Organizing the Global Value Chain

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Motivation and Introduction

Many production processes are sequential in nature:

- R&D $\longrightarrow$ Raw materials processing $\longrightarrow$ Basic components

  $\longrightarrow$ Complex assembly $\longrightarrow$ Final goods $\longrightarrow$ Sales and Distribution

- Downstream stages often cannot commence until upstream stages are completed
- Classic motivating example: Henry Ford's Model T production line
- More recently: Reductions in transport and telecommunications costs have accelerated the fragmentation of production lines across country borders
- Existing literature: consequences of sequential location decisions

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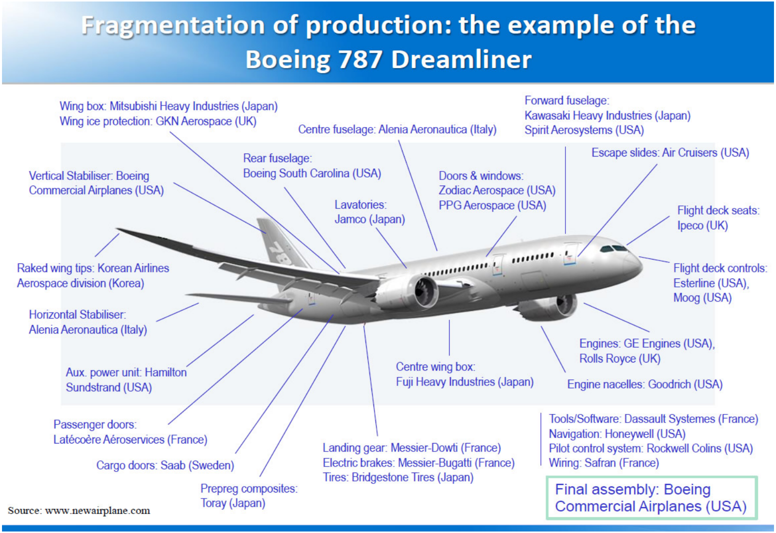
Key Question: What is the optimal way to organize production along such global sequential production processes?

Motivation and Introduction



Some Questions

- Why does the firm not bring the whole production process within its firm boundaries?
- What determines which suppliers are brought inside the firm and which are not, and why might "downstreamness" matter for this?

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- Why does the firm not bring the whole production process within its firm boundaries?
- What determines which suppliers are brought inside the firm and which are not, and why might "downstreamness" matter for this?
- Property-rights theory (Grossman and Hart, 1986, Hart and Moore, 1990) provides the most convincing framework to answer the first question...
- ... so it seems the natural one to use to answer the second question as well

What We Do

To analyze the organizational decisions along sequential production lines:

- Develop a model of firm production with a continuum of uniquely sequenced production stages
- In each stage: Firm contracts with a distinct supplier for a stage-specific input that needs to be made compatible with all other stage inputs
- In an incomplete contracts setting, derive analytical results related to the integrate vs. outsource decisions for securing each stage input
  - Sharp characterization of optimal ownership structure along the value chain
- Empirically test predictions of the model using measures of the prevalence of integration and the level of downstreamness of particular inputs

Related Literature

1. Sequential production
   - Eg: Findlay (1978), Dixit and Grossman (1982), Sanyal (1983), Kremer (1983), Yi (2003), Harms, Lorz, and Urban (2009), Baldwin and Venables (2010), Costinot et al. (2011)
   - Also small literature on incentives in sequential production processes: Winter (2006), Kim and Shin (2011)
2. Property rights theory of the firm in international trade
   - Eg: Grossman and Helpman (2002, 2005), Antràs (2003), Antràs and Helpman (2004, 2008)
3. Empirical evidence
   - Eg: Antràs (2003), Tomiura (2007), Defever and Toubal (2007), Nunn and Trefler (2008a,b), Corcos et al. (2009), Díez (2010), Bernard et al. (2010), Kohler and Smolka (2010)
   - Explore determinants of the intrafirm trade share. Eg: capital intensity.

Plan of Talk

1. Motivation and Introduction
2. **Setup of the Core Model**
3. Key Predictions
4. Extensions
5. Empirical Evidence
6. Conclusion

Basic Setup: Production Function

- Production entails a continuum of stages indexed by $j \in [0, 1]$
- Unique sequence of stages: j increasing as production moves downstream
- Let $x(j)$ be the quantity of compatible intermediate inputs that supplier j delivers to "the firm", then final-good output is

$$q = \theta \left(\int_0^1 x(j)^\alpha dj \right)^{\frac{1}{\alpha}} \quad (1)$$

- θ: firm productivity parameter
- $\alpha \in (0, 1)$: captures how substitutable the stage inputs are

Basic Setup: Sequentiality

- For an input to be compatible, it is necessary that all upstream inputs are compatible

- Alternative recursive representation of technology in (1):

$$q'(m) = \begin{cases} \frac{1}{\alpha}\theta^{\alpha} x(m)^{\alpha} q(m)^{(1-\alpha)} & \text{if all inputs } j < m \text{ are compatible} \\ 0 & \text{otherwise} \end{cases}.$$

- Change in output brought about by supplier at stage m is simple Cobb-Douglas of input m and the value of production up to that stage $q(m)$ (which can be treated as an input to the stage-m production process)

Basic Setup: Supply

- Each intermediate input needs to be produced by a different supplier
- Suppliers need to undertake a relationship-specific investment to produce a compatible input
- Marginal cost of investment is common for all suppliers and equal to c
- One unit of investment generates one unit of the stage j compatible input if previous inputs are compatible; otherwise input is incompatible
- Incompatible inputs can be produced by all agents (including the firm) at a negligible marginal cost, but they add no value to final-good production

