Offshoring and Directed Technical Change

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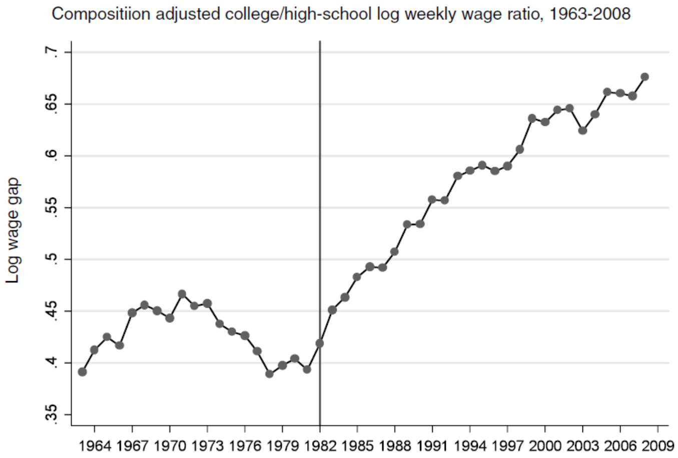
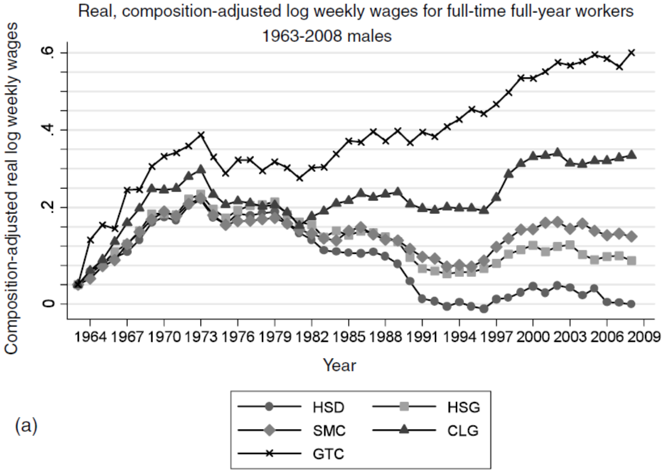
The US Skill Premium



since the 1980s the US skill premium has increased relentlessly...

Trends in US Real Wages



...and the real wage of unskilled workers has declined/stagnated

Conventional Wisdom

- two popular explanations:
  1. Skill-Biased Technical Change
  2. North-South trade
- some shortcomings:
  - SBCT is hard to reconcile with the fall in real wages
  - what triggered SBTC?
  - the volume of NS trade is considered too small
- the recent boom in offshoring to China/India has led to reconsider the role of trade
- this paper:
  - the *interaction* between offshoring and directed technical change can help to solve the above shortcomings

The Rise of Offshoring I

- offshoring:
  - sourcing of input goods or services from a foreign country
- not a new phenomenon:
  - already in the 1970s, IKEA established production facilities in Poland
  - already in the 1980s, Swissair had moved accounting tasks to India
- recent boom triggered by
  - economic transformation in East Asia
  - advances in ICT
- share of imported inputs in total purchases in US manufacturing:
  - 6% in 1980
  - 27% in 2006

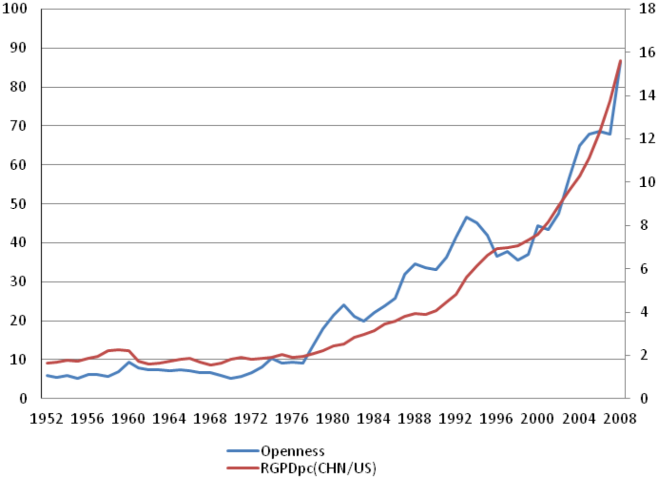
Offshoring: an Example

- Apple's Video iPod:
  - sold at $299 on the US market
  - $163 is captured by American companies
  - $132 by part makers in Asian countries, $4 by Chinese workers
- iPod-related jobs by country and category in 2006:

	Production	Retail and other non-professional	Engineering and other professional	Total
U.S.	30	7,789	6,101	13,920
China	11,715	*	555	12,270
Philippines	4,500	*	250	4,750
Japan	700	*	1,140	1,840
Singapore	825	*	100	925
Korea	600	*	600	1,200
Thailand	750	*	50	800
Taiwan	70	*	270	340
Other	0	4,825*	300	5,125
Total	**19,190**	**12,614**	**9,366**	**41,170**

*Includes all non-U.S. retail and other non-professionals.

