Trading Tasks: 
A Simple Theory of Offshoring

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and

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Introduction

- The nature of international trade has changed

- For centuries, trade largely entailed an exchange of complete goods
  - Transportation and communication were exceedingly slow and costly
  - Specialization by task, as noted by Adam Smith, required proximity

- Paradigm of trade theory conceptualized the production process as generating finished goods from bundles of inputs combined at a single plant

- Now, trade increasingly involves bits of value being added in many different locations: Trade in tasks
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Boom in “offshoring” of both manufacturing tasks and other business functions

- Revolutionary advances in transportation and (especially) communications technology
- Weaker link between specialization and geographic concentration
  - Firms can take advantage of factor cost disparities in different countries without sacrificing the gains from specialization

Need for a new paradigm, one that puts task trade at center stage

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Some Evidence of Task Trade

- Hard evidence on the growing scale of task trade is hard to come by
  - Trade data are collected and reported as gross flows rather than as foreign value added (NRC, 2006)
  - Some of this trade leaves no paper trail
- But hints of the global disintegration of the production process abound:
  - Share of imported inputs in total inputs used by goods-producing sectors in the US rose from 7% in 1972 to 18% in 2000
  - Intra-firm trade accounted for 47% of U.S. total imports in 2005
  - In the US, imports of Business, Professional and Technical (BPT) services have increased by more than 66% in real terms from 1997 to 2004
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Imported Inputs
Source: OECD Input-Output Matrices

- Share of Imported Inputs in Total Inputs in Goods Producing Sectors, US
- Share of Imported Inputs in Gross Output in Goods Producing Sectors, US
Related Party Trade as a Share of U.S. Imports

Source: BEA

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Grossman and Rossi-Hansberg
But world is not (yet) flat

- Trade in tasks is still costly and varies widely across different tasks
  - “Routine” tasks vs. “Nonroutine” tasks (Autor, Levy and Murnane (ALM), 2003)
    - ALM document an increase in the number of “Nonroutine” tasks relative to “Routine” tasks in the US
  - Tasks that require “Codifiable” information and those that require “Tacit” information (Leamer and Storper, 2001)
  - Tasks that require physical contact and geographic proximity and those that generate outputs that can be delivered impersonally and from a distance (Blinder, 2006)

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Trends in Nonroutine and Routine Tasks
Source: Autor, Levy and Murnane (2003)

Year
Mean Task Input in Percentiles of 1960 Task Distribution
Nonroutine Tasks
Routine Tasks

Grossman and Rossi-Hansberg
Trading Tasks
Towards a New Paradigm

- Our approach begins with a different conceptualization of the production process
  - Production of every good requires the performance of a continuum of tasks by each of the factors of production
  - Tasks might be performed in different locations
  - Firms are motivated to offshore tasks by factor-cost savings, but trading tasks is costly
- More general, but here we develop a model with two industries, perfect competition, and an arbitrary number of factors greater than one
- We then study how decreases in offshoring costs affect the wages of different types of labor
- Perhaps surprisingly, we find that low-skilled workers may benefit from the production of low-skilled tasks abroad
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Previous Literature

  - GE structure in these analyses has been kept to a bare minimum
  - Hard to study GE implications of offshoring

  - No marginal decisions about how to organize production
  - Many different configurations could characterize an equilibrium

  - Uniform costs of trading intermediate goods
  - Intermediate good produced in only one location

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The Model

- Model allows trade in tasks, as well as trade in goods
- Production involves a continuum of $L$ tasks, continuum of $H$ tasks, etc., possibly with substitution
- Industries differ in factor intensity, as usual
- Normalize measure of tasks of each type to one, and model factor intensity differences as different required amounts of factors per task
  - Equivalently: different measures of tasks, with one unit of factor per task
- Cost of offshoring task $i$ is given by $\beta t(i) \geq 1$
- Order tasks so $t'(i) \geq 0$ and assume $t(i)$ continuously differentiable
- For the moment only $L$-tasks can be offshored and same $t(i)$ schedule in each industry
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Firm’s Problem

- Consider production in sector $j$
- Assume firms, or industry, produces using a Constant Returns to Scale technology
- Firms maximize profits

$$\max_{Y_j, I_j} p_j Y_j - c_j Y_j$$

where

$$c_j = wa_{Lj}(\cdot)(1 - I) + w^* a_{Lj}(\cdot) \int_{0}^{I} \beta t(i) di + sa_{Hj}(\cdot) + \ldots$$

