Trading Tasks: A Dynamic Theory of Offshoring

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Motivation

- Production is more and more characterized by global supply chains.
- Firms must decide about the location of production for each component.
- Standard models only consider production costs as decision criterion.
- E.g. Autor & Acemoglu (2010), Costinot, Vogel & Wang (2012), Feenstra & Hanson (1997), Grossman & Rossi-Hansberg (2008, 2012).
- These contributions derive important implications for labor demand and relative wages.
- It is not known whether these conclusions are still correct when offshoring is also driven by other factors.

Motivation cont'd

- Branstetter *et al.* (JIE 2011): International activity of MNEs increases significantly after patent reform in developing countries.
- Such a patent reform reduces the risk of imitation for MNEs.
- In the product cycle literature, imitation means that Southern firms take over the production of a Northern variety.
- This implies a large impact on labor demand and potentially on wages.
- Ignoring this fact may lead to misleading conclusions concerning the impact of offshoring on wages.

Preview of results

- Accounting for imitation risk reduces the optimal level of offshoring.
- Offshoring volume is characterized by overshooting and subsequent movement towards the steady state as a reaction to exogenous technology or endowment shocks.
- Creates new channels by which offshoring affects skill premium:
  1. Short-run intertemporal profit effect
  2. Long-run composition effect
- Correlation of changes in offshoring and skill premium depends on the characteristics of the underlying shock.

Model Outline

Offshoring Decision

Wage Inequality

Conclusion

Specification: Consumption

- Intertemporal welfare function:

$$W = \int_0^{\infty} U(t) e^{-\rho t} \mathrm{d}t, \tag{1}$$

- CES utility function with increasing number of varieties:

$$U(t) = \left(\int_0^{N(t)} x_j(t)^{(\sigma-1)/\sigma} \mathrm{d}j \right)^{\sigma/(\sigma-1)} \tag{2}$$

- Yields a standard Euler equation for intertemporal consumption:

$$\dot{E}/E = r - \rho. \tag{3}$$

- No transport costs for final good:

$$\frac{x_j}{x_{j'}} = \left(\frac{p_j}{p_{j'}} \right)^{-\sigma} \tag{4}$$

Specification: Firm entry

- Free entry into innovation and imitation, respectively:

$$\frac{sa}{N} = \frac{\pi}{r+g+m} \quad \text{and} \quad \frac{s^* a^*}{nl} = \frac{\pi^*}{r+g} \tag{5}$$

- Capital market clearing in North:

$$\pi + \dot{v} = rv + mv \tag{6}$$

- Capital market clearing in South:

$$\pi^* + \dot{v}^* = rv^* \tag{7}$$

Specification: Full employment

- Labor endowment L and L^*
- Share of high-skilled researchers h and h^* and share of low-skilled production workers $1-h$ and $1-h^*$.
- Full employment of researchers:

$$hL = ag, \quad \text{with} \quad g := \frac{\dot{N}}{N} = \frac{\dot{n}}{n} \tag{8}$$

$$h^* L^* = a^* m/I, \quad \text{with} \quad m := \frac{\dot{n}^*}{n} \tag{9}$$

- Unit-interval of tasks $i \in [0,1]$ with offshoring costs $\beta\tau(i)$ and $\tau'(i) > 0$.
- Full employment of production workers:

$$(1-h)L = (1-I)nx \tag{10}$$

$$(1-h^*)L^* = \beta \int_0^I \tau(i)\mathrm{d}inx + n^* x^* \tag{11}$$

Static Offshoring

- Maximization of per-period profits.
- Equalization of relative wages and offshoring costs for the marginal task:

$$\frac{\partial \pi}{\partial \tilde{l}} = \frac{x}{\sigma - 1} \underbrace{(w - \beta\tau(\tilde{l})w^*)}_{-\partial c/\partial \tilde{l}} = 0 \tag{12}$$

