.

Aggregation (Consumption and Capital)

- Expenditure for consumption:

$$C_t = \sum_{\tau=t-T+1}^{t} \int_0^\infty c_t(a,\tau)\ dF(a). \tag{4a}$$

- Capital supply:

$$K_t = \sum_{\tau=t-T+1}^{t} \int_0^\infty k_t(a,\tau)\ dF(a). \tag{4b}$$

Equilibrium Conditions

Goods and educational service

- Low-tech goods: $Y_{n,t} = \beta C_t / p_{n,t}$.
- High-tech goods: $Y_{m,t} = (1-\beta)C_t + \left[(K_{t+1} - K_t) + \delta K_t\right]$.
- Educational service: $Y_{e,t} = \gamma S_t$.

Production factors (χ_{ij} is unit factor demand, $\tilde{r}_t \equiv r_t + \delta$.)

- Capital:

$$K_t = \chi_{n1}(\tilde{r}_t, w_{l,t}) \cdot Y_{n,t} + \chi_{m1}(\tilde{r}_t, w_{h,t}) \cdot Y_{m,t} + \chi_{e1}(\tilde{r}_t, w_{h,t}) \cdot Y_{e,t}.$$

- Unskilled labor:

$$L_t = \chi_{n2}(\tilde{r}_t, w_{l,t}) \cdot Y_{n,t}.$$

- Skilled labor:

$$H_t = \chi_{m2}(\tilde{r}_t, w_{h,t}) \cdot Y_{m,t} + \chi_{e2}(\tilde{r}_t, w_{h,t}) \cdot Y_{e,t}.$$

Equilibrium Equations

- Equilibrium conditions on production factors and educational service:

$$K_t = \frac{\chi_{n1}(\tilde{r}_t, w_{l,t})}{\chi_{n2}(\tilde{r}_t, w_{l,t})} \cdot L_t + \frac{\chi_{m1}(\tilde{r}_t, w_{h,t})}{\chi_{m2}(\tilde{r}_t, w_{h,t})} \cdot \left[H_t - \chi_{e2}(\tilde{r}_t, w_{h,t}) \cdot \gamma S_t\right] + \chi_{e1}(\tilde{r}_t, w_{h,t}) \cdot \gamma S_t. \tag{5a}$$

- Equilibrium conditions on low-tech goods and unskilled labor:

$$\frac{L_t}{\chi_{n2}(\tilde{r}_t, w_{l,t})} = \frac{\beta C_t}{p_{n,t}}. \tag{5b}$$

Since $\{r_t, p_{n,t}\}_{t=-\infty}^{\infty}$ determines $\{w_{l,t}, w_{h,t}, p_{e,t}\}_{t=-\infty}^{\infty}$ ($\because$ zero-profit), and hence, $\{C_t, K_t, L_t, H_t, S_t\}_{t=-\infty}^{\infty}$ from Eqs. (1), (2), (3) and (4), equilibrium is characterized by $\{r_t, p_{n,t}\}_{t=-\infty}^{\infty}$ and Eqs. (5a) and (5b).

Steady State

Equilibrium conditions at steady state:

$$EDK(r, p_n) \equiv 0, \ \Rightarrow \ r \equiv EQK(p_n). \tag{5a'}$$

$$EDC(r, p_n) \equiv 0, \ \Rightarrow \ r \equiv EQC(p_n). \tag{5b'}$$

- Conditions of $EQK'(p_n) < 0$: Trade Liberalization
  - K increases with r and p_n.
  - Effect of p_n on supply of K dominates that on demand of K.
- Conditions of $EQC'(p_n) > 0$:
  - C increases with r.
  - Effect of r on demand of L dominates that on supply of L.

$\Rightarrow$ Steady state is unique. Simulation

Small Open Economy

- Tradable goods:
  - Low-tech goods Y_n.
  - High-tech goods Y_m.

  $\Rightarrow p_n$ is fixed at the world level p_n^*.
- Capital is not tradable. (focusing on the effects of goods trade)

  $\Rightarrow$ Interest rate r is endogenous.
- Equilibrium equation is Eq. (5a) only.
- Before trade liberalization,

  the economy is at the steady state of closed economy.

The Effect of Trade on Educational Choice

Assume $p_n^* > \bar{p}_n$.

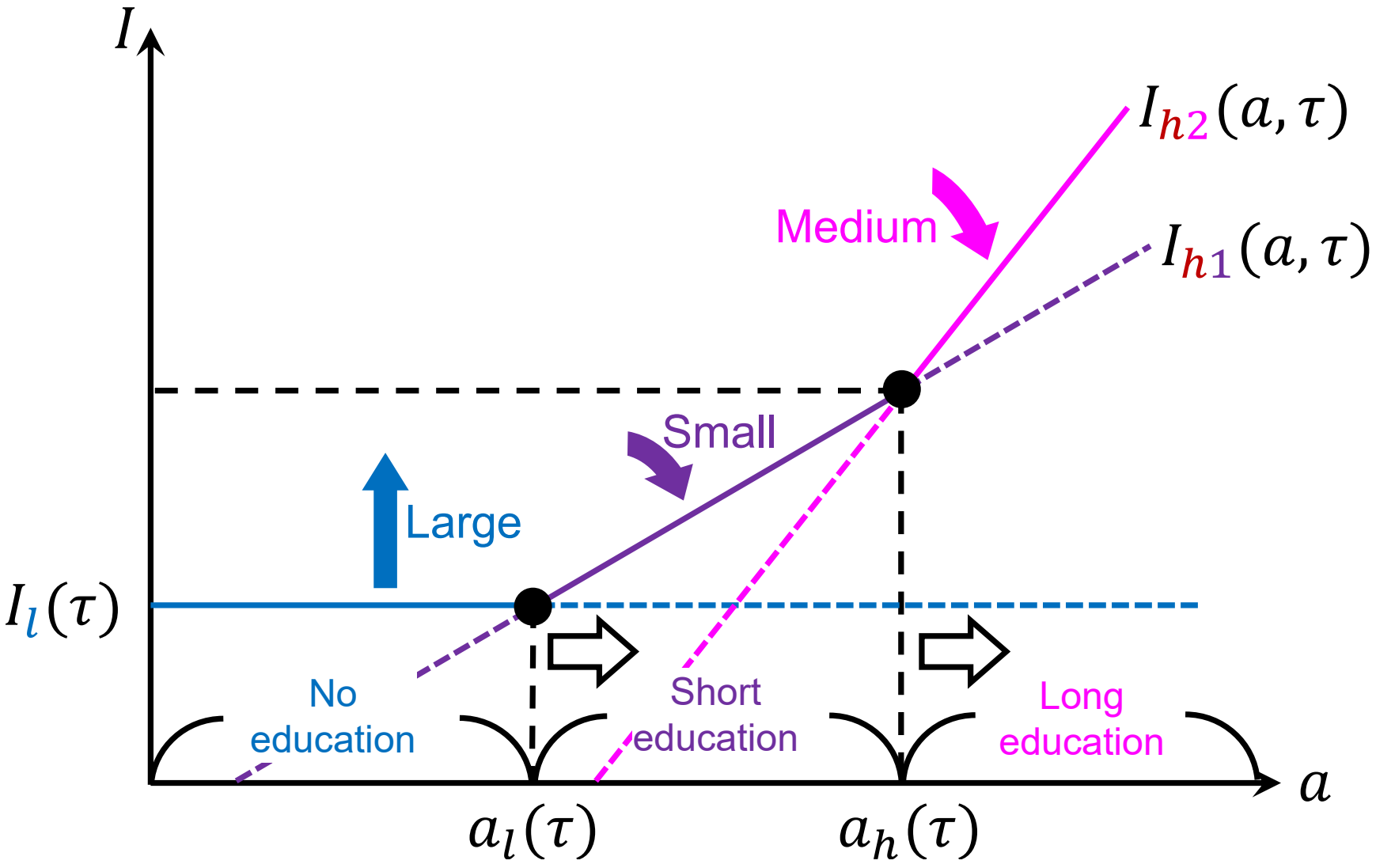
- $\bar{p}_n$: at steady state of closed economy.
- p_n^*: at the world level.