Basic Setup: Demand

- Firm faces demand function: $q = Ap^{-1/(1-\rho)}$, $\rho \in (0,1)$
- Gives rise to revenue function: $A^{1-\rho}q^{\rho}$

Some Key Features

Revenue generated up to stage m if all inputs are compatible:

$$r(m) = A^{1-\rho}\theta^{\rho}\left[\int_0^m x(j)^{\alpha}\ dj\right]^{\frac{\rho}{\alpha}} \tag{2}$$

Incremental revenues generated at stage m by producing a compatible input:

$$r'(m) = \frac{\partial r(m)}{\partial m} = \frac{\rho}{\alpha}\left(A^{1-\rho}\theta^{\rho}\right)^{\frac{\alpha}{\rho}}\left[r(m)\right]^{\frac{\rho-\alpha}{\rho}} x(m)^{\alpha}. \tag{3}$$

How does the value of production up to stage m affect the marginal contribution of supplier m?

- If $\rho > \alpha$, the effect is positive (*sequential complements* case)
- If $\rho < \alpha$, the effect is negative (*sequential substitutes* case)

The Role of the Demand Elasticity

Why does ρ matter?

- From a technological point of view, all inputs are complements since $\alpha \in (0, 1)$.
- But when ρ is small, firm faces an inelastic demand function, so marginal revenue falls very quickly with output
- Large investments prior to stage *m* therefore discourage supplier effort at stage *m*.
- It turns out that when $\rho < \alpha$, this revenue effect is strong enough to dominate the physical input complementarity effect.

Incomplete Contracting

Suppose that the environment is one of incomplete contracts

- Compatibility cannot be verified and enforced by a third-party court and neither can revenue-sharing arrangements
- But firm and suppliers have symmetric information regarding compatibility
- Abstract from mechanisms
- Suppliers' payoffs are determined in *ex post* (re)negotiation, after $x(m)$ has been produced

Bargaining

- Supplier m and firm engage in generalized Nash bargaining over the incremental contribution to total revenue made by supplier m, $r'(m)$
- Supplier m's outside option normalized to 0
- The firm's outside option depends on ownership structure (as in Grossman and Hart, 1986). Firm recovers a fraction $\delta(m)$ of the inputs $x(m)$
  - Under outsourcing: $\delta(m) = 0$
  - Under integration: $\delta(m) = \delta \in (0, 1)$
- Let $\beta(m)$ be the share of $r'(m)$ that accrues to the firm in the bargain:

$$\beta(m) = \begin{cases} \beta_O = \beta & \text{if the firm outsources stage } m \\ \beta_V = \beta + (1-\beta)\,\delta^{\alpha} & \text{if the firm integrates stage } m \end{cases}$$

What Does the Firm Do?

- Firm provides the production technology
- Does not carry out investments (but see extensions)
- Decides on organizational mode for each stage

Timing

1. Firm posts contracts for suppliers for each stage $j \in [0,1]$, stating the organizational mode (integration vs outsourcing)
2. Suppliers apply. Firm chooses one supplier for each stage j
3. Production takes place sequentially. At the beginning of each stage m, the supplier is handed the final good completed up to stage m. The supplier chooses $x(m)$ after observing the value of $r(m)$
4. At the end of stage m, the supplier and firm bargain over $r'(m)$. The firm pays the supplier.
5. Output of the final good, q, is realized once the final stage is completed. Total revenue, $A^{1-\rho}q^{\rho}$, $\rho \in (0,1)$, from the sale of the final good is collected by the firm.

Discussion

- Firm and the supplier bargain only at stage m and the terms of exchange are not renegotiated at a later stage
- So bargaining is over supplier's marginal contribution at stage m, not its ultimate (or average marginal) contribution
- Can be rationalized by introducing limited commitment frictions: Hart and Moore (1994), Thomas and Worrall (1994).
- Supplier does not want to delay receiving payment; firm might be constrained in borrowing more than $r'(m)$
- We also rule out side transfers or collusion between different stage suppliers.

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Key Tradeoffs

- Ownership confers a higher fallback option to the firm and allows it to extract more surplus
- But foreseeing a lower return to their investments, integrated suppliers will underinvest relatively more

$$\max_{x(m)} \quad (1-\beta(m))\, r'(m) - cx(m) \tag{4}$$

- Dynamic effect: effect on the incentives to invest of all suppliers that are positioned downstream relative to the supplier being integrated
- This dynamic effect is negative in the complements case, but it is positive in the substitutes case

Supplier Behavior Along the Value Chain

Plug the expression for $x(m)$ to obtain a differential equation in $r(m)$:

$$r'(m) = \frac{\rho}{\alpha}\left(\frac{(1-\beta(m))\,\rho\theta}{c}\right)^{\frac{\alpha}{1-\alpha}} A^{\frac{\alpha(1-\rho)}{\rho(1-\alpha)}}\left(r(m)\right)^{\frac{\rho-\alpha}{\rho(1-\alpha)}}.$$

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Solving this yields revenues up to stage m as a function of model parameters and in particular, the $\beta(j)$'s for $j < m$:

$$r(m) = A\left(\frac{1-\rho}{1-\alpha}\right)^{\frac{\rho(1-\alpha)}{\alpha(1-\rho)}}\left(\frac{\rho\theta}{c}\right)^{\frac{\rho}{1-\rho}}\left[\int_{j=0}^{m}(1-\beta(j))^{\frac{\alpha}{1-\alpha}}\,dj\right]^{\frac{\rho(1-\alpha)}{\alpha(1-\rho)}} \tag{5}$$

And from this expression solve for overall profits of the firm by integrating over stages.