$$\frac{w}{w^*} = \beta\tau(\tilde{l}) \tag{13}$$

Dynamic Offshoring

- Maximization of discounted lifetime profits $\pi/(\rho+g+m)$:

$$\frac{d\pi}{\pi} = \frac{dm}{r+g+m} \tag{14}$$

$$\underbrace{w-\beta\tau(l)w^*}_{-\partial c/\partial l} = \frac{\overbrace{\left(w^*\beta\int_0^l \tau(i)\mathrm{d}i + w(1-l)\right)}^{c}}{r+g+m}\frac{1}{(\sigma-1)}\underbrace{m/l}_{\partial m/\partial l} > 0 \tag{15}$$

- Implicit defininition of long-run offshoring costs $\beta\nu(i)$: International wage difference compensates for long-run offshoring costs at the marginal task:

$$\frac{w}{w^*} = \beta\nu(l) \tag{16}$$

Offshoring adjustment

- Definition of short run: composition of varieties is constant $\hat{\boldsymbol{n}} = 0$

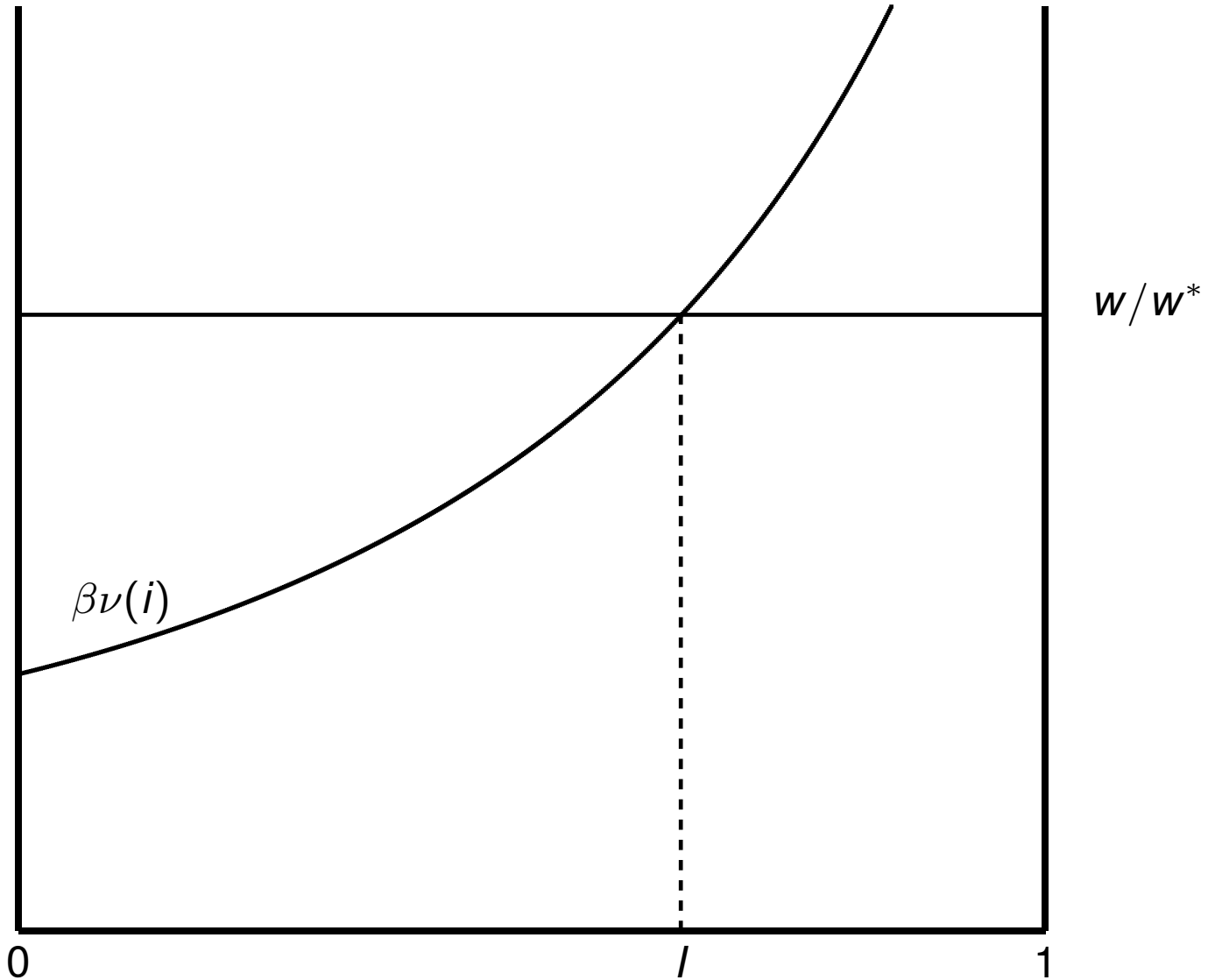
$$\frac{\hat{\boldsymbol{l}}^{\boldsymbol{s}}}{\hat{\beta}} = -\frac{\beta \int_0^{\boldsymbol{l}} \tau(i)\mathrm{d}i + \frac{\sigma}{\boldsymbol{nx}}}{\boldsymbol{l}\left(\beta\tau(\boldsymbol{l}) + \frac{1}{(\boldsymbol{1-h})\boldsymbol{L}}\right) + \frac{\sigma}{\boldsymbol{nx}}\frac{\hat{\Psi}}{\hat{l}}} < 0, \tag{17}$$