$\Rightarrow$ Exports of low-tech (agricultural) goods.

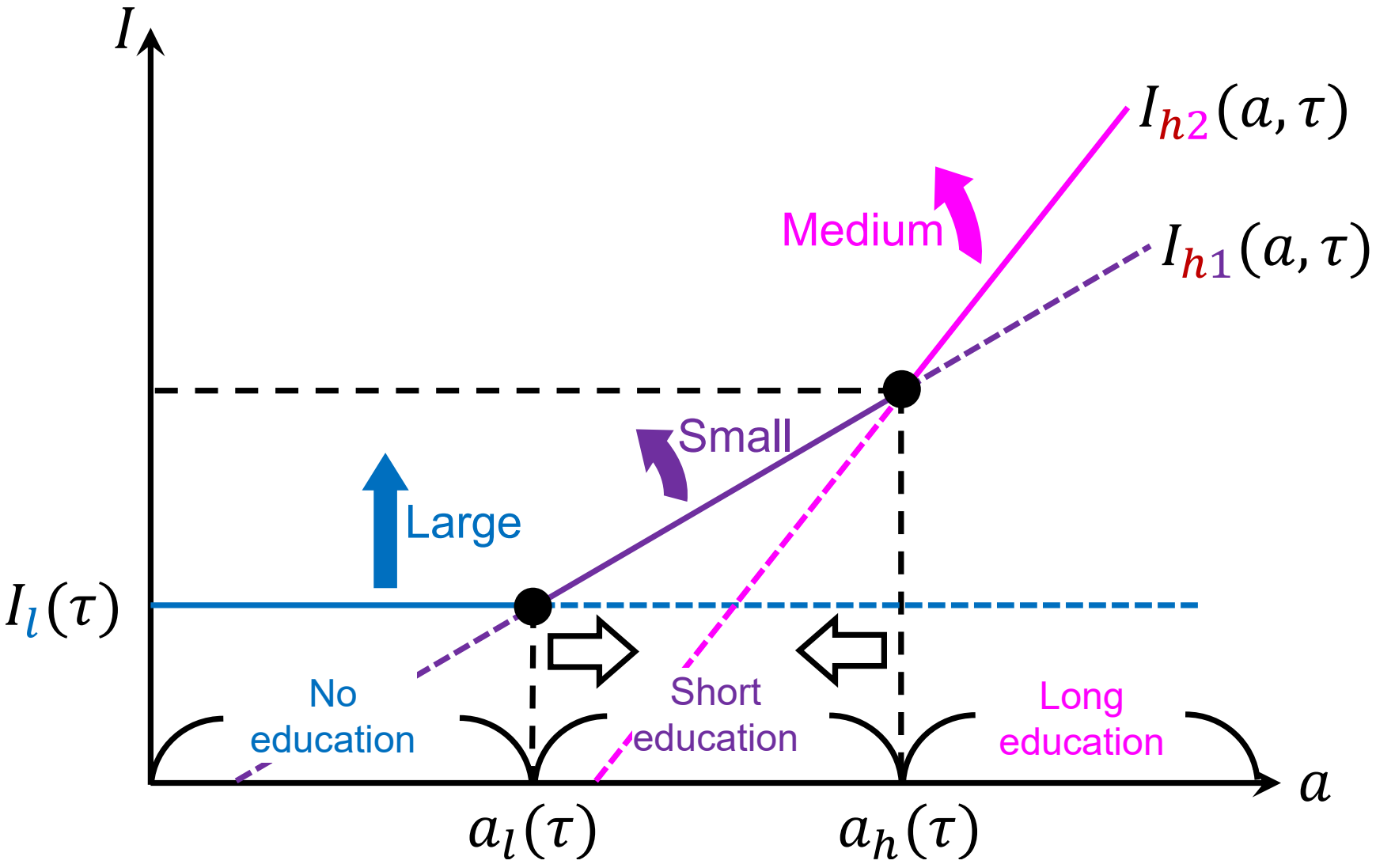
The effects on income inequality:

- Between skilled and unskilled: $w_l \uparrow\uparrow \Rightarrow a_l \uparrow \Rightarrow$ inequality $\downarrow$
- Among skilled labor:
  - If $r \uparrow$ (short run: demand of $K \uparrow >$ supply of $K \uparrow$),
    $w_h \downarrow \Rightarrow$ return of long education $\downarrow \Rightarrow a_h \uparrow \Rightarrow$ inequality $\downarrow$
  - If $r \downarrow$ (long run: supply of $K \uparrow >$ demand of $K \uparrow$), Steady State
    $w_h \uparrow \Rightarrow$ return of long education $\uparrow \Rightarrow a_h \downarrow \Rightarrow$ inequality $\uparrow$

Long Education ↓ (Before Capital Accumulation)



Long Education ↑ (After Capital Accumulation)



Parameters

Parameters in Detail

assumed values	
T	52
A_n	1
A_m	1
A_e	1
α_n	0.4487
α_m	0.3469
α_e	0.3257
δ	0.04
β	0.5
θ_1	6
θ_2	10
h_1	1
h_2	1.25

