Internalizing Global Value Chains: A Firm-Level Analysis

Laura Alfaro
HBS

Pol Antràs
Harvard

Davin Chor
NUS

Paola Conconi
ECARES

GVC Training Workshop, UIBE
14 Jul 2015

Preamble

- Production processes of global firms have become increasingly complex:
  - Procurement and assembly of multiple inputs from multiple suppliers.

Preamble

- Production processes of global firms have become increasingly complex:
  - Procurement and assembly of multiple inputs from multiple suppliers.
- Global production lines feature (at least some element) of sequentiality.

Preamble

- Production processes of global firms have become increasingly complex:
  - Procurement and assembly of multiple inputs from multiple suppliers.
- Global production lines feature (at least some element) of sequentiality.
- Growing interest in how the sequential nature of production affects location and organizational decisions of global firms.

  (Harms, Lorz and Urban 2012; Baldwin and Venables 2013; Costinot, Vogel and Wang 2013; Antràs and Chor 2013; Kikuchi, Nishimura and Stachurski 2014; Fally and Hillberry 2014)

Preamble

- Production processes of global firms have become increasingly complex:
  - Procurement and assembly of multiple inputs from multiple suppliers.
- Global production lines feature (at least some element) of sequentiality.
- Growing interest in how the sequential nature of production affects location and organizational decisions of global firms.

  (Harms, Lorz and Urban 2012; Baldwin and Venables 2013; Costinot, Vogel and Wang 2013; Antràs and Chor 2013; Kikuchi, Nishimura and Stachurski 2014; Fally and Hillberry 2014)
- **However:** Firm-level tests of the implications of these theories still relatively sparse.

Preamble

- Production processes of global firms have become increasingly complex:
  - Procurement and assembly of multiple inputs from multiple suppliers.
- Global production lines feature (at least some element) of sequentiality.
- Growing interest in how the sequential nature of production affects location and organizational decisions of global firms.

  (Harms, Lorz and Urban 2012; Baldwin and Venables 2013; Costinot, Vogel and Wang 2013; Antràs and Chor 2013; Kikuchi, Nishimura and Stachurski 2014; Fally and Hillberry 2014)
- **However:** Firm-level tests of the implications of these theories still relatively sparse.
  - Data on sourcing strategies of global firms often limited to individual case studies or "teardown reports". E.g.: iPhone (Dedrick et al. 2008); Airbus.
  - Existing tests often look at model implications at more aggregate levels. E.g.: intrafirm import shares at the industry level.

Introduction and Overview: This Project

- A firm-level exploration of firm boundary choices along value chains.

Introduction and Overview: This Project

- A firm-level exploration of firm boundary choices along value chains.
- Build on the model of Antràs and Chor (2013), by introducing asymmetries across production stages other than their position in the value chain.

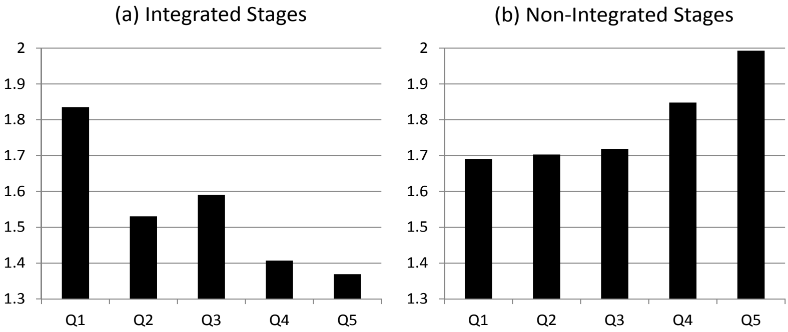
Introduction and Overview: This Project

- A firm-level exploration of firm boundary choices along value chains.
- Build on the model of Antràs and Chor (2013), by introducing asymmetries across production stages other than their position in the value chain.
- From Dun & Bradstreet WorldBase: Detailed information on ownership linkages and the SIC activities of parents/subsidiaries
  - Combine with U.S. Input-Output Tables to identify firms' integrated vs non-integrated inputs.
- Sequentiality: Compute a measure of upstreamness of each input i in the production of final good j (from U.S. Input-Output Tables)