- Firm will offshore tasks $[0, I]$ where

$$w = \beta t(I) w^*,$$

and if the firm produces a positive amount

$$p_j = c_j$$
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\max_{Y_j, I_j} Y_j - c_j Y_j
\]

where

\[
c_j = w a_L (\cdot) (1 - I) + w^* a_L (\cdot) \int_0^I \beta t(i) di + s a_H (\cdot) + \ldots
\]

- Firm will offshore tasks \([0, I]\) where

\[
w = \beta t(I) w^*,
\]

and if the firm produces a positive amount

\[
p_j = c_j
\]
Marginal Costs

Cost of producing good $j$ using home technology are given by

$$
c_j = w a_{Lj} (\cdot) (1 - I) + w^* a_{Lj} (\cdot) \int_0^l \beta t(i) di + s a_{Hj} (\cdot) + \ldots
$$

$$
= w a_{Lj} (\cdot) (1 - I) + w a_{Lj} (\cdot) \frac{\int_0^l t(i) di}{t(l)} + s a_{Hj} (\cdot) + \ldots
$$

$$
= w a_{Lj} (\cdot) \Omega(I) + s a_{Hj} (\cdot) + \ldots
$$

where

$$
\Omega(I) = 1 - I + \frac{\int_0^l t(i) di}{t(l)}
$$

$$
\Omega'(I) = -\frac{\int_0^l t(i) di}{t^2(l)} t'(I) \leq 0
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So possibility of offshoring affects costs exactly as labor-augmenting technological change
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So possibility of offshoring affects costs exactly as labor-augmenting technological change.
The Three Effects of Offshoring

- To allow for all the potential effects of offshoring, we need a model with (at least) three factors and (at least) two goods.

- Price less or equal than unit cost implies

\[
1 = w\Omega a_{Lx}(s/w\Omega, \cdot) + sa_{Hx}(s/w\Omega, \cdot) + \ldots
\]

\[
p \leq w\Omega a_{Ly}(s/w\Omega, \cdot) + sa_{Hy}(s/w\Omega, \cdot) + \ldots
\]

- Factor market clearing implies

\[
a_{Lx}x(1-I) + a_{Ly}y(1-I) = L
\]

\[
\iff a_{Lx}x + a_{Ly}y = \frac{L}{1-I}
\]

\[
a_{Fx}x + a_{Fy}y = F \text{ for } F = H, \ldots
\]

- These \(2 + \nu\) equations determine \(x, y, \Omega w, s\) as functions of \(p, I\) and \(L, H, \ldots\)
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The Three Effects of Offshoring

- $p$ and $I$ are endogenous—determined in world equilibrium
- To close the model, we need to specify the foreign country’s equilibrium conditions and the world market clearing conditions, which will allow us to determine $I$ and $p$
- But instructive to treat $I$ and $p$ as exogenous for the moment
- Differentiating totally the $2 + v$-equation system on the previous slide we obtain

$$
\hat{w} = -\hat{\Omega} + \mu_1 \hat{p} - \mu_2 \frac{dl}{1 - I}
$$

$$
\hat{s} = -\mu_3 \hat{p} + \mu_4 \frac{dl}{1 - I}
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Small Heckscher-Ohlin Economy

- Consider a small economy ($p$ and $w^*$ fixed) with two factors, $L$ and $H$ and two goods. Then

$$\theta_{Lx} (\hat{w} + \hat{\Omega}) + \theta_{Hx} \hat{s} = 0$$
$$\theta_{Ly} (\hat{w} + \hat{\Omega}) + \theta_{Hy} \hat{s} = \hat{p} = 0$$

which implies that

$$\hat{w} = -\hat{\Omega} \quad \text{and} \quad \hat{s} = 0$$

- Since $w = \beta t(I) w^*$ and $w^*$ is fixed, $\hat{w} = \hat{\beta} + \hat{t}(I)$, so

$$\frac{dl}{d\beta} = - \frac{(1 - I) t(I) + \int_0^I t(i) di}{\beta t'(I)(1 - I)} < 0$$

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Offshoring increases productivity of workers that remain employed at home