Density function of ability: log-normal,

$$f(a) = \frac{1}{\sqrt{2\pi}\sigma a} \exp\left(-\frac{(\log a - \mu)^2}{2\sigma^2}\right).$$

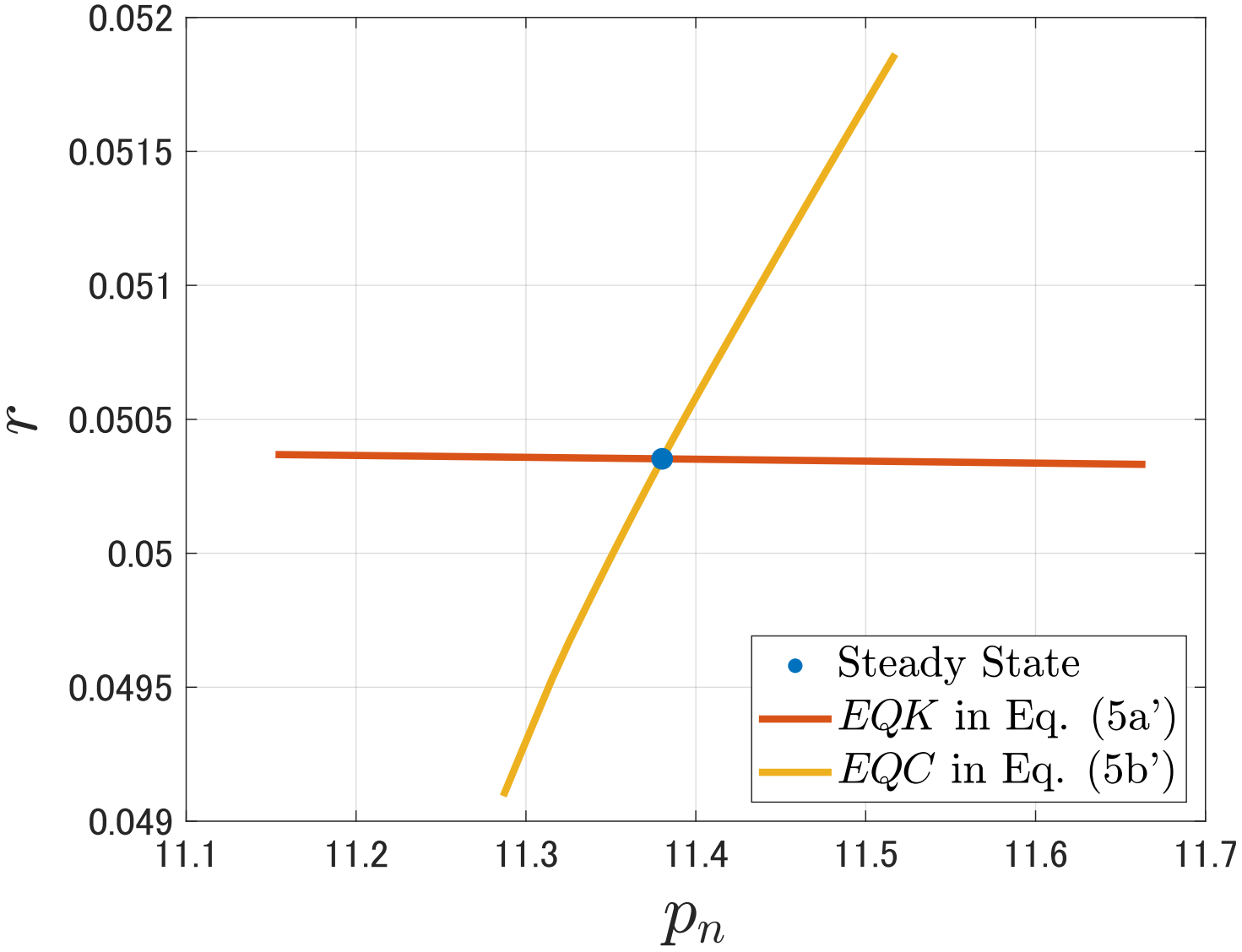
derived values	
ρ	0.0060
γ	12.6620
μ	5.0534
σ	0.9958

targets	data	model
interest rate	0.05	0.0504
edu. share	0.003	0.0038
short edu.	0.292	0.2982
long edu.	0.057	0.0574

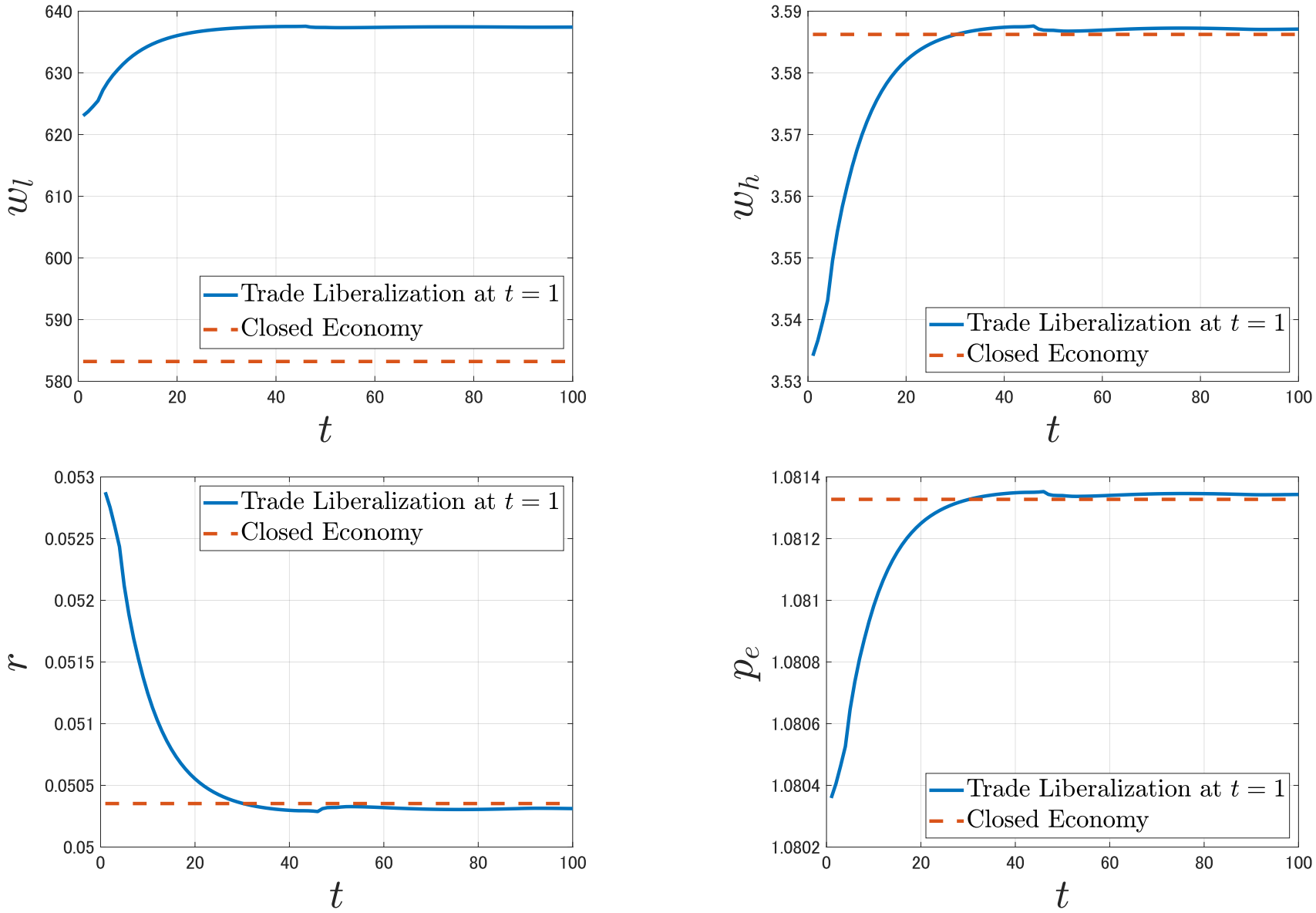
$p_n^* = 1.05\bar{p}_n$: $5\% \uparrow$ of p_n by trade liberalization.