Introduction and Overview: This Project

- A firm-level exploration of firm boundary choices along value chains.
- Build on the model of Antràs and Chor (2013), by introducing asymmetries across production stages other than their position in the value chain.
- From Dun & Bradstreet WorldBase: Detailed information on ownership linkages and the SIC activities of parents/subsidiaries
  - Combine with U.S. Input-Output Tables to identify firms' integrated vs non-integrated inputs.
- Sequentiality: Compute a measure of upstreamness of each input i in the production of final good j (from U.S. Input-Output Tables)
- In line with model's predictions, find strong and robust evidence that firms' propensity to integrate upstream vs downstream inputs depends on the
  - elasticity of demand for the final good
  - profile of contractibility along the value chain

A Sneak Preview



- As the elasticity of demand faced by the parent company increases:
  - Upstreamness of integrated inputs declines
  - Upstreamness of non-integrated inputs increases
- Result holds in *cross-firm* and *within-firm* specifications.

Related Literature

1. Theoretical work on integration vs outsourcing decisions of global firms

   (Grossman and Helpman 2002, 2005; Antràs 2003; Antràs and Helpman 2004, 2008; Acemoglu, Antràs and Helpman 2007)

2. Empirical work based on detailed industry/product-level variation

   (Nunn and Trefler 2008, 2013; Bernard et al. 2010; Fernandes and Tang 2012; Antràs 2013; Díez 2014; Luck 2014)

3. Empirical work based on firm-level data

   (Tomiura 2007; Debeare et al. 2009; Novak and Stern 2009; Corcos et al. 2013; Defever and Toubal 2013; Kohler and Smolka 2014)

4. Empirical work based on the D&B (and other related datasets)

   (Fan and Lang 2000; Acemoglu, Johnson and Mitton 2009; Alfaro and Charlton 2009; Alfaro and Chen 2012; Alfaro, Conconi, Fadinger and Newman 2013; Fajgelbaum, Grossman and Helpman 2014; Del Prete and Rungi 2014)

Plan of Talk

1. Introduction and Motivation
2. **Theory**
   - Baseline model
   - The role of contractibility
3. Empirical Setting
   - Data and measures
   - Regression specifications
4. Findings
   - From cross-firm variation
   - From within-firm, cross-input variation
5. Conclusions

Model Environment

- Develop a property rights model of firm boundaries in the tradition of Grossman-Hart-Moore.
- Production entails a continuum of uniquely sequenced inputs, $i \in [0, 1]$.
- Each i is sourced from a distinct supplier (facing a marginal cost $c(i)$); assume a competitive market of potential suppliers for each i.

The Model

- For a given firm/"parent", production in quality-adjusted units of output:

$$q = \left(\int_0^1 \left(\psi\left(i\right) x(i) \right)^{\alpha} I(i) di \right)^{1/\alpha}, \qquad (1)$$

$$I\left(i\right) = \begin{cases} 1, & \text{if input } i \text{ is produced after all inputs } i' < i, \\ 0, & \text{otherwise.} \end{cases}$$

where $x(i)$ is the services of compatible stage-i inputs.

- Analogous to Antràs and Chor (2013), but includes $\psi(i)$.
- Firm lives in a Dixit-Stiglitz industry and faces demand $q = Ap^{-1/(1-\rho)}$.

The Model

- For a given firm/"parent", production in quality-adjusted units of output:

$$q = \left(\int_0^1 \left(\psi\left(i\right) x(i) \right)^{\alpha} I(i) di \right)^{1/\alpha}, \tag{1}$$

$$I\left(i\right) = \begin{cases} 1, & \text{if input } i \text{ is produced after all inputs } i' < i, \\ 0, & \text{otherwise.} \end{cases}$$

where $x(i)$ is the services of compatible stage-i inputs.