- Definition of long run: composition of varieties adjusts $\hat{\boldsymbol{n}} = \hat{\boldsymbol{h}} + \hat{\boldsymbol{L}} - \hat{l}$

$$\frac{\hat{\boldsymbol{l}}^{\boldsymbol{l}}}{\hat{\beta}} = -\frac{\beta \int_0^{\boldsymbol{l}} \tau(i)\mathrm{d}i + \frac{\sigma}{\boldsymbol{nx}}}{\boldsymbol{l}\left(\beta\tau(\boldsymbol{l}) + \frac{1}{(\boldsymbol{1-h})\boldsymbol{L}}\right) + \frac{\sigma}{\boldsymbol{nx}}\frac{\hat{\Psi}}{\hat{l}} + \frac{1}{\boldsymbol{nx}}} < 0, \tag{18}$$

- It is easy to see that $\frac{\partial l^s}{\partial \beta} < \frac{\partial l^l}{\partial \beta} < 0$.

Offshoring adjustment cont'd



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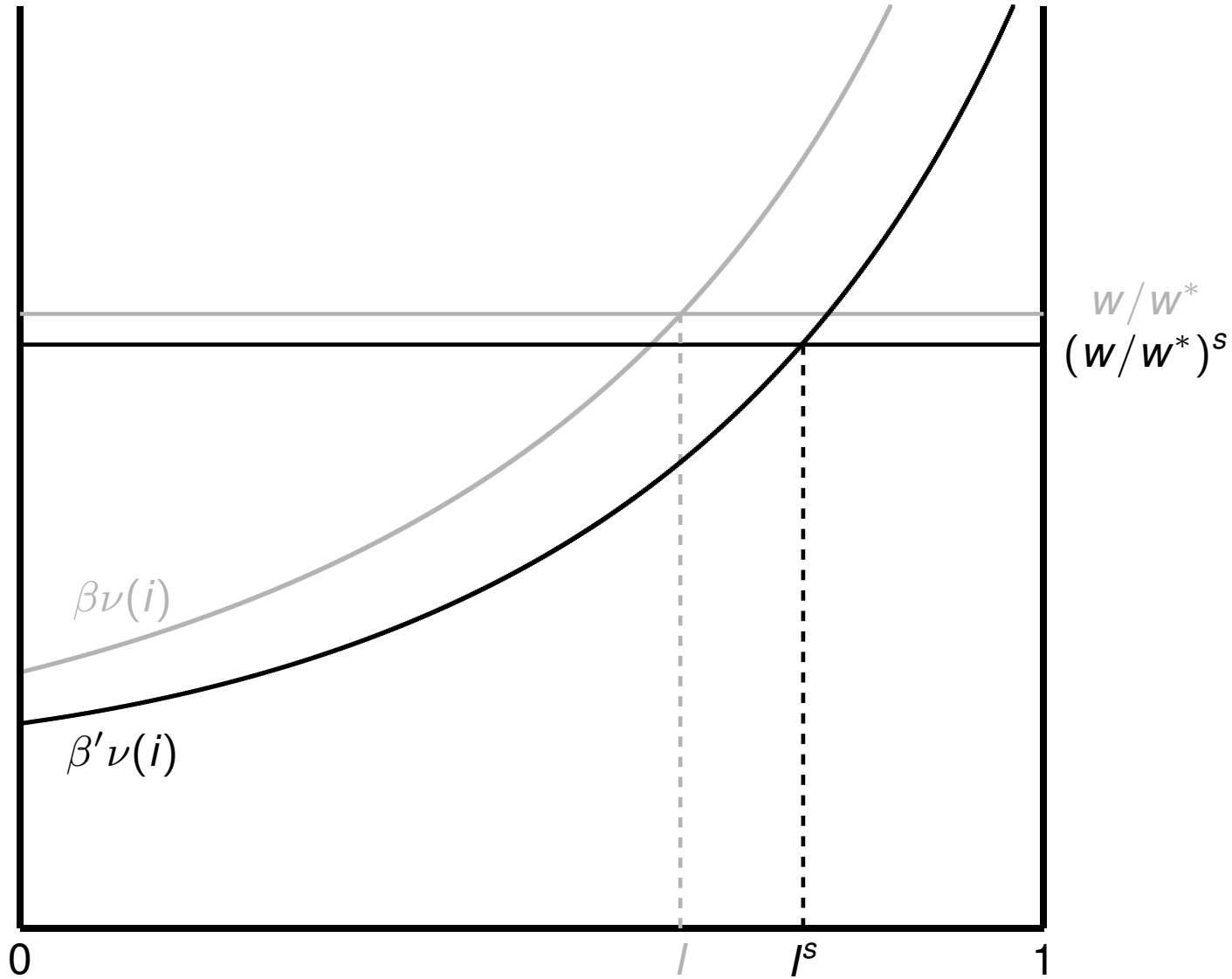