Uniqueness of Steady State in Closed Economy

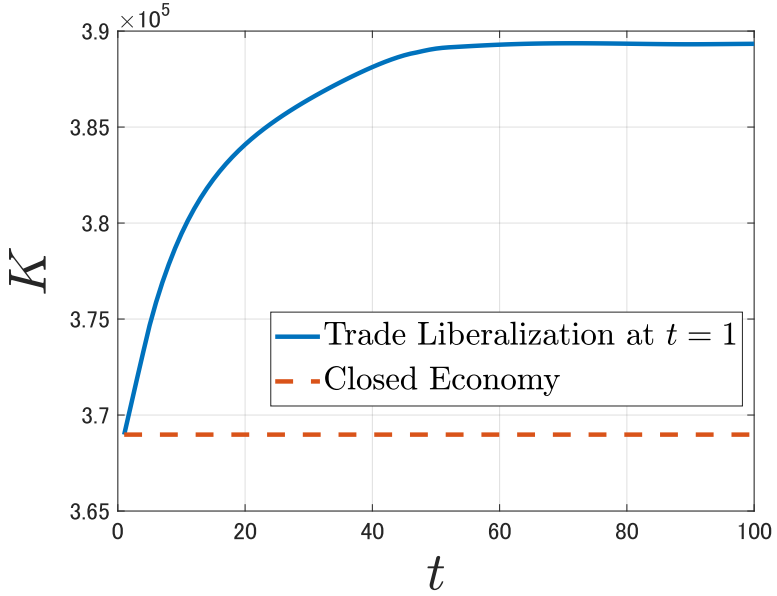
Steady State

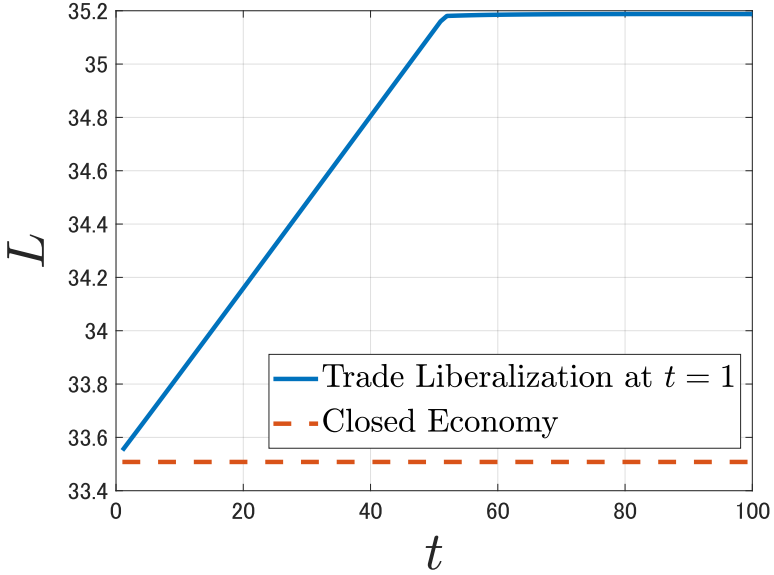


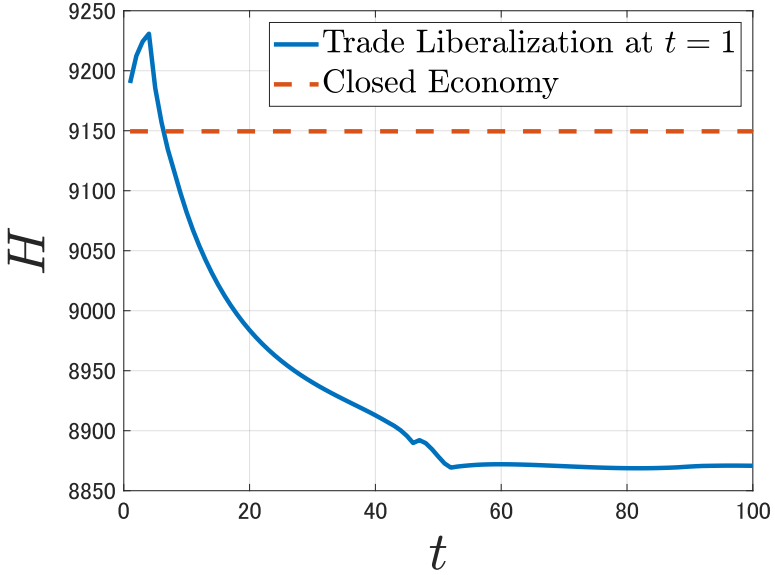
Factor Prices



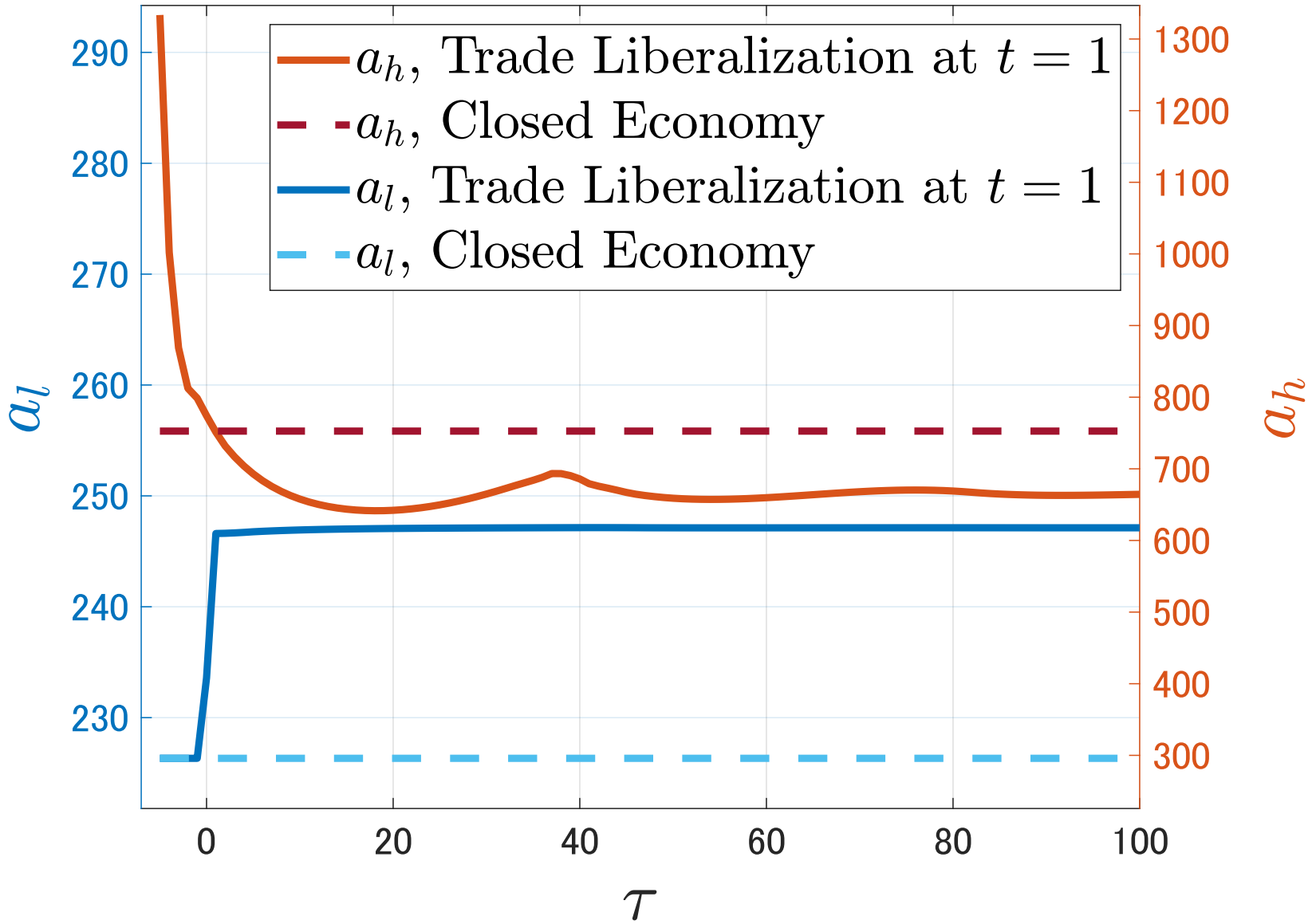
Factor Supplies







Cutoff Levels of Ability



Interpretation of Inequality among Skilled Labor

- Short run

  capital demand $\uparrow$ (due to price of low-tech goods $p_n \uparrow$)

  $\Rightarrow$ capital movement from high-tech to low-tech sector.

  $\Rightarrow$ wage of skilled labor $w_h \downarrow$

  $\Rightarrow$ return of long education $\downarrow$ ($a_h(\tau) \uparrow$, $\tau = -5, -4, ..., 0$)

  $\Rightarrow$ inequality for generations born before trade liberalization $\downarrow$

- Long run

  capital supply $\uparrow$ (due to import of consumable capital goods)

  $\Rightarrow$ wage of skilled labor $w_h \uparrow$ (wage of unskilled labor $w_l \uparrow$ too)

  $\Rightarrow$ return of long education $\uparrow$ ($a_h(\tau) \downarrow$, $\tau = 1, 2, ..., \infty$)

  $\Rightarrow$ inequality for generations born after trade liberalization $\uparrow$

Concluding Remarks

- In model where individuals can choose the length of education, we analyze the effects of trade on income inequality.
- effects through education $\Rightarrow$ inequality among skilled labor