The Make-or-Buy Decision

Proposition

In the complements case ($\rho > \alpha$), there exists a unique $m_C^* \in (0, 1]$, such that: (i) all production stages $m \in [0, m_C^*)$ are outsourced; and (ii) all stages $m \in [m_C^*, 1]$ are integrated within firm boundaries.

In the substitutes case ($\rho < \alpha$), there exists a unique $m_S^* \in (0, 1]$, such that: (i) all production stages $m \in [0, m_S^*)$ are integrated within firm boundaries; and (ii) all stages $m \in [m_S^*, 1]$ are outsourced.

Remark:

- m_C^* and m_S^* can be solved for in closed-form

The Make-or-Buy Decision (cont.)

Additional predictions:

Proposition

Whenever integration and outsourcing coexist along the value chain, i.e., $m_C^* \in (0, 1)$ when $\rho > \alpha$ or $m_S^* \in (0, 1)$ when $\rho < \alpha$, a decrease in ρ or β will necessarily expand the range of stages that are vertically integrated.

Intuition:

- When ρ is low, firm has high market power, and hence will focus on the rent extraction motive for integration
- When β is low, firm's primitive bargaining power is low, so this raises the incentive to integrate

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Extensions

Benchmark model can be readily extended to connect it to the global sourcing framework in Antràs and Helpman (2004) by adding:

1. Headquarter intensity
2. Firm heterogeneity
3. Supplier heterogeneity

Extensions are important for helping us to map the theoretical predictions to the empirics.

Summary of Extensions

1. Headquarter intensity:
   - integration more prevalent in headquarter intensive sectors
   - otherwise similar to core model, but with ρ replaced by $\tilde{\rho} \equiv (1-\eta)\rho$
2. Firm heterogeneity:
   - converts previous within-firm results into predictions regarding the relative prevalence of integration of an input as a function of downstreamness
3. Supplier heterogeneity
   - results generalize but it might be important to control for unobserved cost differences and for selection

Plan of Talk

Empirical specification

$$S_{it} = \beta_1 D_i \times \mathbf{1}(\rho_i < \rho_{med}) + \beta_2 D_i \times \mathbf{1}(\rho_i > \rho_{med}) + \beta_3 \mathbf{1}(\rho_i > \rho_{med}) + \beta_X X_i + \alpha_t + \mu_i + \varepsilon_{it}$$

- S_{it}: share of intrafirm trade in U.S. imports for industry i, year t
  - Data source: U.S. Census Bureau Related Party Database
  - 257 manufacturing industries, 11 years (2000-2010)
- D_i: "downstreamness" of an industry
- $\mathbf{1}(\rho_i \gtrless \rho_{med})$: indicator for complements vs substitutes case
- X_i: other industry controls
- α_t: year fixed effects (if country-industry-year observations are used, include country-year fixed effects, α_{ct}, instead)
- Cluster standard errors by industry

Pros and Cons of Using Intrafirm Trade Data

Some pros:

- Compiled from administrative records from official import and export merchandise trade statistics
- There is plenty of variation in the data
- Easier to spot "fundamental" forces that appear to shape whether international transactions are internalized or not
- Potential to exploit 'exogenous' changes in sector characteristics or in institutional features of importing/exporting countries

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Some cons:

- Aggregates firm decisions; cannot control for firm-level determinants
- Information only on the sector of the good being transacted (not the buying industry)
- Not always clear who is integrating whom (backward vs. forward integration) and how large is the ownership stake
- U.S. firm level sourcing decisions might not be reflected in U.S. trade data

Measuring downstreamness: Preliminaries

- Note the following identity

$$\begin{aligned} Y_i &= F_i + Z_i \\ &= F_i + \underbrace{\sum_j d_{ij} F_j}_{\text{direct use of } i \text{ as input}} + \underbrace{\sum_j \sum_k d_{ik} d_{kj} F_j + \sum_j \sum_k \sum_l d_{il} d_{lk} d_{kj} F_j + \ldots}_{\text{indirect use of } i \text{ as input}} \end{aligned}$$

- In compact matrix form

$$\begin{aligned} Y &= F + DF + D^2 F + D^3 F + D^4 F \ldots \\ &= F + D \left[I - D \right]^{-1} F. \end{aligned}$$

- D is the $N \times N$ matrix of direct requirements; F is the $N \times 1$ matrix of final use values of industry output Y

Measures of downstreamness 1

Constructed from 2002 U.S. Input-Output Use Tables:

- *$DUse\_TUse_i$*: Ratio of aggregate direct requirements to aggregate total requirements of i's goods in production of final goods
  - Direct Requirements $= DF$
  - Total Requirements $= D\,[I - D]^{-1}\,F$
  - Final Use, F: Taken as value going to consumption and investment

Interpretation: Higher $DUse\_TUse_i$ implies larger share of input i is used directly rather than entering indirectly earlier in the production process, consistent with input being used further downstream on average

Measures of downstreamness 2

- *$DownIndex_i$*: Weighted index of the average position in the value chain at which the input enters into use
  - First, construct: $F + 2DF + 3D^2F + 4D^3F + ... = [I - D]^{-2} F$

    Interpretation: This gives a weighted sum of the value of input use, where the weight equals one plus the number of stages removed from final use at which input enters the value chain
  - Divide the i-th entry of the above by the i-th entry of Y

    Interpretation: This gives an index value (≥ 1) that is increasing in upstreamness
  - Reciprocate to get $DownIndex_i$, which is increasing in downstreamness

Measures of downstreamness (cont.)