- Analogous to Antràs and Chor (2013), but includes $\psi(i)$.
- Firm lives in a Dixit-Stiglitz industry and faces demand $q = Ap^{-1/(1-\rho)}$.

Two key parameters:

- $\alpha \in (0, 1)$: degree of substitutability between stage inputs
- $\rho \in (0, 1)$: degree of concavity of revenue function ($pq = A^{1-\rho} q^{\rho}$)

Marginal revenue

- Revenue accrued up to stage m:

$$r(m) = A^{1-\rho} \left(\int_0^m (\psi(i) x(i))^\alpha I(i) di \right)^{\frac{\rho}{\alpha}} . \tag{2}$$

- *Incremental marginal revenue* generated at stage m:

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

- How do upstream input services embodied in $r(m)$ affect $r'(m)$?

  Two cases:

  - $\rho > \alpha$: Sequential complements
  - $\rho < \alpha$: Sequential substitutes

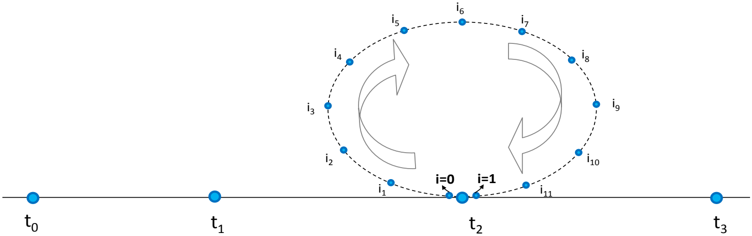
Contracting Environment

- Firm specifies integration or outsourcing for each stage before contracting with suppliers.
- Contracts are incomplete. Agents' payoffs are determined in ex-post (generalized) Nash Bargaining.
- Baseline: Bargain with stage-i supplier over the *incremental marginal revenue* at that stage.

Contracting Environment

- Firm specifies integration or outsourcing for each stage before contracting with suppliers.
- Contracts are incomplete. Agents' payoffs are determined in ex-post (generalized) Nash Bargaining.
- Baseline: Bargain with stage-i supplier over the *incremental marginal revenue* at that stage.
- Tradeoff: Outsourcing provides supplier with better incentives to invest in quality, but integration confers the firm a better bargaining position by virtue of her residual rights of control ($\beta_V > \beta_O$).
- Sequentiality: Organizational decisions made upstream have *spillovers on downstream stages*.

Timing of Events



t_0: Firm posts **contracts** for each stage i ∈[0,1]

Contract states whether i is integrated or not

t_1: Suppliers apply and the firm **selects** one supplier for each i

t_2: **Sequential production**. At each stage i:

- the supplier is handed the semi-finished good completed up to i;
- after observing its value, the supplier chooses an input level, x(i);
- After observing x(i), the firm and supplier bargain over the supplier's addition to total revenue

t_3: **Final good** assembled and sold to consumers

Solving the Model

- Each supplier i chooses $x(i)$, taking the organizational decisions of the firm and the upstream investment levels – i.e., $x(i')$ for all $i' < i$ – as given.
- At the start of the game, parent firm's decision problem is to decide on integration ($\beta(i) = \beta_V$) vs outsourcing ($\beta(i) = \beta_O$) for each stage i.

Solving the Model

- Each supplier i chooses $x(i)$, taking the organizational decisions of the firm and the upstream investment levels – i.e., $x(i')$ for all $i' < i$ – as given.
- At the start of the game, parent firm's decision problem is to decide on integration ($\beta(i) = \beta_V$) vs outsourcing ($\beta(i) = \beta_O$) for each stage i.

After some algebra:

$$\begin{array}{ll} \max\limits_{\beta(i)} & \pi_F = \Theta \int_0^1 \beta(i) \left(\frac{(1-\beta(i))\psi(i)}{c(i)} \right)^{\frac{\alpha}{1-\alpha}} \left[\int_0^i \left(\frac{(1-\beta(k))\psi(k)}{c(k)} \right)^{\frac{\alpha}{1-\alpha}} dk \right]^{\frac{\rho-\alpha}{\alpha(1-\rho)}} di \\ \text{s.t.} & \beta(i) \in \{\beta_V, \beta_O\}. \end{array}$$

- If $\psi(i) = c(i) = 1$ for all stages i, we are back to the maximization problem in Antràs and Chor (2013).