- Lower $\beta$ implies a lower cost of offshoring the marginal tasks and lower cost of offshoring all the infra-marginal tasks
- Benefits from improved offshoring in proportion to the share of low-skilled labor

Compare: Offshoring vs. Immigration

- For marginal immigrant, $w = w^* \beta \tau(I)$
- But domestic firms may pay $w$ to all immigrants, unless they can price discriminate. Then rents may go to immigrants

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The effect of changes in $\beta$ on wages is given by

$$\hat{w} = -\hat{\Omega} = -\hat{\beta} \frac{1}{(1 - I)} \int_0^I \frac{t(i)}{t(I)} di$$

- If $I = 0$, $\hat{w} = -\hat{\Omega} = 0$, and so there is no productivity effect.
- If $I > 0$, $\hat{w} = -\hat{\Omega} > 0$. Moreover, if $\eta(i) = t'(i) (1 - i) / t(i)$ constant or $\eta(i) < 1$ for all $i$, the productivity effect increases with $I$ everywhere.

What if easier to offshore in $L$-intensive industry relative to $H$-intensive industry?

- This strengthens effect. If offshoring only possible in $L$-intensive industry $y$,

$$\hat{w} = -\hat{\Omega} \left( \frac{\theta_{Hx} \theta_{Ly}}{\theta_{Hx} \theta_{Ly} - \theta_{Lx} \theta_{Hy}} \right) > -\hat{\Omega} > 0 \quad \text{and} \quad \hat{s} = -\frac{\theta_{Lx}}{\theta_{Hx}} \hat{w} < 0$$
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Characterization

• In general

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where \(\Omega_x\) is defined analogously to \(\Omega_y\).

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- Take, for example, the case in which \(t_x(i) = \alpha t_y(i)\) with common factor \(\beta\).
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  - Then, if \(\eta_x\) and \(\eta_y\) are constants, or if \(\eta_x(l_x) < 1\) and \(\eta_y(l_y) < 1\), \(\alpha < 1\) implies \(l_x > l_y\) and \(-\hat{\Omega}_y > -\hat{\Omega}_x\)
Large Heckscher-Ohlin Economy

- Need a reason for differences in factor prices across countries
  - Assume foreign country has inferior technology so that offshoring flows in one direction (with $\beta_t(i) \geq 1$ all $i$)
  - Let $A^*$ measure Hicks-neutral technological inferiority in both industries, then with incomplete specialization
    \[
    A^*a^*_L w^* + A^*a^*_H s^* = 1
    \]
    \[
    A^*a^*_L w^* + A^*a^*_H s^* = p
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- Incomplete specialization implies that in equilibrium there is adjusted Factor Price Equalization:
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  w \Omega = w^* A^*
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Incomplete specialization implies that in equilibrium there is adjusted Factor Price Equalization:

$$w \Omega = w^* A^*$$
$$s = s^* A^*$$
This implies that both countries have similar $a_{Fj}$'s, so factor clearing conditions are given by

$$A^*a_{Lx}x^* + A^*a_{Ly}y^* + \beta \int_0^l t(i)di (a_{Lx}x + a_{Ly}y) = L^*$$

$$A^*a_{Hx}x^* + A^*a_{Hy}y^* = H^*$$

or

$$a_{Lx}x^* + a_{Ly}y^* = \frac{L^*}{A^*} - \frac{\beta}{(1 - l)A^*} \left[ \int_0^l t(i)di \right] L$$

$$a_{Hx}x^* + a_{Hy}y^* = \frac{H^*}{A^*}$$
After some algebra we obtain

\[ x + x^* = \frac{a_{Ly} \left( H + \frac{H^*}{A^*} \right) - a_{Hy} \left( \frac{L^*}{A^*} + \frac{L}{\Omega} \right)}{\Delta_a} \]

\[ y + y^* = \frac{a_{Hx} \left( \frac{L^*}{A^*} + \frac{L}{\Omega} \right) - a_{Lx} \left( H + \frac{H^*}{A^*} \right)}{\Delta_a} \]

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\[ \Delta_a = a_{Hx}a_{Ly} - a_{Lx}a_{Hy} > 0 \]

So \( \beta \downarrow \Rightarrow I \uparrow \Rightarrow \Omega \downarrow \Rightarrow \frac{x + x^*}{y + y^*} \downarrow \Rightarrow p \downarrow \) (with standard preferences)