IO2002	Industry	DUse_TUse
Lowest 10 values		
331314	Secondary smelting and alloying of aluminum	0.0000
331411	Primary smelting and refining of copper	0.0421
325110	Petrochemical	0.0510
335991	Carbon and graphite product	0.1008
325910	Printing ink	0.1226
33131A	Alumina refining and primary aluminum	0.1249
325211	Plastics material and resin	0.1347
311119	Other animal food	0.1383
333220	Plastics and rubber industry machinery	0.1442
327992	Ground or treated mineral and earth	0.1632
Highest 10 values		
336211	Motor vehicle body	0.9655
336411	Aircraft	0.9669
316200	Footwear	0.9728
337910	Mattress	0.9777
322291	Sanitary paper product	0.9784
337121	Upholstered household furniture	0.9861
337212	Office furniture and custom architectural woodwork & millwork	0.9882
336213	Motor home	0.9891
33299A	Ammunition	0.9961
336111	Automobile	0.9995

IO2002	Industry	DownIndex
Lowest 10 values		
331411	Primary smelting and refining of copper	0.1150
33721A	Wood television, radio and sewing machine cabinet	0.1243
334411	Electron tube	0.1321
313240	Knit fabric mills	0.1436
316100	Leather and hide tanning and finishing	0.1634
331419	Primary smelting and refining of nonferrous metal	0.1687
335991	Carbon and graphite product	0.1697
325110	Petrochemical	0.1699
313220	Narrow fabric mills and schiffli machine embroidery	0.1946
313310	Textile and fabric finishing mills	0.1948
Highest 10 values		
335222	Household refrigerator and home freezer	0.9483
337920	Blind and shade	0.9560
337910	Mattress	0.9703
311111	Dog and cat food	0.9722
321991	Manufactured home (mobile home)	0.9787
336612	Boat building	0.9794
336212	Truck trailer	0.9816
336213	Motor home	0.9903
337121	Upholstered household furniture	0.9922
336111	Automobile	0.9993

Measure of ρ_i

Constructed from Broda and Weinstein's (2006) estimates of U.S. import demand elasticities for HS10 products:

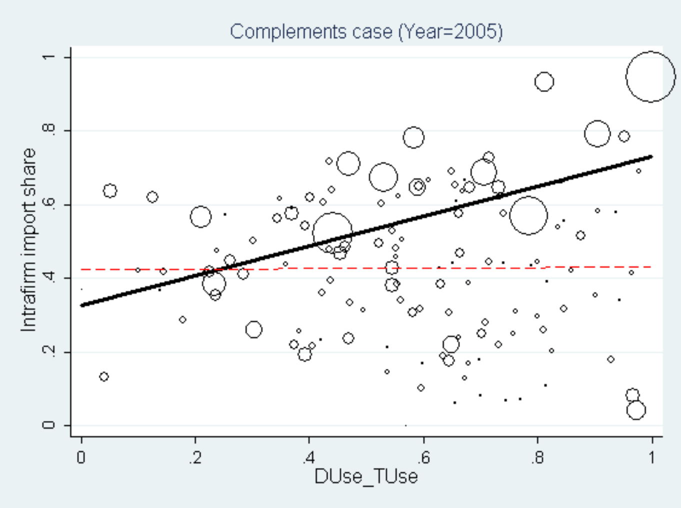
- Convert to IO2002 categories using HS-IO concordance
- ρ_i is the average elasticity taken over all "buying" industries, i.e. industries that use i as an input, weighted by the value of input i use in the 2002 Input-Output Tables

  (Final-use value is included in this calculation; assign it the elasticity of industry i itself.)
- Baseline specification uses a median value cutoff:
  - $\mathbf{1}(\rho_i > \rho_{med})$: complements case
  - $\mathbf{1}(\rho_i < \rho_{med})$: substitutes case

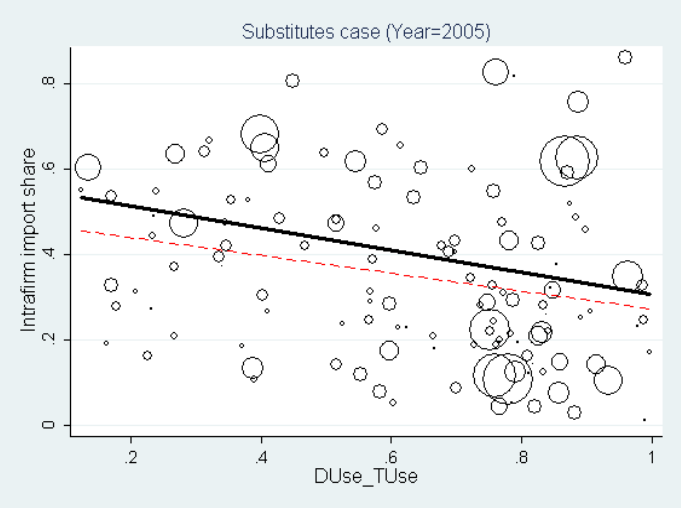
Other industry variables

- HQ intensity: $\log(s/l)$, $\log(k/l)$, $\log(m/l)$ from NBER-CES Manufacturing Database
  - 2000-2005 averages
  - Also: consider a breakdown of $\log(k/l)$ into $\log(\textit{equipment } k/l)$ and $\log(\textit{plant } k/l)$, in the spirit of Nunn and Trefler (2008b)
- R&D intensity: $\log(R\&D/Sales)$ from Orbis, from Nunn and Trefler (2008b)
- Dispersion: log sd of U.S. exports across ports and destinations (Nunn and Trefler 2008a)
- Distinguish between industry variables constructed for the:
  - input "selling" industry vs.
  - input "buying" industry (more consistent with our model)