The Rise of China



since the 1980s, spectacular growth of GDP and trade volumes

This Paper

- the *interplay*

$$\text{offshoring} \leftrightarrows \text{technical progress}$$

  can explain both skill premia and the level of wages worldwide
- take the canonical model of DTC:
  - skilled and unskilled workers (H and L)
  - two sectors producing/using imperfectly substitutable "intermediates"
  - endogenous factor-augmenting technologies
- add offshoring:
  - two countries, West and East
  - the West can produce all intermediates
  - by paying a fixed cost, a Western firm can produce in East
- offshoring has:
  - an "efficiency" effect → tends to benefit all workers and foster growth
  - redistributional effects, which depends also on DTC

Preview of Results

- in our preferred parametrization, offshoring:
  - raises the skill premium in the short run
  - lowers the real wage of unskilled workers in West
  - triggers SBTC initially, but UBTC after a critical level
- the skill premium is a inverted-U function of offshoring:
  - highest for relatively low volumes of trade
- offshoring and innovation are complements in the long run, but substitute in the short run
  - offshoring may be Pareto improving if technical progress is fast enough
- including high-skill offshoring:
  - offshoring can increase skill premia both in East and West

Some Related Literature

- DTC and trade:
  - Acemoglu (1998), Acemoglu & Zilibotti (2001), Acemoglu (2003)
- offshoring and wages:
  - Samuleson (2004), Rodriguez-Clare (2011), di Giovanni et al. (2012)
  - Feenstra & Hanson (1999 , 2003), Trefler & Zhu (2005), Antras & al. (2006), Grossman & Rossi-Hansberg (2008)
- offshoring and growth:
  - Helpman (1993), Dinopoulos & Segerstrom (2008), Branstetter & Saggi (2011)
- empirics:
  - Autor, Dorn & Hanson (2011), Liu & Trefler (2011), Hummels et al. (2011), Crinó (2010)

A Model of Offshoring and DTC

- world output (numeraire):

$$Y = \left(Y_l^{\frac{\epsilon-1}{\epsilon}} + Y_h^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}},$$

where:

$$Y_l = E_l \left[\int_0^{A_l} x_{l,i}^{\alpha} di \right]^{1/\alpha} \quad \text{and} \quad Y_h = E_h \left[\int_0^{A_h} x_{h,i}^{\alpha} di \right]^{1/\alpha}$$

- note:
  - Y_l, Y_h are produced with *sector-specific* intermediates
  - A_l, A_h = state of technology in the two sectors
- key parameters:
  - $\epsilon > 1$, elasticity of substitution between Y_l and Y_h
  - $\sigma = 1/(1-\alpha) > 1$, elasticity of substitution between intermediates

Production and Market Structure

- Y, Y_L and Y_H are produced by competitive firms: $\frac{P_h}{P_l} = \left[\frac{Y_l}{Y_h}\right]^{1/\epsilon}$
- intermediates are produced by monopolists, either in West or East:
  - linear technology using one type of labor:

$$x_{l,i} = l_i \quad \text{and} \quad x_{h,i} = Zh_i$$

  - prices = markup over wages:

$$\begin{aligned} p_{h,w} &= w_{h,w}/Z\alpha \\ p_{l,w} &= w_{l,w}/\alpha \\ p_{l,e} &= w_{l,e}/\alpha \end{aligned}$$

  - resource constraint:

$$\int_0^{A_l} l_i di \leq L_w + L_e \quad \text{and} \quad \int_0^{A_h} h_i di \leq H_w$$

note: $H_e = 0$ (for now)

Exogenous Offshoring and Technology

- assumptions:
  - West can produce all intermediates
  - a fraction $\kappa < \bar{\kappa} \equiv \frac{L_e}{L_e + L_w}$ of intermediates A_l can be offshored to East
- implications:
  - $\kappa < \bar{\kappa} \longrightarrow w_{l,e} < w_{l,w}$
  - all offshorable goods will be produced in East
- symmetry and labor market clearing pin down production, $x_{h,w}$, $x_{l,w}$ and $x_{l,e}$
- West/East wage gap:

$$\frac{w_{l,w}}{w_{l,e}} = \left(\frac{L_e}{L_w} \frac{1-\kappa}{\kappa} \right)^{1-\alpha}$$