Relaxed Problem

- Consider the relaxed problem where the firm chooses $\beta(i)$ flexibly, instead of constraining it to be a discrete choice between β_V and β_O.
- Assume $\beta(i)$ is piecewise continuous and differentiable. Euler-Lagrange condition of this calculus of variations problem yields:

$$\beta^*(i) = 1 - \alpha \left[\frac{\int_0^i \left(\psi(k)/c(k)\right)^{\frac{\alpha}{1-\alpha}} dk}{\int_0^1 \left(\psi(k)/c(k)\right)^{\frac{\alpha}{1-\alpha}} dk} \right]^{\frac{\alpha-\rho}{\alpha}} . \tag{4}$$

Relaxed Problem

- Consider the relaxed problem where the firm chooses $\beta(i)$ flexibly, instead of constraining it to be a discrete choice between β_V and β_O.
- Assume $\beta(i)$ is piecewise continuous and differentiable. Euler-Lagrange condition of this calculus of variations problem yields:

$$\beta^*(i) = 1 - \alpha \left[\frac{\int_0^i \left(\psi(k)/c(k)\right)^{\frac{\alpha}{1-\alpha}} dk}{\int_0^1 \left(\psi(k)/c(k)\right)^{\frac{\alpha}{1-\alpha}} dk} \right]^{\frac{\alpha-\rho}{\alpha}} . \tag{4}$$

- When $\rho > \alpha$: $\beta^*(i)$ is increasing in i.

  When $\rho < \alpha$: $\beta^*(i)$ is decreasing in i.
- $\beta^*(i)$ depends on the *entire profile* of $\psi(k)/c(k)$.

Relaxed Problem

- Consider the relaxed problem where the firm chooses $\beta(i)$ flexibly, instead of constraining it to be a discrete choice between β_V and β_O.
- Assume $\beta(i)$ is piecewise continuous and differentiable. Euler-Lagrange condition of this calculus of variations problem yields:

$$\beta^*(i) = 1 - \alpha \left[\frac{\int_0^i (\psi(k)/c(k))^{\frac{\alpha}{1-\alpha}} dk}{\int_0^1 (\psi(k)/c(k))^{\frac{\alpha}{1-\alpha}} dk} \right]^{\frac{\alpha-\rho}{\alpha}} . \quad (4)$$

- When $\rho > \alpha$: $\beta^*(i)$ is increasing in i.

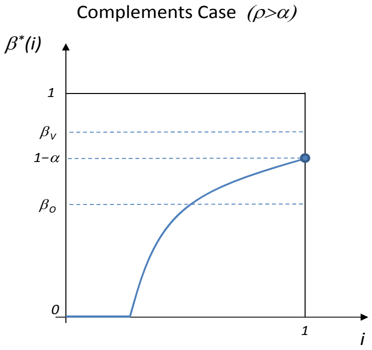
  When $\rho < \alpha$: $\beta^*(i)$ is decreasing in i.
- $\beta^*(i)$ depends on the *entire profile* of $\psi(k)/c(k)$.
- When no within-chain heterogeneity in marginal productivity or costs,

$$\beta^*(i) = 1 - \alpha i^{\frac{\alpha-\rho}{\alpha}} . \quad (5)$$

Core Prediction

Main prediction of Antràs and Chor (2013) is preserved:

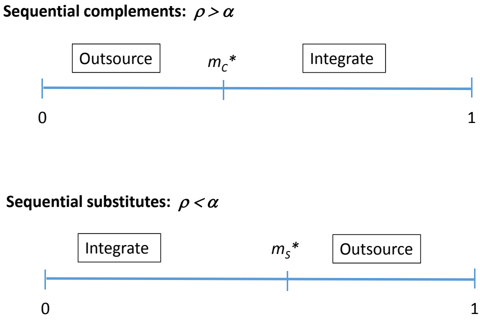
- Complements case ($\rho > \alpha$): Greater propensity to integrate *downstream*.
- Substitutes case ($\rho < \alpha$): Greater propensity to integrate *upstream*.