Downstreamness and the Intrafirm Trade Share (Complements case)



Downstreamness and the Intrafirm Trade Share (Substitutes case)



Evidence: $DUse\_TUse_i$

- Greater propensity to integrate downstream in complements case
- Greater propensity to outsource downstream in substitutes case (weaker)

	Dependent variable: Intrafirm Import Share						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Imp < Median	Imp >= Median	Weighted		Weighted
Log (s/l)	0.012	0.045	0.010	0.051	-0.073	0.002	-0.050
	[0.042]	[0.042]	[0.054]	[0.054]	[0.070]	[0.019]	[0.067]
Log (equipment k / l)	0.095***	0.099***	0.088**	0.158***	0.193***	0.029*	0.155***
	[0.035]	[0.034]	[0.042]	[0.047]	[0.062]	[0.016]	[0.052]
Log (plant k / l)	-0.077*	-0.092**	-0.064	-0.140**	-0.141**	-0.061***	-0.139***
	[0.046]	[0.046]	[0.061]	[0.054]	[0.068]	[0.019]	[0.046]
Log (materials/l)	0.061*	0.058*	0.023	0.058	0.036	0.024*	0.044
	[0.034]	[0.034]	[0.041]	[0.046]	[0.057]	[0.015]	[0.047]
Log (0.001+ R&D/Sales)	0.055***	0.053***	0.033***	0.058***	0.079***	0.031***	0.063***
	[0.009]	[0.009]	[0.012]	[0.013]	[0.017]	[0.004]	[0.014]
Dispersion	0.133*	0.126	0.020	0.239*	0.225	0.107***	0.185
	[0.075]	[0.077]	[0.092]	[0.127]	[0.147]	[0.040]	[0.125]
DUse_TUse	0.014						
	[0.055]						
DUse_TUse X 1(Elas < Median)		-0.128*	-0.111	-0.128	-0.141	-0.090***	-0.036
		[0.070]	[0.080]	[0.092]	[0.100]	[0.033]	[0.086]
DUse_TUse X 1(Elas > Median)		0.175***	0.069	0.298***	0.481***	-0.049	0.362***
		[0.067]	[0.074]	[0.094]	[0.121]	[0.030]	[0.112]
1(Elas > Median)		-0.143**	-0.072	-0.231***	-0.372***	-0.019	-0.257***
		[0.059]	[0.069]	[0.080]	[0.083]	[0.028]	[0.072]
Industry controls for:	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Year fixed effects	Yes	Yes	Yes	Yes	Yes	No	No
Country-Year fixed effects	No	No	No	No	No	Yes	Yes
Observations	2823	2823	1411	1412	2823	209592	209592
R-squared	0.28	0.31	0.14	0.46	0.60	0.18	0.59

Evidence: $DownIndex_i$

- Similarly strong evidence particularly for the complements case

	(1)	(2)	(3) Imp < Median	(4) Imp >= Median	(5) Weighted	(6)	(7) Weighted
Log (s/l)	-0.003	0.022	-0.006	0.017	-0.141**	-0.001	-0.095**
	[0.042]	[0.041]	[0.052]	[0.053]	[0.055]	[0.020]	[0.046]
Log (equipment k / l)	0.126***	0.136***	0.121***	0.156***	0.172***	0.043***	0.157***
	[0.033]	[0.034]	[0.043]	[0.041]	[0.056]	[0.015]	[0.040]
Log (plant k / l)	-0.099**	-0.114**	-0.087	-0.118**	-0.098	-0.067***	-0.120***
	[0.046]	[0.048]	[0.063]	[0.056]	[0.077]	[0.020]	[0.045]
Log (materials/l)	0.057*	0.046	0.017	0.035	0.009	0.017	0.018
	[0.032]	[0.032]	[0.041]	[0.042]	[0.050]	[0.014]	[0.038]
Log (0.001+ R&D/Sales)	0.059***	0.057***	0.040***	0.055***	0.086***	0.033***	0.068***
	[0.010]	[0.010]	[0.012]	[0.014]	[0.017]	[0.004]	[0.013]
Dispersion	0.157**	0.166**	0.034	0.337**	0.309*	0.113***	0.257**
	[0.075]	[0.078]	[0.091]	[0.145]	[0.160]	[0.041]	[0.125]
DownIndex	0.144***						
	[0.051]						
DownIndex X 1(Elas < Median)		0.059	0.071	-0.018	-0.055	0.012	0.042
		[0.055]	[0.064]	[0.077]	[0.091]	[0.029]	[0.080]
DownIndex X 1(Elas > Median)		0.257***	0.140	0.356***	0.490***	-0.054	0.414***
		[0.078]	[0.086]	[0.103]	[0.089]	[0.033]	[0.077]
1(Elas > Median)		-0.060	0.005	-0.173**	-0.283***	0.042	-0.209***
		[0.054]	[0.061]	[0.075]	[0.074]	[0.027]	[0.066]
Industry controls for:	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Year fixed effects	Yes	Yes	Yes	Yes	Yes	No	No
Country-Year fixed effects	No	No	No	No	No	Yes	Yes
Observations	2823	2823	1411	1412	2823	209592	209592
R-squared	0.30	0.32	0.14	0.47	0.63	0.18	0.61