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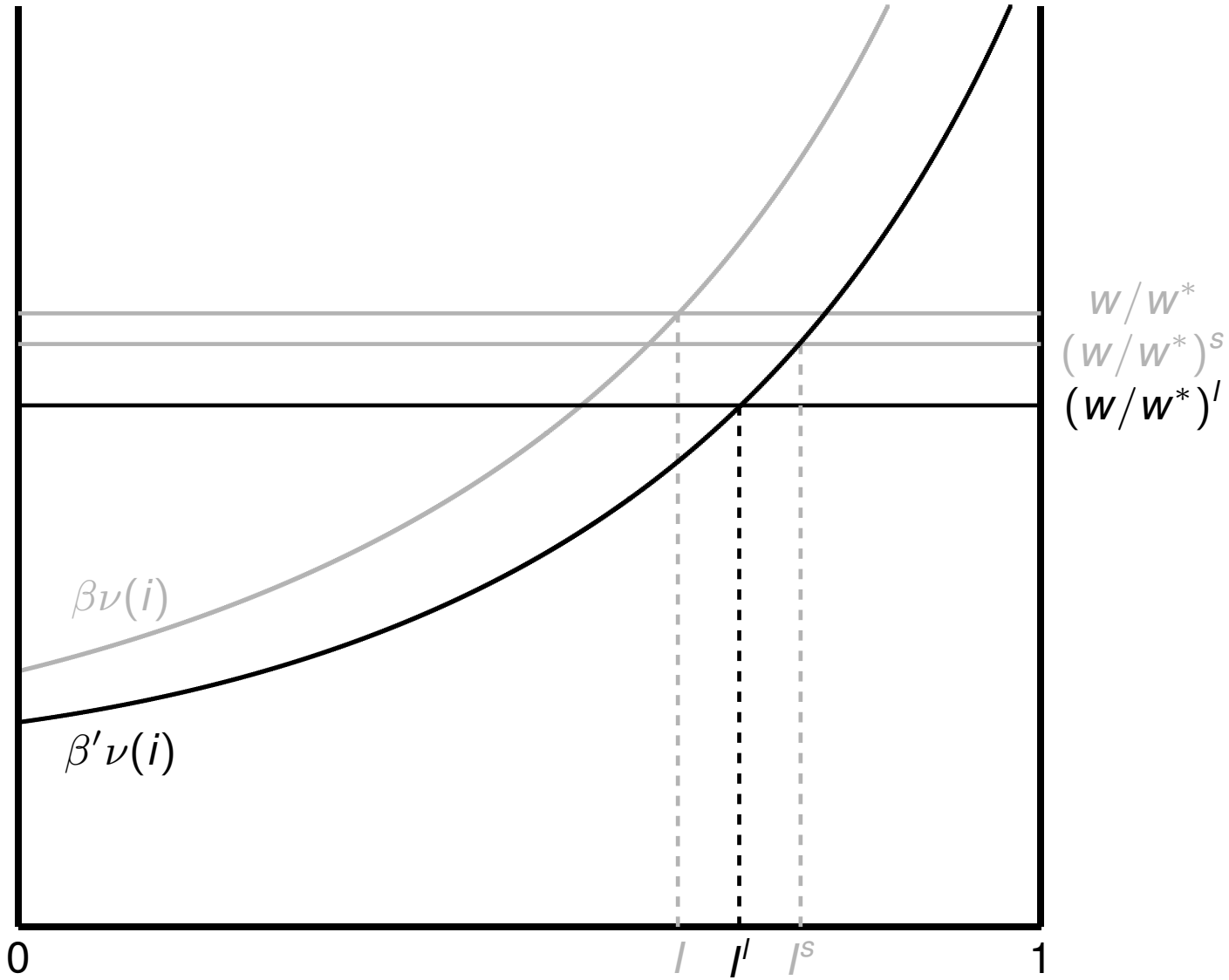

Skill premium

$$\omega := \frac{s}{w} = \frac{1-h}{h}\frac{\Theta(l)}{1-l} \cdot \frac{n+n^*}{n} \cdot \frac{g}{r+g+m} \cdot \frac{1}{\sigma-1}$$

Four components

1. Efficiency units of low skilled workers in domestic production relative to high-skilled workers.
2. Inverse share of Northern varieties
3. Innovation rate relative to the discount rate of firm profits in North.
4. Firm profits relative to production costs

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Offshoring and the skill premium

$$\hat{\omega} = \hat{\Theta}(I) + \frac{\mathrm{d}I}{1-I} + \mu\hat{m}(I), \tag{19}$$

where

$$\mu := \frac{n^*}{n+n^*}\hat{n}^*(m) - \frac{m}{r+g+m} \tag{20}$$

- Productivity effect is < 0 while labor supply effect is > 0.
- First bit of offshoring does not feature a productivity increase: unambiguously in favor of high-skilled. Productivity effect may dominate when offshoring volume large and offshoring costs $\tau(i)$ rise steeply.
- Intertemporal profit effect caused by instantaneous increase of the discount rate: higher probability that the high-skilled are harmed from offshoring.
- Composition effect requires adjustment of produced varieties towards the new steady-state $\hat{n}^*(m) \neq 0$: in the long-run, high-skilled more likely to gain.