Core Prediction

Main prediction of Antràs and Chor (2013) is preserved:

- Complements case ($\rho > \alpha$): Greater propensity to integrate *downstream*.
- Substitutes case ($\rho < \alpha$): Greater propensity to integrate *upstream*.



Introducing Contractibility

Mapping $\psi(i)$ to the contractibility of inputs:

- Let $x(i)$ refer to the non-contractible investments embodied in input i (chosen by supplier i).
- Let $\psi(i)$ refer to contractible investments that can be specified in the initial contract (chosen by the firm at time t_0).

Introducing Contractibility

Mapping $\psi(i)$ to the contractibility of inputs:

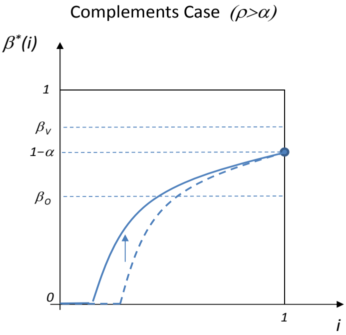
- Let $x(i)$ refer to the non-contractible investments embodied in input i (chosen by supplier i).
- Let $\psi(i)$ refer to contractible investments that can be specified in the initial contract (chosen by the firm at time t_0).
- Suppose that per unit contracting costs for specifying $\psi(i)$ are exogenously given by $\psi(i)^{\phi}/\mu(i)$, where $\phi > 1$
- Then, the level of $\psi(i)$ specified in the initial contract will be inversely related to $1/\mu(i)$, so long as $\phi > \alpha/(1-\alpha)$.

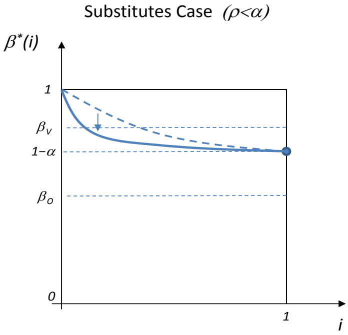
$\Rightarrow$ Can interpret a high value of $\psi(i)$ as reflecting high contractibility of that stage input.

The Profile of Contractibility

A higher level of "upstream contractibility" $\left(\frac{\int_0^i \psi(k)^{\frac{\alpha}{1-\alpha}}\,dk}{\int_0^1 \psi(k)^{\frac{\alpha}{1-\alpha}}\,dk}\right)$:

- Complements case: *Greater* propensity to integrate upstream relative to downstream.
- Substitutes case: *Lower* propensity to integrate upstream relative to downstream.



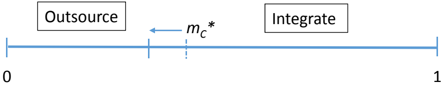


The Profile of Contractibility

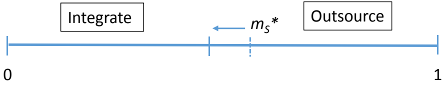
A higher level of "upstream contractibility" $\left(\frac{\int_0^i \psi(k)^{\frac{\alpha}{1-\alpha}} dk}{\int_0^1 \psi(k)^{\frac{\alpha}{1-\alpha}} dk} \right)$:

- Complements case: *Greater* propensity to integrate upstream relative to downstream.
- Substitutes case: *Lower* propensity to integrate upstream relative to downstream.