Evidence: Production Line Position and the Boundaries of the Firm

- Results evident with a more flexible quintile treatment of ρ_i

	(1)	(2)	(3)	(4)	(5)	(6)
Downstreamness:	DUse_TUse	DUse_TUse Weighted	DUse_TUse Weighted	DownIndex	DownIndex Weighted	DownIndex Weighted
Downstream X 1(Elas Quintile 1)	-0.180*	-0.305**	-0.155	0.035	-0.283	-0.099
	[0.093]	[0.140]	[0.100]	[0.115]	[0.173]	[0.122]
Downstream X 1(Elas Quintile 2)	-0.118	-0.048	0.027	0.039	-0.001	0.079
	[0.110]	[0.143]	[0.128]	[0.073]	[0.118]	[0.101]
Downstream X 1(Elas Quintile 3)	-0.067	0.030	0.066	0.032	0.097	0.171
	[0.119]	[0.158]	[0.149]	[0.114]	[0.164]	[0.164]
Downstream X 1(Elas Quintile 4)	0.226**	0.300**	0.252***	0.342***	0.189	0.211*
	[0.102]	[0.152]	[0.094]	[0.119]	[0.186]	[0.120]
Downstream X 1(Elas Quintile 5)	0.173*	0.693***	0.546***	0.267**	0.654***	0.553***
	[0.100]	[0.190]	[0.190]	[0.125]	[0.101]	[0.083]
Industry controls for:	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Elas Quintile dummies?	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Country-Year fixed effects	No	No	Yes	No	No	Yes
Observations	2823	2823	209592	2823	2823	209592
R-squared	0.32	0.63	0.60	0.33	0.66	0.62

Extension 1: Headquarter Intensity

Theory predicts that:

- In complements case ($\rho(1-\eta)$ high), greater propensity to integrate downstream when ρ is high and η is low
- In substitutes case ($\rho(1-\eta)$ low), greater propensity to outsource downstream when ρ is low and η is high
- Suggests a triple interaction approach, including a further interaction with hq intensity

Use first principal component of $\log(s/l)$, $\log(equipment\ k/l)$, and $\log(R\&D/Sales)$ as measure of headquarter intensity.

- In complements case: results indeed tend to be strongest in lowest quintile of η
- In substitutes case: results more noisy but broadly supportive when using *DownIndex*

Extension 1: Headquarter Intensity (cont.)

	(1)	(2)	(3)	(4)	(5)	(6)
Downstreamness:	DUse_TUse	DUse_TUse	DUse_TUse	DownIndex	DownIndex	DownIndex
Buyer industry hq intensity:	First Principal Component Log (s/l), Log (equipment k/l), and Log (0.001+R&D/Sales)					
		Weighted	Weighted		Weighted	Weighted
Downstream X 1 (Elas < Med) X (HQ Quintile 1)	0.101	0.072	0.071	0.251**	0.253**	0.208**
	[0.120]	[0.133]	[0.121]	[0.109]	[0.124]	[0.104]
Downstream X 1 (Elas < Med) X (HQ Quintile 2)	-0.236**	-0.482**	-0.308*	-0.080	-0.163	-0.031
	[0.107]	[0.196]	[0.169]	[0.079]	[0.177]	[0.141]
Downstream X 1 (Elas < Med) X (HQ Quintile 3)	-0.044	-0.169	-0.162	0.129	-0.017	-0.045
	[0.177]	[0.148]	[0.134]	[0.133]	[0.152]	[0.139]
Downstream X 1 (Elas < Med) X (HQ Quintile 4)	-0.394***	-0.224	-0.049	-0.077	-0.130	0.014
	[0.110]	[0.185]	[0.156]	[0.117]	[0.183]	[0.158]
Downstream X 1 (Elas < Med) X (HQ Quintile 5)	0.207	-0.180	-0.053	0.130	-0.303**	-0.142
	[0.173]	[0.205]	[0.183]	[0.129]	[0.124]	[0.139]
Downstream X 1 (Elas > Med) X (HQ Quintile 1)	0.172	0.831**	0.807***	0.369**	0.570***	0.539***
	[0.230]	[0.325]	[0.279]	[0.151]	[0.083]	[0.064]
Downstream X 1 (Elas > Med) X (HQ Quintile 2)	-0.033	-0.088	-0.188	0.002	-0.055	-0.056
	[0.141]	[0.157]	[0.152]	[0.110]	[0.205]	[0.173]
Downstream X 1 (Elas > Med) X (HQ Quintile 3)	0.201*	0.046	-0.046	0.351***	0.295	0.100
	[0.119]	[0.214]	[0.146]	[0.123]	[0.238]	[0.181]
Downstream X 1 (Elas > Med) X (HQ Quintile 4)	0.170	0.714*	0.389	0.142	0.234	-0.036
	[0.152]	[0.368]	[0.305]	[0.185]	[0.372]	[0.295]
Downstream X 1 (Elas > Med) X (HQ Quintile 5)	0.099	0.174	0.106	0.115	0.157	0.152
	[0.103]	[0.150]	[0.105]	[0.127]	[0.172]	[0.100]
Industry controls for:	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Main and double interaction effects?	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Country-Year fixed effects	No	No	Yes	No	No	Yes
Observations	2823	2823	209592	2823	2823	209592
R-squared	0.40	0.68	0.63	0.40	0.71	0.64

Extension 2: Firm Heterogeneity

- Highest propensity to integrate in the first quintile of downstreamness when $\rho < \rho_{med}$; and in the last quintile of downstreamness when $\rho > \rho_{med}$