  - falls with κ, $w_{l,e} \longrightarrow w_{l,w}$ as $\kappa \longrightarrow \bar{\kappa}$

Offshoring and World Efficiency

- world output:

$$Y_l = A_l \hat{L},$$

where

$$\hat{L} \equiv \left[\kappa^{1-\alpha} L_e^{\alpha} + (1-\kappa)^{1-\alpha} L_w^{\alpha} \right]^{1/\alpha}$$

- efficiency effect ($\kappa < \bar{\kappa}$):

$$\frac{\partial \hat{L}}{\partial \kappa} \geq 0$$

$$\lim_{\kappa \to 0} \frac{\partial \hat{L}}{\partial \kappa} = \infty \quad \text{and} \quad \lim_{\kappa \to \bar{\kappa}} \frac{\partial \hat{L}}{\partial \kappa} = 0$$

- intuition:
  - moving production where labor is cheaper raises efficiency
  - the marginal effect is infinite when $w_{l,e} \simeq 0$ and vanishes at $w_{l,e} \simeq w_{l,w}$

Offshoring and the Skill Premium

- skill premium in West:

$$\omega_w \equiv \frac{w_{h,w}}{w_{l,w}} = \left(\frac{ZA_h}{A_l}\right)^{1-1/\epsilon} \left(\frac{L_w}{1-\kappa}\right)^{1-\alpha} \left(\frac{H_w}{\hat{L}}\right)^{-1/\epsilon} \frac{1}{\hat{L}^{1-\alpha}}$$

- effects of κ:
  - *labor-supply effect*: fewer firms in the West $\rightarrow$ less demand for L_w $\rightarrow$ higher skill premium
  - *price effect*: lower P_l/P_h $\rightarrow$ higher skill premium
  - *efficiency effect*: cost saving on intermediates $[0,\kappa]$ increases the demand for intermediates $[\kappa, 1]$ $\rightarrow$ lower skill premium
- if $\sigma > \epsilon$:
  - the efficiency effect is dominated $\rightarrow$ $\frac{\partial \omega_w}{\partial \kappa} > 0$
  - otherwise, ω_w is U-shaped in κ

Offshoring and Real Wages

- real wage of unskilled in West:

$$w_{l,w} = \alpha A_l P_l \hat{L}^{1-\alpha} \left(\frac{1-\kappa}{L_w} \right)^{1-\alpha}$$

- effects of κ:
  - *price effect*: lower $P_l \longrightarrow$ lower $w_{l,w}$
  - *efficiency effect*: cost saving on intermediates $[0, \kappa]$ increases the real wage of all workers $\longrightarrow$ higher $w_{l,w}$
  - *labor-supply effect*: less firms in the West $\longrightarrow$ less demand for $L_w \longrightarrow$ lower $w_{l,w}$
- iff $\omega_w \frac{H_w}{L_w} > \frac{\epsilon}{\sigma - \epsilon}$:
  - the real wage of the unskilled must fall with κ
  - otherwise, $w_{l,w}$ is an inverted-U function of κ

Which is the Empirically Relevant Case?

- conventional estimates are:

$$\begin{aligned} \epsilon &\in [1.5, 2] \\ \sigma &> 4 \end{aligned}$$

- under this parametrization, offshoring always raises the skill premium
- moreover, the condition:

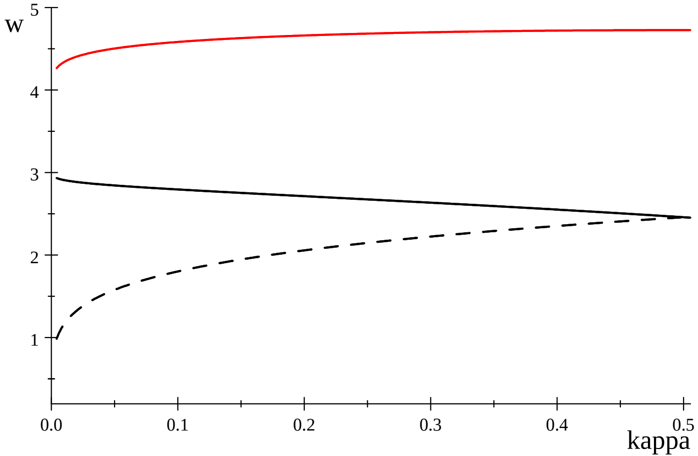
$$\omega_w \frac{H_w}{L_w} > \frac{\epsilon}{\sigma - \epsilon}$$

  is likely to be satisfied too

  - offshoring lowers the real wage of unskilled workers

- focus mostly on the case $\epsilon < \sigma$

Offshoring and Wages



Red: $w_{h,w}$, Dashed: East, $\epsilon = 1.6$, $\sigma = 5$

Comparison with Grossman & Rossi-Hansberg (2008)