  (In existing studies, export choice of entrepreneur $\Rightarrow$ inequality)
- price of low-tech (agricultural) goods $\uparrow$

  Education (consistent to empirics of Blanchard and Olney (2017)):
  - total (short and long) education: $\downarrow$
  - long education: short run $\downarrow$, long run $\uparrow$

  Inequality:
  - between skilled and unskilled labor: $\downarrow$ for all generations
  - among skilled labor: $\downarrow$ for generations born before liberalization

    $\uparrow$ after

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Appendix

Lifetime Income

◂ Educational Choice and Cutoff Levels of Ability

- No education:

$$I_l(\tau) = \sum_{t=\tau}^{\tau+T-1} \frac{w_{l,t}}{R(\tau,t)}. \tag{7a}$$

- Short education:

$$I_{h1}(a,\tau) = -P_{e1}(\tau) + aW_{h1}(\tau), \tag{7b}$$

- Long education:

$$I_{h2}(a,\tau) = -P_{e2}(\tau) + aW_{h2}(\tau), \tag{7c}$$

where

$$P_{e1}(\tau) \equiv \sum_{t=\tau}^{\tau+\theta_1-1} \frac{\gamma p_{e,t}}{R(\tau,t)}, \quad W_{h1}(\tau) \equiv \sum_{t=\tau+\theta_1}^{\tau+T-1} \frac{h_1 w_{h,t}}{R(\tau,t)},$$

$$P_{e2}(\tau) \equiv \sum_{t=\tau}^{\tau+\theta_2-1} \frac{\gamma p_{e,t}}{R(\tau,t)}, \quad W_{h2}(\tau) \equiv \sum_{t=\tau+\theta_2}^{\tau+T-1} \frac{h_2 w_{h,t}}{R(\tau,t)}.$$