	(1)	(2)	(3)	(4)	(5)	(6)
Downstreamness:	DUse_TUse	DUse_TUse Weighted	DUse_TUse Weighted	DownIndex	DownIndex Weighted	DownIndex Weighted
(Downstream Quin 1) X 1(Elas < Median)	0.068	0.205***	0.130***	-0.029	0.102	0.082
	[0.045]	[0.060]	[0.048]	[0.048]	[0.067]	[0.059]
(Downstream Quin 2) X 1(Elas < Median)	0.011	0.137**	0.110**	0.042	0.086	0.044
	[0.043]	[0.059]	[0.051]	[0.049]	[0.078]	[0.061]
(Downstream Quin 3) X 1(Elas < Median)	-0.006	0.081	0.033	-0.044	0.063	0.049
	[0.043]	[0.059]	[0.047]	[0.052]	[0.066]	[0.051]
(Downstream Quin 4) X 1(Elas < Median)	-0.065	0.026	0.012	0.011	0.022	0.022
	[0.045]	[0.086]	[0.067]	[0.045]	[0.071]	[0.057]
(Downstream Quin 5) X 1(Elas < Median)	0.012	0.113*	0.114**	0.005	0.003	0.054
	[0.042]	[0.063]	[0.052]	[0.045]	[0.068]	[0.051]
(Downstream Quin 2) X 1(Elas > Median)	0.013	0.053	0.025	-0.005	-0.005	-0.038
	[0.036]	[0.062]	[0.051]	[0.041]	[0.057]	[0.046]
(Downstream Quin 3) X 1(Elas > Median)	0.032	0.123*	0.047	-0.009	-0.058	-0.022
	[0.045]	[0.074]	[0.053]	[0.052]	[0.083]	[0.074]
(Downstream Quin 4) X 1(Elas > Median)	0.057	0.129*	0.071	0.040	0.047	0.007
	[0.050]	[0.067]	[0.060]	[0.045]	[0.064]	[0.047]
(Downstream Quin 5) X 1(Elas > Median)	0.150***	0.337***	0.248***	0.170***	0.349***	0.289***
	[0.048]	[0.074]	[0.068]	[0.060]	[0.083]	[0.068]
Industry controls for:	Buyer	Buyer	Buyer	Buyer	Buyer	Buyer
Year fixed effects	Yes	Yes	No	Yes	Yes	No
Country-Year fixed effects	No	No	Yes	No	No	Yes
Observations	2823	2823	209592	2823	2823	209592
R-squared	0.33	0.62	0.60	0.33	0.65	0.62

Further Robustness Tests

- Two-stage Heckman selection test
  - Excluded variable in the second-stage: interaction of measure of costs of entry and R&D intensity of the selling industry
  - Results qualitatively similar, but quantitatively larger
- Additional controls for contractibility and intermediation
  - Variables from Nunn and Trefler (2008) and Bernard et al. (2010)
  - Results qualitatively similar, but quantitatively smaller

Plan of Talk

1. Motivation and Introduction
2. Setup of the Core Model
3. Key Predictions
4. Extensions
5. Empirical Evidence
6. **Conclusion**

Concluding Remarks

- Developed a model of organizational and sourcing decisions for a production function with a continuum of sequential stages
- For each stage, firm's make-or-buy decision depends on that stage's position in the value chain
  - When stage inputs are sequential complements: Outsource upstream and Integrate downstream
  - When stage inputs are sequential substitutes: Integrate upstream and Outsource downstream
  - Intuition driven by how effort choices of upstream stage suppliers affects effort levels downstream
- Can be readily embedded into existing global sourcing frameworks
- Evidence based on U.S. related-party trade shares is broadly consistent with the model's predictions

Extension 1: Headquarter Intensity

$$q = \theta \left(\frac{h}{\eta} \right)^{\eta} \left(\int_0^1 \left(\frac{x(j)}{1-\eta} \right)^{\alpha} dj \right)^{\frac{1-\eta}{\alpha}} \tag{6}$$

- Headquarter services, h, are fully noncontractible
- Provided by the firm before stage 0 commences
- All stage suppliers take h as given when they decide on $x(j)$
- $\eta \in (0,1)$: intensity of headquarter services

Extension 1: Headquarter Intensity (cont.)

- With the same demand function as before, this yields:

$$r(m) = A^{1-\rho}\theta^{\rho}\left(\frac{h}{\eta}\right)^{\rho\eta}(1-\eta)^{-\tilde{\rho}}\left[\int_0^m x(j)^{\alpha}dj\right]^{\frac{\tilde{\rho}}{\alpha}}$$

- This turns out to behave like the core model, but with ρ replaced by $\tilde{\rho} \equiv (1-\eta)\rho$.

Proposition

In the presence of headquarter services provided by the firm, the results in Propositions 1 and 2 continue to hold except for the fact that: (i) the complements and substitutes cases are now defined by $\tilde{\rho} \equiv (1-\eta)\,\rho > \alpha$ and $\tilde{\rho} \equiv (1-\eta)\,\rho < \alpha$, respectively, and (ii) the range of stages that are vertically integrated is now also (weakly) increasing in η.

Extension 1: Headquarter Intensity (cont.)