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Hence, $\hat{p} \downarrow$ implies Relative Price Effect favors $H$ and harms $L$

Overall:

$$\hat{w} = -\hat{\Omega} + \mu_1 \hat{p}$$

and

$$\hat{s} = -\mu_3 \hat{p}$$

$H$ must gain, $L$ may gain or lose

Possible Pareto gains for home country if productivity effect large enough

Note complete analogy with labor-augmenting technological progress in home country
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The Labor-Supply Effect

- Present as long as there are more factors than goods
  - Short term effect if factors are specific because of frictions on factor mobility across industries
- Simplest setting to illustrate the effect is small country specialized in producing one good with two factors
- Then, if price of good normalized to one, equilibrium is given by

\[ \Omega w a_L + s a_H = 1 \]

\[ a_L x = \frac{L}{1 - I} \]

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Grossman and Rossi-Hansberg
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Differentiate to obtain

\[ \theta_L (\hat{w} + \hat{\Omega}) + (1 - \theta_L) \hat{s} = 0 \]

and since

\[ \frac{a_L}{a_H} \frac{H}{L} = \frac{L}{1-l} \]

if \( \sigma \) is the elasticity of substitution between low and high-skilled labor

\[ \sigma(\hat{s} - \hat{w} - \hat{\Omega}) = \frac{dl}{1-l} \]

So

\[ \hat{w} = -\hat{\Omega} - \frac{1 - \theta_L}{\sigma} \frac{dl}{1-l} \]
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- From the definition of \( \Omega = 1 - l + \int_0^l t(i) / t(l) \, di \) we know that

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\]

\[
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\]

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- Labor-supply effect is given by

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- Large when \( \sigma \) small or labor share, \( \theta_L \), small

- At \( I = 0 \),

\[
\hat{w} = \frac{1 - \theta_L}{\sigma} \frac{dl}{1 - l} < 0
\]

- At \( I > 0 \), \( \hat{w} > 0 \) iff

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- Can also handle Specific-Factors model, which has all three effects
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Offshoring Skill-Intensive Tasks

- Recent policy debate has focused on offshoring of white collar jobs
- May interpret this as offshoring of $H$-tasks
- Offshoring of $H$-tasks can be easily incorporated, for example, in small HO economy. Then

$$w = w^* \beta_L t_L(l_L) \quad \text{and} \quad s = s^* \beta_H t_H(l_H)$$

and

$$a_{Lx} w \Omega_L + a_{Hx} s \Omega_H = 1$$
$$a_{Ly} w \Omega_L + a_{Hy} s \Omega_H = p$$

determine $l_L(\beta_L)$ and $l_H(\beta_H)$ and

$$\hat{w} = -\hat{\Omega}_L \quad \text{and} \quad \hat{s} = -\hat{\Omega}_H$$

- Thus, $\beta_H \downarrow$ implies $s \uparrow$, $w$ unchanged
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US wages for blue collar workers roughly flat over last 10 years

Assume $A$ has been rising in US at rate of TFP growth

Look at TOT in manufactured goods vis-a-vis non-industrialized countries

- TOT have been improving dramatically for US

Take plausible values for Stolper-Samuelson coefficient, using labor shares in various import and export industries. These imply that low-skill wages should be falling, despite TFP improvement

Thus, positive residual

- A bit heroic to associate this with net positive productivity plus labor supply effects of offshoring

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Average Blue Collar Wage Decomposition

Nominal Wage
Wage 97 + TFP
Real Wage
Wage 97 + TFP + SS

Year
Wage
$12.00 $12.50 $13.00 $13.50 $14.00 $14.50 $15.00 $15.50

Conclusion

- **In the past:**
  - Countries produced mostly complete products that they consumed and traded with other nations
  - Gains from worker specialization by dividing the production process into a variety of tasks required proximity: Industrial factory

- **Today:**
  - Drastic reductions in transport and communication costs have facilitated direct trade in tasks
  - Traditional benefits from worker specialization plus gains generated when tasks are performed at the lowest cost location

- Proposed a new paradigm where task trade takes center stage and:
  
  *Offshoring of a particular factor’s tasks is equivalent to factor-augmenting technological progress*

- Offshoring may lead to Pareto gains for source country
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