Sequential complements: $\rho > \alpha$



Sequential substitutes: $\rho < \alpha$



Plan of Talk

1. Introduction and Motivation
2. Theory
   - Baseline model
   - The role of contractibility
3. **Empirical Setting**
   - Data and measures
   - Regression Specifications
4. Findings
   - From cross-firm variation
   - From within-firm, cross-input variation
5. Conclusions

Core Dataset: Dun & Bradstreet (D&B) WorldBase

- Comprehensive coverage of establishments in 120 countries (year: 2005)
- Compiled from different sources, including: registers, telephone directory records, websites, self-registration etc.
- Good information of a "business register" nature
  - Each observation has a unique identifier (DUNS number)
  - Name, Location, Global Parent (if any)
  - Up to six 4-digit SIC87 industry activities

Core Dataset: Dun & Bradstreet (D&B) WorldBase

- Comprehensive coverage of establishments in 120 countries (year: 2005)
- Compiled from different sources, including: registers, telephone directory records, websites, self-registration etc.
- Good information of a "business register" nature
  - Each observation has a unique identifier (DUNS number)
  - Name, Location, Global Parent (if any)
  - Up to six 4-digit SIC87 industry activities
- Extract 320,254 firms from 116 countries with a minimum total employment of 20 and primary SIC activity in manufacturing (*parents*)
- D&B enables us to link each of these to their subsidiaries, including information on country and SIC activities (70,008 *subsidiaries*)
- Average parent has 1.22 establishments; active in 1.05 countries and in 1.95 SIC activities. Details
- 6,370 of these parents are multinationals, i.e., $\geq$ 1 one foreign subsidiary

Merging D&B with Input-Output Data

- Some notation:
  - p to index parent
  - j to index parent *output* industry (primary SIC)
  - i to index SIC *input* industry
  - $S(j)$: set of inputs used in the production of j, i.e., for which the total requirements coefficient, $tr_{ij} > 0$ (from U.S. Input-Output Tables)

Merging D&B with Input-Output Data

- Some notation:
  - p to index parent
  - j to index parent *output* industry (primary SIC)
  - i to index SIC *input* industry
  - $S(j)$: set of inputs used in the production of j, i.e., for which the total requirements coefficient, $tr_{ij} > 0$ (from U.S. Input-Output Tables)
- **Key idea:** View SICs of parent p and all its subsidiaries as inputs that p could in principle obtain within firm boundaries.
  - Call the set of these integrated SICs: $I(p)$.
  - Call the set of non-integrated SICs: $NI(p) = S(j) \setminus I(p)$.
  - 98.0% of the observed (i, j) pairs in the D&B data have $tr_{ij} > 0$. More

Measuring Upstreamness

We need a measure of the production line position of each input i vis-à-vis output j:

- Fally (2012) and Antràs et al. (2012) developed a measure of the upstreamness between i and final use
- Now: Build an analogous measure of the upstreamness between input i and output j
  - Closely related to the concept of "average propagation lengths" in the Input-Output literature (Dietzenbacher et al. 2005)

Measuring Upstreamness (Cont.)

In an N-industry economy, accounting for the value of input i that goes into the production of \$1 of output j:

- d_{ij}: Value used directly (1 stage), aka direct requirements coefficient.
- $\sum_{k=1}^{N} d_{ik} d_{kj}$: Value used indirectly (2 stages).
- $\sum_{k=1}^{N} \sum_{l=1}^{N} d_{ik} d_{kl} d_{lj}$: Value used indirectly (3 stages), etc...

Measuring Upstreamness (Cont.)

In an N-industry economy, accounting for the value of input i that goes into the production of \$1 of output j:

- d_{ij}: Value used directly (1 stage), aka direct requirements coefficient.
- $\sum_{k=1}^{N} d_{ik} d_{kj}$: Value used indirectly (2 stages).
- $\sum_{k=1}^{N} \sum_{l=1}^{N} d_{ik} d_{kl} d_{lj}$: Value used indirectly (3 stages), etc…