Remarks:

- Part (ii) of the proposition implies that the propensity to integrate rises as hq services become more important in production (η rises).
- Recovers the Antràs (2003) result, although the empirical implementation will call for a slight variation:

  If we interpret hq services as being capital- or R&D-intensive, then would expect the share of intrafirm trade for a given input to be increasing in the (average) capital or R&D intensity of industries that buy the input in question
- Also from part (i) of the proposition, note that the likelihood that we find ourselves in the sequential complements case is lower the higher is headquarter intensity
  - This is an auxiliary prediction of the model that we will test

Extension 2: Firm Heterogeneity

Introduce two new features:

1. Industry contains many other firms that differ only in their productivity, θ, which is drawn from a Pareto distribution:

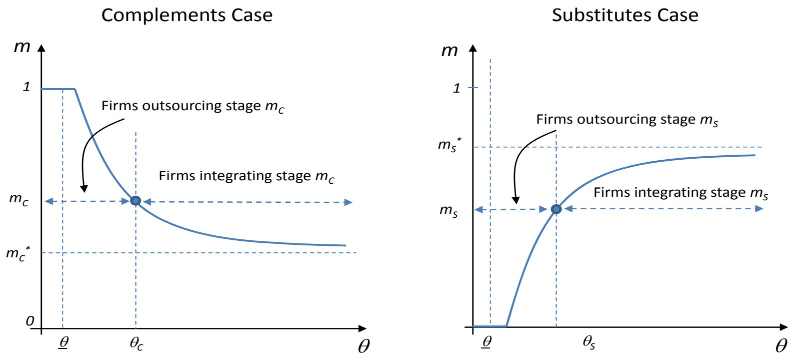
$$G(\theta) = 1 - (\underline{\theta}/\theta)^z \quad \text{for } \theta \geq \underline{\theta} > 0.$$

2. Each production stage m incurs fixed organizational costs. Specifically, assume that:

$$f_V > f_O.$$

Firm's objective is thus to maximize revenues net of total fixed costs, $\int_{j=0}^{1} f(j)dj$.

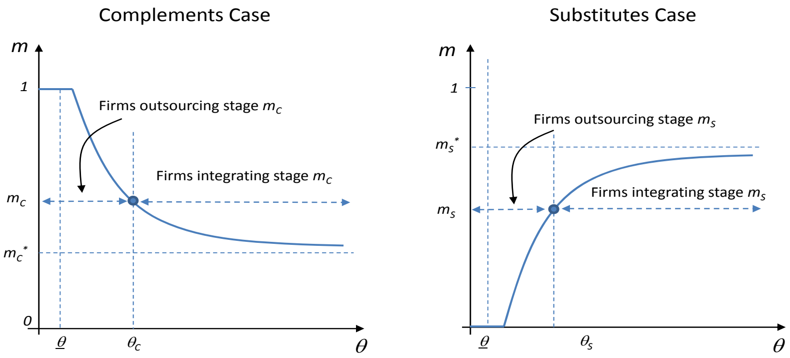
Extension 2: Firm Heterogeneity (cont.)



Complements case ($\rho > \alpha$):

- For each θ, there exists a cutoff stage $m_C(\theta)$ such that all stages before $m_C(\theta)$ are outsourced, and all stages after are integrated
- $m_C(\theta)$ is decreasing in θ

Extension 2: Firm Heterogeneity (cont.)



Conversely, in the substitutes case ($\rho < \alpha$):

- For each θ, there exists a cutoff stage $m_S(\theta)$ such that all stages before $m_S(\theta)$ are integrated, and all stages after are outsourced
- $m_S(\theta)$ is increasing in θ

Extension 2: Firm Heterogeneity (cont.)

Importantly, this generates smooth predictions for how the intrafirm trade share varies with production line position:

Proposition

The share of firms integrating a particular stage m is weakly increasing in the downstreamness of that stage in the complements case ($\rho > \alpha$), while it is decreasing in the downstreamness of the stage in the substitutes case ($\rho < \alpha$).

Furthermore, the share of firms integrating a particular stage m, is weakly increasing in the dispersion of productivity within the industry.

- This converts previous within-firm variation on the propensity to integrate different stages into predictions regarding the relative prevalence of integration of an input with a particular level of downstreamness
- If fixed costs of integration are relatively high, only most downstream (in complements case) or most upstream stages (in substitutes case) will be integrated

Extension 3: Input and Supplier Heterogeneity

Relaxing the symmetry in the production function:

$$q = \theta \left(\int_0^1 \left(\psi \left(j \right) x(j) \right)^{\alpha} dj \right)^{1/\alpha} \tag{7}$$

In practice:

- Production stages can have different weights
- Stage suppliers could defer in their productivity levels

Separately, production costs for stage j, $c(j)$, might depend on which country the stage is located in.

Extension 3: Input and Supplier Heterogeneity (cont.)

This more general model can be solved using a similar heuristic:

Proposition

Suppose that technology allows for input heterogeneity as in (7) and that marginal costs of production of inputs are also heterogeneous and given by $c(j)$ for $j \in [0, 1]$.

Then the share of firms integrating a particular stage m is weakly increasing in the downstreamness of that stage in the complements case ($\rho > \alpha$), while it is decreasing in the downstreamness of that stage in the substitutes case ($\rho < \alpha$).

Extension 3: Input and Supplier Heterogeneity (cont.)

Caveats:

- $c(m)$ is in principle endogenous, it being a function of location choice
- In general, we have: $\partial\pi_F/\partial c\,(m) < 0$

  So firm will typically seek the minimum cost location for each stage.
- However, the marginal incentive to reduce $c(m)$ depends non-monotonically on m.
- Empirically: Control for country fixed effects, to ensure that effects of downstreamness are not being estimated off cross-country variation in production costs. Also, run a two-stage Heckman procedure to correct for selection bias.