- GRH (2008) assume:
  - no substitutability across "tasks"
  - foreign wage fixed
  - offshoring requires a per-unit cost which varies across tasks
- main results:
  - fall in offshoring costs increases the "effective productivity" of the offshored factor
  - wages for the offshored factor may increase
- our model incorporates the productivity effect, but raises two *caveats*:
  - offshoring increases wages in East $\rightarrow$ the productivity effect may get weaker
  - allowing for substitutability shows that the productivity effect may well be dominated

Endogenous Technical Change and Offshoring

- both innovation and offshoring require a setup investment
  - cost of innovation: μ units of Y
  - cost of offshoring: f units of Y
- value of firms:

$$
\begin{aligned}
rV_h &= \pi_h + \dot{V}_h \\
rV_{l,w} &= \max\left\{\pi_{l,w} + \dot{V}_l,\ r\left(V_l^o - f\right)\right\} \\
rV_{l,e}^o &= \max\{\pi_{l,w}, \pi_{l,e}\} + \dot{V}_l^o
\end{aligned}
$$

- Free-Entry conditions:

$$
\begin{aligned}
V_{l,e} - V_{l,w} &\leq f \\
V_{l,w} &\leq \mu \\
V_h &\leq \mu
\end{aligned}
$$

BGP: Offshoring

- in a BGP, all FE conditions holds as equalities
- combining them, offshoring goes on until:

$$\pi_{l,e} = \left(\frac{f}{\mu} + 1\right) \pi_{h,w}$$

  - i.e, until the profit difference compensates the additional cost
- solving for offshoring:

$$\kappa = \left[1 + (f/\mu + 1)^{1/\alpha} L_w / L_e\right]^{-1}$$

  - increases with the relative size of East, L_e / L_w
  - decreases with its cost, f
  - increases with the cost of innovation, μ

BGP: Offshoring and Technical Change

- relative value of innovations:

$$\frac{V_{h,w}}{V_{l,w}} = \frac{P_h}{P_l} \frac{ZH_w}{\hat{L}^{1-\alpha} \left[L_w / (1-\kappa)\right]^{\alpha}}$$

- offshoring:
  - raises $P_h/P_l = [Y_l/Y_h]^{1/\epsilon} \rightarrow$ SBTC ($\uparrow A_h/A_l$)
  - increases the market for unskilled technologies $\rightarrow$ UBTC ($\downarrow A_h/A_l$)
  - which effect dominates depends on the level of offshoring

- imposing $V_{l,w} = V_{h,w}$:

$$\frac{A_h}{A_l} = \frac{(ZH_w)^{\epsilon-1} \hat{L}^{1-\epsilon+\epsilon\alpha}}{\left[L_w / (1-\kappa)\right]^{\epsilon\alpha}}$$

- if $\sigma > \epsilon$:
  - at $\kappa \rightarrow 0$ $\frac{\partial \hat{L}}{\partial \kappa} \rightarrow \infty$, strong price effect $\rightarrow$ SBTC
  - at $\kappa \rightarrow \bar{\kappa}$, $\frac{\partial \hat{L}}{\partial \kappa} \rightarrow 0$, no price effect $\rightarrow$ UBTC

Comparison with Acemoglu (2002)

- in models of DTC, the relative value of innovations is:

$$\frac{V_h}{V_l} = \frac{P_h}{P_l}\frac{H}{L}$$

- effect of NS trade:
  - without IPR protection in S, $\frac{P_h}{P_l}$ increases in N $\longrightarrow$ SBTC (price effect)
  - with IPR protection in S, $\frac{H}{L}$ falls $\longrightarrow$ UBTC (market size effect)
- in our model the relative strength of the two effects depends on the level of offshoring
  - endogenous switch from SBTC to UBTC

BGP: Skill Premium

- Skill Premium:

$$\omega_w = Z^{\epsilon-1} H_w^{\epsilon-2} \hat{L}^{1-\epsilon+\epsilon\alpha} \left(\frac{L_w}{1-\kappa} \right)^{1-\epsilon\alpha}$$