Cutoff Levels of Ability

◂ Educational Choice and Cutoff Levels of Ability

- Short or long education from Eqs (7b) and (7c):

$$a_h(\tau) = \begin{cases} \infty & \text{if } W_{h2}(\tau) \leq W_{h1}(\tau), \\ \dfrac{P_{e2}(\tau) - P_{e1}(\tau)}{W_{h2}(\tau) - W_{h1}(\tau)} & \text{otherwise.} \end{cases} \tag{8a}$$

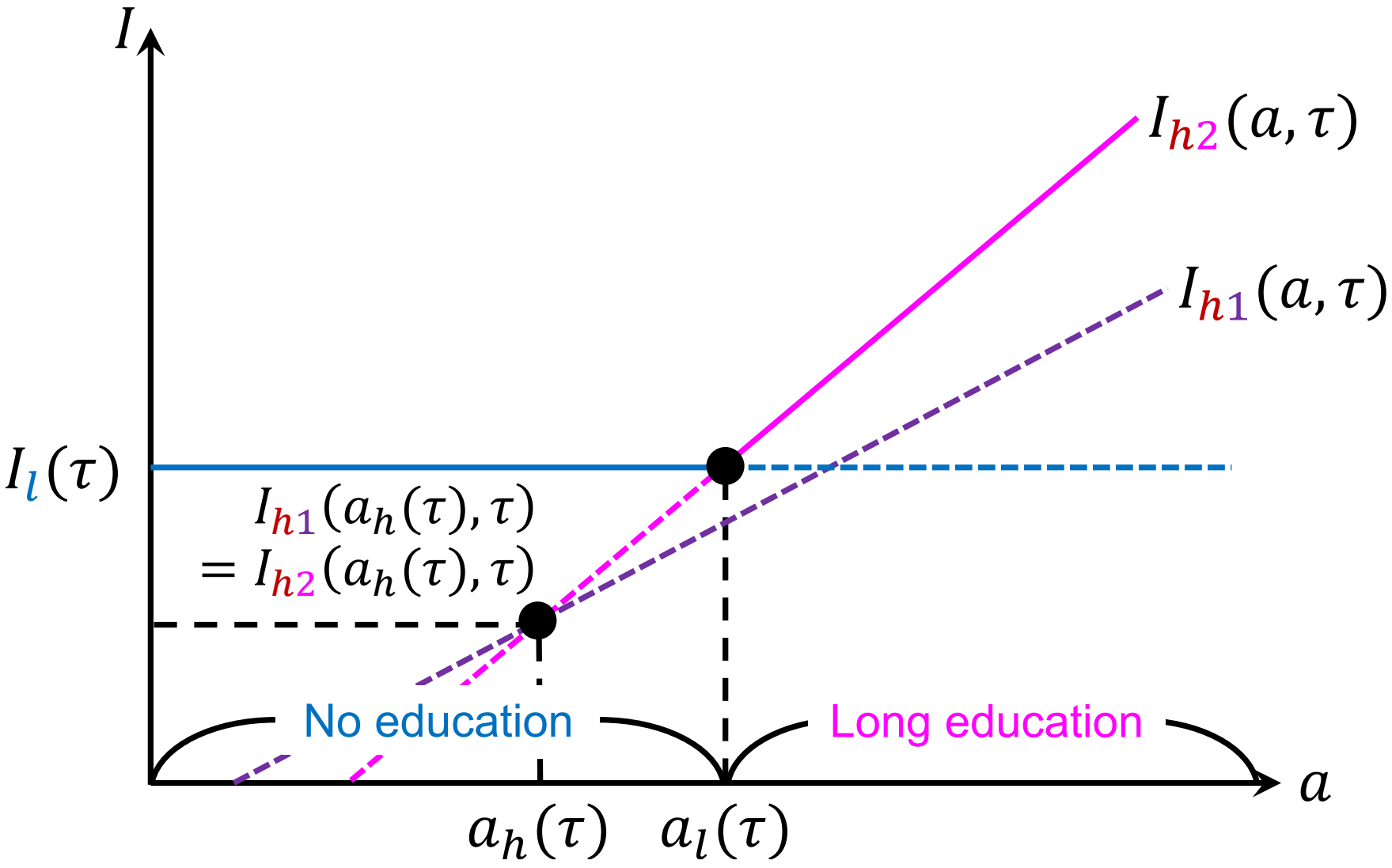
$a_h \uparrow \Rightarrow$ return of long education $\downarrow$ and long education itself $\downarrow$
$\Rightarrow$ income inequality among skilled labor $\downarrow$

- Education or not: from Eqs. (7a) and (7b), or from Eqs. (7a) and (7c):