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Patterns of wage changes

β high ($\mathbf{I = 0}$)

Period	$\Delta\beta$	ΔI	$\Delta s/w$	Prod. E	LS E	Int.P. E	Comp. E
1	$\downarrow$	$\uparrow$	$\uparrow$	-	$\uparrow$	$\downarrow$	-
2	-	$\downarrow$	$\uparrow$	-	-	-	$\uparrow$
3	-	$\downarrow$	$\uparrow$	-	-	-	$\uparrow$
1	$\downarrow$	$\uparrow$	$\uparrow$	-	$\uparrow$	$\downarrow$	-
2	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$
3	$\downarrow$	$\uparrow$	$\uparrow$	$\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$

β low ($\mathbf{I > 0}$)

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3	-	$\downarrow$	$\uparrow$	-	-	-	$\uparrow$
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2	$\downarrow$	$\uparrow$	$\uparrow$?	$\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$
3	$\downarrow$	$\uparrow$	$\uparrow$?	$\downarrow$	$\uparrow$	$\downarrow$	$\uparrow$

Main contributions

- Dynamic model that explicitly takes into account the role of imitation for firms' offshoring decisions.
- Allows to show that the dynamic transition path of the offshoring volume is characterized by overshooting when the offshoring technology changes.
- Creates new channels by which offshoring affects skill premium:
  1. Short-run intertemporal profit effect
  2. Long-run composition effect
- Correlation of changes in offshoring and skill premium depends on the characteristics of the underlying shock.

Appendix

Motivation cont'd

- Branstetter *et al.* (JIE 2011): International activity of MNEs increases significantly after patent reform in developing countries.

Table 2
U.S. multinational affiliate responses to reform.

Dependent variable:	Log of affiliate assets		Log of affiliate net PPE		Log of affiliate employment compensation		100 × log of intrafirm royalty payments/ affiliate sales	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post reform dummy	0.1590	0.1114	0.1248	0.0245	0.1634	0.1210	0.0787	−0.1311
	(0.0140)**	(0.0173)**	(0.0328)**	(0.0430)	(0.0157)**	(0.0205)**	(0.0268)**	(0.0274)**