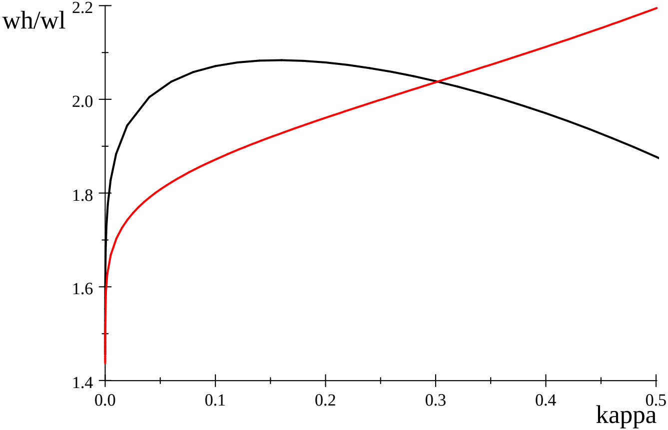
- effect of offshoring:
    - relationship between ω_w and κ is inverted-U if

$$\frac{\sigma}{\sigma-1} = \frac{1}{\alpha} < \epsilon < \frac{1}{1-\alpha} = \sigma$$

    - plausible: if $\sigma = 5 \longrightarrow$ the condition is satisfied for $\epsilon \in (1.25, 5)$

- intuition:
    - given (A_l, A_h), offshoring increases ω_w
    - for low $\kappa \longrightarrow$ SBTC, ω_w increases even further
    - for high $\kappa \longrightarrow$ UBTC, ω_w decreases

Offshoring and the Skill Premium



Red: constant (A_h, A_l) ; $\epsilon = 1.6$, $\sigma = 5$

- SBTC: large amplification effect for low levels of offshoring

Offshoring and Economic Growth

- in the BGP:

$$r = \frac{\pi_{l,e} - \pi_{l,w}}{f} = \frac{\pi_{l,w}}{\mu} = \frac{\pi_{h,w}}{\mu}$$

- solving:

$$r = \left\{ \left[\hat{L}^{1-\alpha} \left(\frac{L_w}{1-\kappa} \right)^{\alpha} \right]^{\epsilon-1} + (ZH)^{\epsilon-1} \right\}^{\frac{1}{\epsilon-1}} \frac{1-\alpha}{\mu}$$

- offshoring increases profitability and overall growth

Transitional Dynamics

- dynamic system (log utility):

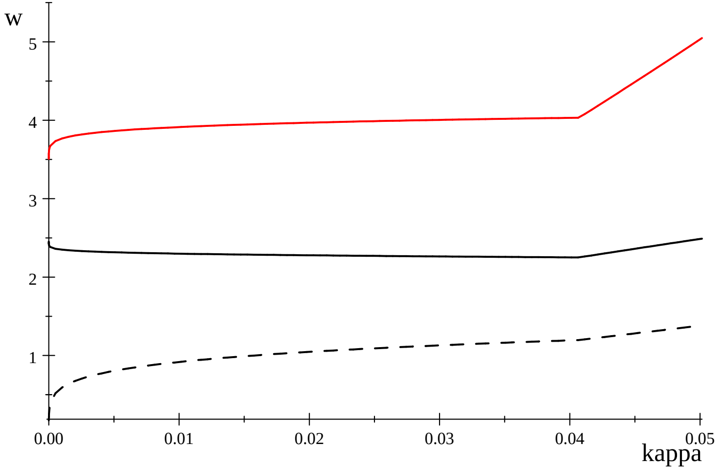
$$\frac{\dot{C}_t}{C_t} = r_t - \rho$$

$$\left(\dot{A}_{h,t} + \dot{A}_{l,t}\right)\mu + \left(\kappa \dot{A}_{l,t} + A_{l,t}\dot{\kappa}_t\right) f = Y_t - C_t$$

$$r_t = \max\left\{\frac{\pi_{l,e,t} - \pi_{l,w,t}}{f}, \frac{\pi_{l,w,t}}{\mu}, \frac{\pi_{h,w,t}}{\mu}\right\}$$

- an unexpected fall in offshoring costs f triggers a 2-stage transition:
    - stage 1: offshoring only ($\dot{\kappa} > 0$, $\dot{A}_l = \dot{A}_h = 0$)
    - stage 2: offshoring + SBTC (low κ) or + UBTC (high κ)
- offshoring and innovation:
    - are complements in the long run, but substitutes in the short run