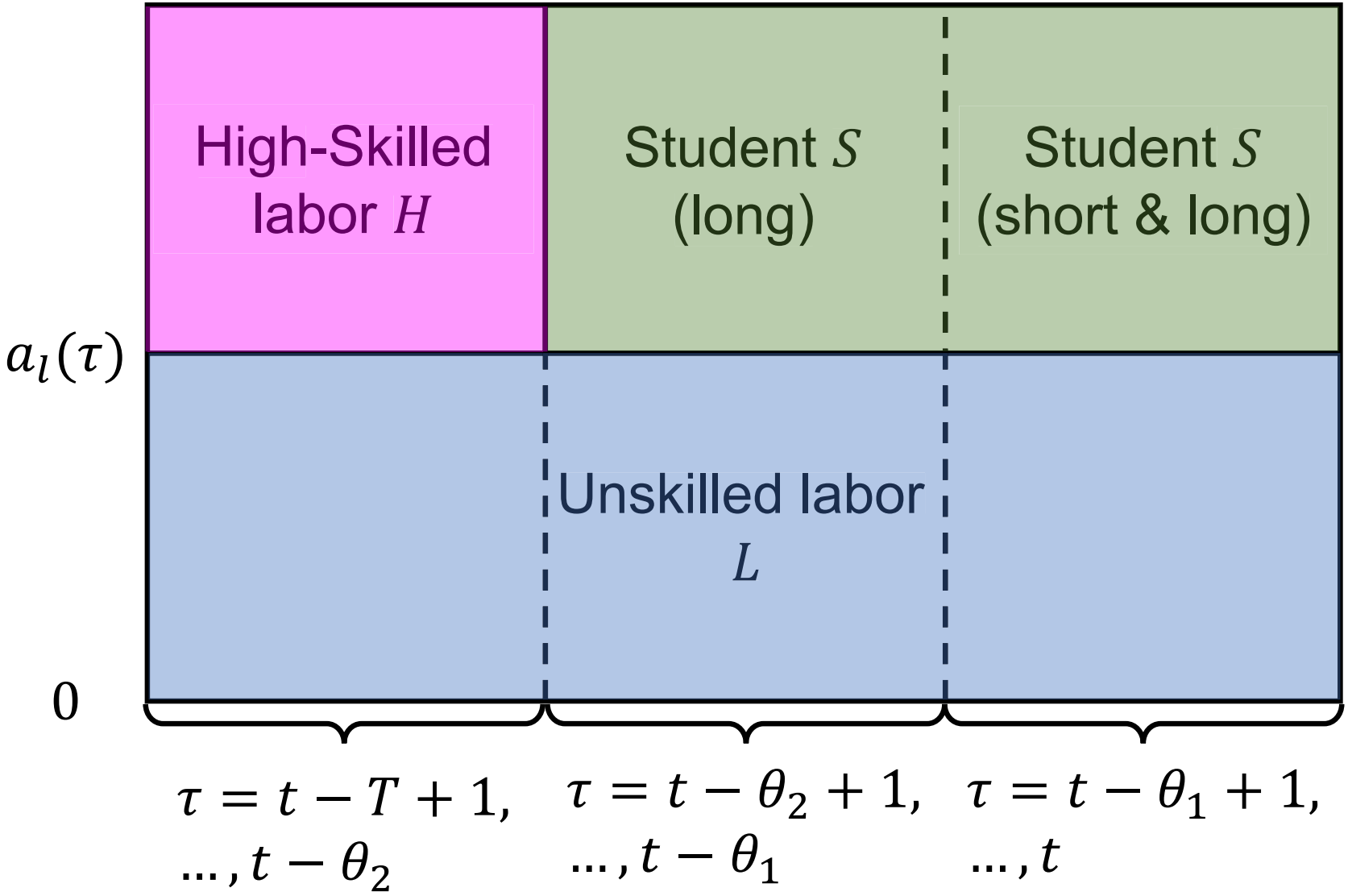
$$a_l(\tau) = \begin{cases} \dfrac{P_{e1}(\tau) + I_l(\tau)}{W_{h1}(\tau)} & \text{if } I_l(\tau) \leq I_{h1}\big(a_h(\tau), \tau\big), \\ \dfrac{P_{e2}(\tau) + I_l(\tau)}{W_{h2}(\tau)} & \text{otherwise.} \end{cases} \tag{8b}$$

$a_l \uparrow \Rightarrow$ return of education $\downarrow$
$\Rightarrow$ income inequality between skilled and unskilled labor $\downarrow$

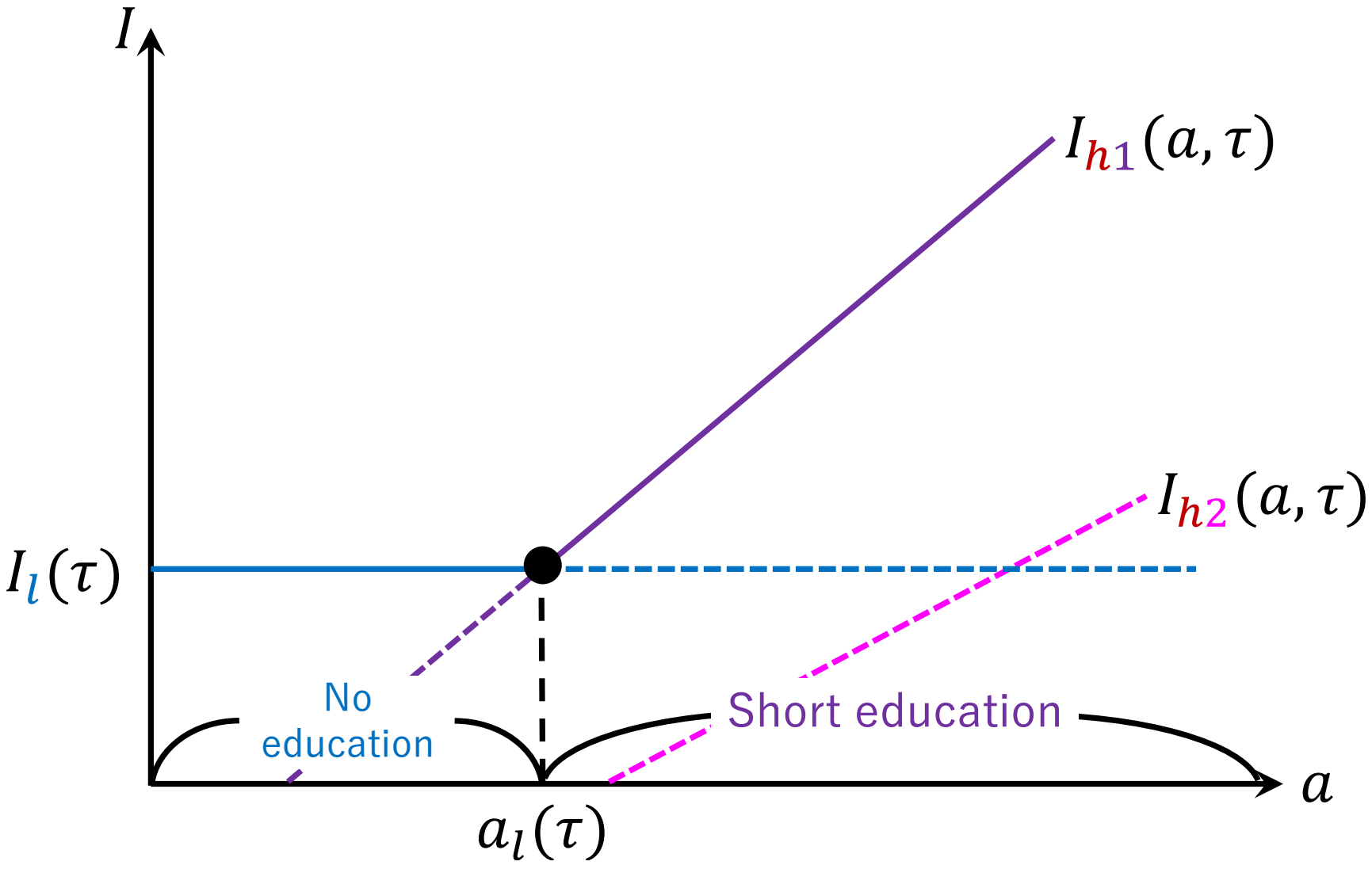
Educational Choice (Long Education Only)



Labor Supplies (Long Education Only)