Post reform dummy * high Technology transfer dummy		0.0912		0.1882		0.0790		0.3985
		(0.0181)**		(0.0443)**		(0.0217)**		(0.0323)**
Host country corporate tax rate	0.1315	0.1361	0.4965	0.5099	0.4701	0.4746	−0.0567	−0.0286
	(0.0985)	(0.0985)	(0.2371)*	(0.2370)*	(0.1104)**	(0.1104)**	(0.1690)	(0.1680)
Host country inward FDI restrictions	−0.0610	−0.0601	−0.0993	−0.0971	−0.0488	−0.0483	0.0373	0.0407
	(0.0386)	(0.0386)	(0.0749)	(0.0748)	(0.0328)	(0.0327)	(0.0512)	(0.0512)
Host Country Capital Controls	−0.0675	−0.0664	−0.0825	−0.0819	−0.0382	−0.0376	−0.0957	−0.0926
	(0.0235)**	(0.0235)**	(0.0556)	(0.0555)	(0.0244)	(0.0244)	(0.0436)*	(0.0431)*
Host Country Withholding Tax Rate	0.3340	0.3365	0.4333	0.4473	−0.4594	−0.4565	−0.5805	−0.5657
	(0.1387)*	(0.1386)*	(0.3137)	(0.3135)	(0.1646)**	(0.1646)**	(0.2342)*	(0.2324)*
Host Country Trade Openness	0.0063	0.0062	0.0072	0.0071	0.0001	0.0001	−0.0072	−0.0074
	(0.0016)**	(0.0016)**	(0.0035)*	(0.0035)*	(0.0016)	(0.0016)	(0.0029)*	(0.0029)*
Log of Host Country GDP per Capita	0.3335	0.3406	0.6986	0.7166	0.4639	0.4713	0.6684	0.6963
	(0.1522)*	(0.1518)*	(0.2916)*	(0.2908)*	(0.1904)*	(0.1900)*	(0.3208)*	(0.3193)*
Log of Host Country GDP	0.9086	0.9037	−0.1305	−0.1374	0.6229	0.6179	0.0196	−0.0007
	(0.1635)**	(0.1632)**	(0.3234)	(0.3226)	(0.1928)**	(0.1924)**	(0.3357)	(0.3339)
Log of Real Exchange Rate	−0.3179	−0.3161	−0.3280	−0.3231	−0.3673	−0.3657	−0.1181	−0.1097
	(0.0198)**	(0.0198)**	(0.0483)**	(0.0483)**	(0.0238)**	(0.0238)**	(0.0403)**	(0.0401)**
Log of Parent R&D Expenditures	0.0079	0.0076	0.0322	0.0315	0.0056	0.0054	0.0079	0.0072
	(0.0036)*	(0.0035)*	(0.0089)**	(0.0089)**	(0.0040)	(0.0040)	(0.0041)	(0.0040)
Log of Parent System Sales	0.0461	0.0467	0.0544	0.0555	0.0596	0.0601	0.0087	0.0058
	(0.0089)**	(0.0088)**	(0.0143)**	(0.0143)**	(0.0093)**	(0.0093)**	(0.0091)	(0.0092)
No. of obs.	26,184	26,184	22,342	22,342	24,844	24,844	25,600	25,600
R-squared	0.8882	0.8884	0.8375	0.8377	0.8788	0.8789	0.6625	0.6651