Transitional Dynamics: Wages



Red: $w_{h,w}$, Dashed: East, $\epsilon = 1.6$, $\sigma = 5$

Welfare Analysis I

- consider an agent i with wage $w_{i,t}$ and assets $a_{i,0}$
  - integrating the Euler equation at $t = 0$:

$$
\begin{aligned}
U_{i,0} &= \frac{\ln C_{i,0}}{\rho} + \int_0^\infty e^{-\rho t} \left(\int_0^t r_s ds - \rho t \right) dt \\
C_{i,0} &= \rho \left[\int_0^\infty w_{i,t} \exp \left(- \int_0^t r_s ds \right) dt + a_{i,0} \right]
\end{aligned}
$$

- welfare effects of offshoring:
  - higher growth, $[r_t]_{t=0}^\infty$
  - affects the present value of wages, $[w_{i,t}, r_t]_{t=0}^\infty$
  - capital loss: $a_{i,0}$ falls because during the transition:

$$
\begin{aligned}
V_{l,w} &\leq \mu \\
V_h &\leq \mu
\end{aligned}
$$

  - new effect: offshoring reduces (temporarily) the value of existing firms

Welfare Analysis II

- some preliminary simulations
  - basic parameters:

$$H_w = L_w = L_e, \ \epsilon = 1.6, \ Z = 1.8, \ \rho = 0.04, \ a_{i,0} \propto w_{i,0}$$

  - offshoring shock: $\kappa_0 = 0.02 \to \kappa_T = 0.05$

	$\alpha = 0.8$	$\alpha = 0.7$
g	$\Delta\omega = +4.6\%$	$\Delta\omega = +4.7\%$
1%	$\Delta c_l^* = -1\%; \Delta c_h^* = +2\%$	$\Delta c_l^* = -0.27\%, \Delta c_h^* = +3\%$
2%	$\Delta c_l^* = -0.19\%; \Delta c_h^* = +3\%$	$\Delta c_l^* = +0.6\%, \Delta c_h^* = +4\%$

- who gains from offshoring?
  - skilled workers in West, East (big time)
  - unskilled in West only if growth is high enough
  - agents with low assets

High-Skill Offshoring I

- new assumptions:
  - East is endowed with H_e units of skilled labor and $H_w / L_w > H_e / L_e$
  - cost of offshoring is identical
- free entry in BGP imply:

$$\frac{\pi_{l,e}}{\pi_{l,w}} = (1 + f/\mu) = \frac{\pi_{h,e}}{\pi_{h,w}}$$

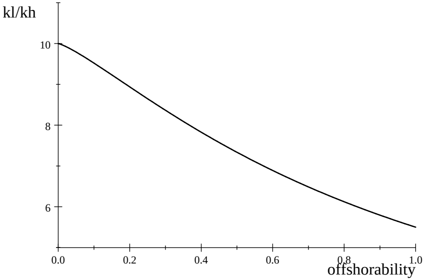
  - but then the wage gap for both workers must be the same
  - conditional FPE:

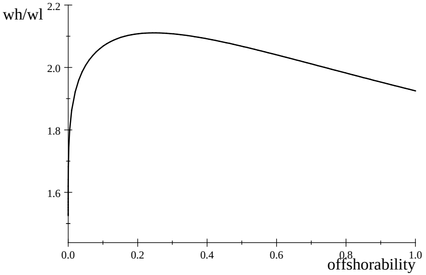
$$\frac{w_{l,w}}{w_{l,e}} = \frac{w_{h,w}}{w_{h,e}}$$

  - same skill-premium in East and West, despite complete specialization

High-Skill Offshoring II

- to equalize skill premia, there must be more offshoring in the L sector
- effects on wages:
  - qualitatively, same results as before
  - initially, offshoring will increase skill premia worldwide





- offshorability: $\left[f/\mu+1\right]^{-1}=\lambda\in[0,1]$

Conclusions

- offshoring and technical change are key determinants of wages
  - we argue that their interaction is important in explaining wage dynamics
- in our preferred parametrization, offshoring:
  - lowers the real wage of unskilled workers in West
  - induces SBTC initially, then UBTC
  - crowds out innovation initially, but foster growth in the long run
- unlike trade integration:
  - offshoring increases the skill premium for low volumes of trade
  - offshoring may increase skill premia in all countries
- welfare and redistributional implications vary with the level of offshoring and with asset holdings
  - all workers benefit if growth is sufficiently high