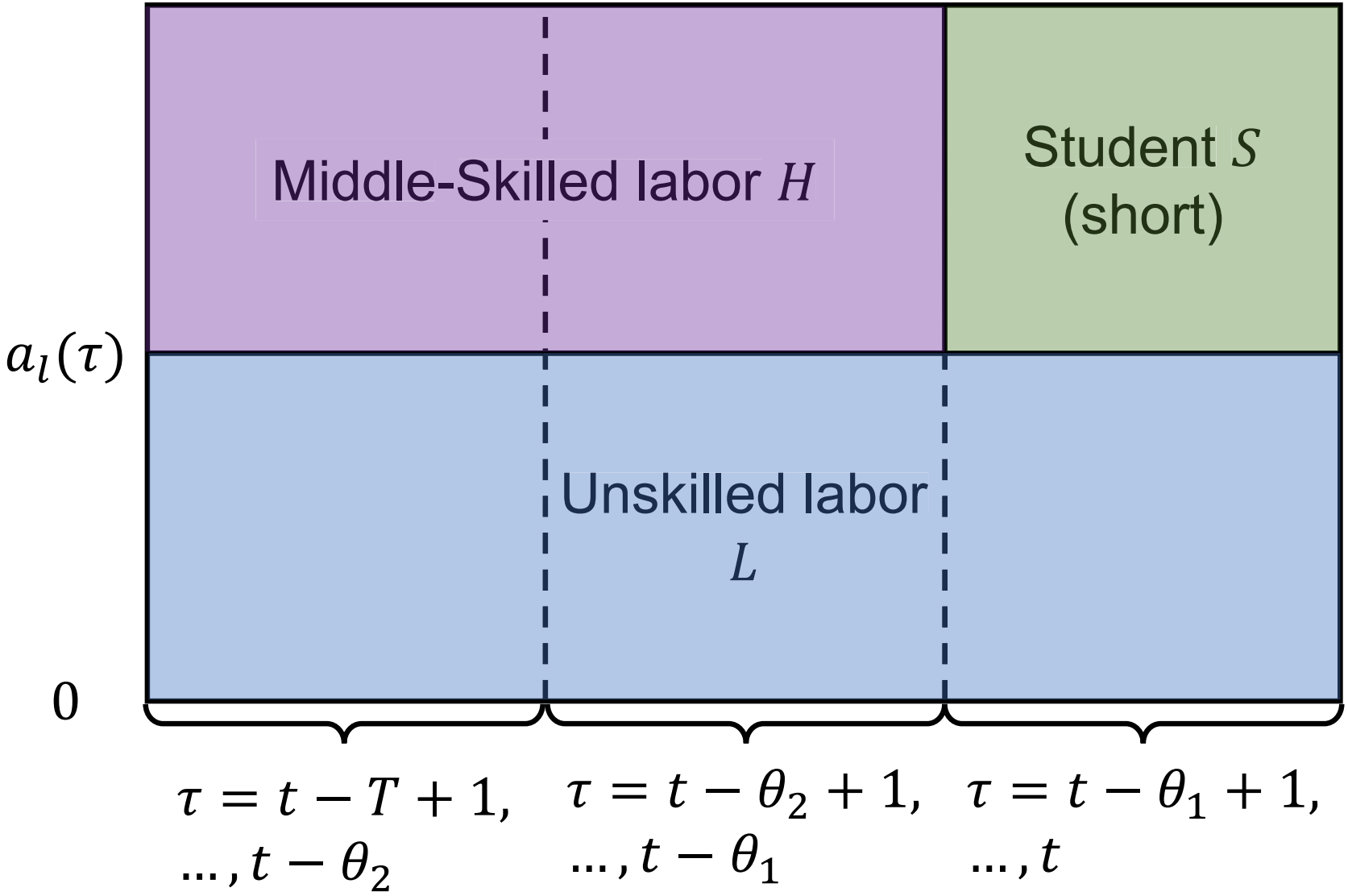


Educational Choice (Short Education Only)



Labor Supplies (Short Education Only)

◂ Short and Long Education



Parameters (Assumption) I

- lifetime $T = 52$: ages from 13 to 64.
- total factor productivity:
  - $A_n = 1$: normalization.
  - $A_m = 1$: normalized to 1 in developing counties.
    (differs from developed countries $\Rightarrow$ difference in relative price.)
  - $A_e = 1$: normalization. ($A_e \uparrow$ is equivalent to $\gamma \downarrow$)
- capital income shares: Valentinyi and Herrendorf (2008), Table 6.

$$\left.\begin{aligned} \alpha_n &= 0.20 + 0.27\alpha_n + 0.18\alpha_m + 0.20\alpha_e, \\ \alpha_m &= 0.12 + 0.03\alpha_n + 0.39\alpha_m + 0.24\alpha_e, \\ \alpha_e &= 0.21 + 0.00\alpha_n + 0.08\alpha_m + 0.27\alpha_e. \end{aligned}\right\} \quad \begin{aligned} \alpha_n &= 0.4487, \\ \alpha_m &= 0.3469, \\ \alpha_e &= 0.3257. \end{aligned}$$

Parameters (Assumption) II

- depreciation rate $\delta = 0.04$: Harris and Robertson (2013).
- consumption share $\beta = 0.5$: Harris and Robertson (2013).
- length of education:

  http://www.ibe.unesco.org/fileadmin/user_upload/Publications/WDE/2010/pdf-versions/China.pdf

  - $\theta_1 = 6$: secondary education (6 yrs).
  - $\theta_2 = 10$: secondary (6 yrs) + tertiary education (4 yrs).
- return of education:
  - $h_1 = 1$: normalization.
  - $h_2 = 1.25$: Harmon et al. (2001), Figure 1.3 (Ability).
    $\log(h_2/h_1) = return(\theta^2 - \theta^1)$, $return \approx 0.055$.

Parameters (Calibration)

Parameters calibrated in steady state of closed economy: Parameters

- discount rate ρ
- educational cost γ.
- ability distribution (log-normal distribution) μ and σ.

Targets:

- interest rate: $r = 0.05$: to avoid $a_h = \infty$.
  0.06 in Harris and Robertson (2013), but under 0.06 in China from 2000.
  https://data.worldbank.org/indicator/FR.INR.RINR?locations=CN&name_desc=false
- education spending share 0.3% of GDP: from OECD data
  https://data.oecd.org/eduresource/private-spending-on-education.htm#indicator-chart
- educational attainment: Barro and Lee (2013), Table 3 (developing, 2010).
  - short education: $F(a_h) - F(a_l) = 0.292$.
    completed secondary (24.4%) + dropped tertiary $(10.5\% - 5.7\%)$
  - long education: $1 - F(a_h) = 0.057$.
    completed tertiary (5.7%)