Trade in tasks

According to Grossman & Rossi-Hansberg (2008):

> *"bits of value being added in many different locations"*

- Continuum of "intermediate inputs" $\in [0; 1]$.
- Strictly monotonic function determines the extensive margin of task trade, e.g. by:
  - factor input coefficients (Feenstra & Hanson, 1997)
  - coordination costs (Grossman & Rossi-Hansberg, 2008)
  - relative productivity of factors (Autor & Acemoglu, 2010)
- $\rightarrow$ Endogenous productivity increase from task trade.

Labor market clearing

$$(1-h)L = \frac{s}{w}\frac{1-I}{\Theta(I)}ag\frac{g+\rho+m}{g+m}(\sigma-1)$$
$$= hL\frac{(1-I)}{\Theta(I)}\frac{s}{w}\frac{h_N L/a + Ih_S L^*/a^* + \rho}{hL/a + IhL^*/a^*}(\sigma-1)$$

and

$$(1-h^*)L^* = \frac{s^*}{w^*}\frac{a^* m}{I}\frac{\rho+g}{g}(\sigma-1)$$
$$+ \frac{hL}{\Theta(I)}\frac{s}{w}\frac{g+\rho+m}{g+m}(\sigma-1)\beta\int_0^I \tau(i)\mathrm{d}i$$
$$= h^*L^*\frac{s^*}{w^*}\frac{hL/a+\rho}{hL/a}(\sigma-1)$$
$$+ \frac{hL}{\Theta(I)}\frac{s}{w}\frac{hL/a + Ih^*L^*/a^* + \rho}{hL/a + IhL^*/a^*}(\sigma-1)\beta\int_0^I \tau(i)\mathrm{d}i$$

Dynamic Offshoring

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$$\frac{w}{w^*} = \beta\nu(l), \tag{23}$$

- where

$$\nu(l) := \frac{\frac{r+g+m}{m}l(\sigma-1)\tau(l) + \int_0^l \tau(i)\mathrm{d}i}{\frac{r+g+m}{m}l(\sigma-1) - (1-l)} > \tau(l) \tag{24}$$

Short-run offshoring adjustment

- Definition of short run: composition of varieties is constant $\hat{\boldsymbol{n}} = 0$
- I can analyze changes in e.g. β, $\boldsymbol{L}$, and $\boldsymbol{h}$
- The effect on I from changes in β:

$$\frac{\hat{\boldsymbol{I}}^{s}}{\hat{\beta}} = -\frac{\beta \int_0^I \tau(i)\mathrm{d}i + \frac{\sigma}{\boldsymbol{nx}}}{I\left(\beta\tau(I) + \frac{1}{(1-\boldsymbol{h})\boldsymbol{L}}\right) + \frac{\sigma}{\boldsymbol{nx}}\frac{\hat{\Psi}}{\hat{I}}} < 0, \tag{25}$$

- Direct effect on labor demand
- Effect on labor demand via price change of Northern varieties
- Effect of I on labor demand at the extensive margin
- Effect of I on labor demand at the intensive margin of offshoring. It is positive if relative wages of Northern workers rise faster than the offshoring productivity factor $\Theta(I)$ and negative else: $\hat{\Psi}/\hat{I} := \hat{\boldsymbol{w}}/\hat{I} + \hat{\Theta}/\hat{I}$

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$$\frac{\hat{\boldsymbol{I}}^{s}}{\hat{\beta}} = -\frac{\beta \int_0^I \tau(i)\mathrm{d}i + \frac{\sigma}{\boldsymbol{nx}}}{I\left(\beta\tau(I) + \frac{1}{(1-\boldsymbol{h})\boldsymbol{L}}\right) + \frac{\sigma}{\boldsymbol{nx}}\frac{\hat{\Psi}}{\hat{I}}} < 0, \tag{25}$$

- Direct effect on labor demand
- Effect on labor demand via price change of Northern varieties
- Effect of I on labor demand at the extensive margin
- Effect of I on labor demand at the intensive margin of offshoring. It is positive if relative wages of Northern workers rise faster than the offshoring productivity factor $\Theta(I)$ and negative else: $\hat{\Psi}/\hat{I} := \hat{\boldsymbol{w}}/\hat{I} + \hat{\Theta}/\hat{I}$

Short-run offshoring adjustment

- Definition of short run: composition of varieties is constant $\hat{\boldsymbol{n}} = 0$
- I can analyze changes in e.g. β, $\boldsymbol{L}$, and $\boldsymbol{h}$
- The effect on I from changes in β:

$$\frac{\hat{\boldsymbol{I}}^{s}}{\hat{\beta}} = -\frac{\beta \int_0^I \tau(i)\mathrm{d}i + \frac{\sigma}{\boldsymbol{nx}}}{I\left(\beta\tau(I) + \frac{1}{(1-\boldsymbol{h})\boldsymbol{L}}\right) + \frac{\sigma}{\boldsymbol{nx}}\frac{\hat{\Psi}}{\hat{I}}} < 0, \tag{25}$$

- Direct effect on labor demand
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Long-run offshoring adjustment

- Definition of long run: composition of varieties adjusts $\hat{\boldsymbol{n}} \neq 0$
- More precisely, I can write:

$$\hat{\boldsymbol{n}} = \hat{\boldsymbol{h}} + \hat{\boldsymbol{L}} - \hat{I} \tag{26}$$

- This yields as long-run effect on I from changes in β:

$$\frac{\hat{I}^I}{\hat{\beta}} = -\frac{\beta \int_0^I \tau(i)\mathrm{d}i + \frac{\sigma}{\boldsymbol{nx}}}{I\left(\beta\tau(I) + \frac{1}{(\mathbf{1}-\boldsymbol{h})\boldsymbol{L}}\right) + \frac{\sigma}{\boldsymbol{nx}}\frac{\hat{\Psi}}{\hat{I}} + \frac{1}{\boldsymbol{nx}}} < 0, \tag{27}$$

- It is easy to see that $\frac{\partial I^S}{\partial \beta} < \frac{\partial I^I}{\partial \beta} < 0$.