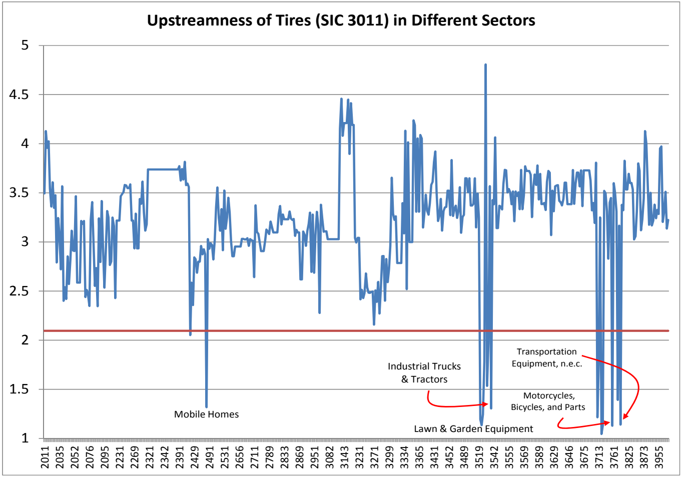
Define the following measure of i's upstreamness in the production of j:

$$upst_{ij} = \frac{d_{ij} + 2\sum_{k=1}^{N} d_{ik} d_{kj} + 3\sum_{k=1}^{N} \sum_{l=1}^{N} d_{ik} d_{kl} d_{lj} + \ldots}{d_{ij} + \sum_{k=1}^{N} d_{ik} d_{kj} + \sum_{k=1}^{N} \sum_{l=1}^{N} d_{ik} d_{kl} d_{lj} + \ldots}$$

- Weighted-average of the number of production stages to get from i to j, with weights proportional to the value of input use that takes the said number of stages.
- Note: Denominator is tr_{ij}. Practical Implementation Issues

Measuring Upstreamness (Cont.)

Comparing $upst_{ij}$ (this paper) against the upstreamness of i wrt final demand (from Antràs et al. 2012)



Regression Specifications: Dependent Variable

- *Cross-firm* regressions: dependent variable is "ratio-upstreamness":

$$R_{jp} \equiv \frac{\sum_{i \in I(p)} \theta^{I}_{ijp} upst_{ij}}{\sum_{i \in NI(p)} \theta^{NI}_{ijp} upst_{ij}}$$

  where $\theta^{I}_{ijp} = tr_{ij} / \sum_{i \in I(p)} tr_{ij}$ and $\theta^{NI}_{ijp} = tr_{ij} / \sum_{i \in NI(p)} tr_{ij}$.

- Upstreamness of a parent's integrated inputs divided by upstreamness of its non-integrated inputs.

- By design, R_{jp} increases the greater is p's propensity to integrate relatively upstream inputs, while outsourcing its more downstream inputs.

- Also consider several variants of R_{jp} ("ever-integrated" inputs; manuf. inputs only; drop parent SIC; ...) Summary statistics

Regression Specifications: Dependent Variable

- *Cross-firm* regressions: dependent variable is "ratio-upstreamness":

$$R_{jp} \equiv \frac{\sum_{i \in I(p)} \theta^{I}_{ijp} upst_{ij}}{\sum_{i \in NI(p)} \theta^{NI}_{ijp} upst_{ij}}$$

where $\theta^{I}_{ijp} = tr_{ij} / \sum_{i \in I(p)} tr_{ij}$ and $\theta^{NI}_{ijp} = tr_{ij} / \sum_{i \in NI(p)} tr_{ij}$.

- Upstreamness of a parent's integrated inputs divided by upstreamness of its non-integrated inputs.
- By design, R_{jp} increases the greater is p's propensity to integrate relatively upstream inputs, while outsourcing its more downstream inputs.
- Also consider several variants of R_{jp} ("ever-integrated" inputs; manuf. inputs only; drop parent SIC; ...) Summary statistics
- *Within-firm* regressions: dependent variable is a 0-1 indicator for whether $i \in I(p)$.

Cross-Firm Analysis

$$\log R_{jpc} = \beta_0 + \beta_1 \mathbf{1}(\rho_j > \rho_{med}) + \beta_X X_j + \beta_W W_p + D_c + \epsilon_{jpc}$$

- Focus on differences in demand elasticities to distinguish between complements and substitutes cases, following Antràs and Chor (2013)
  - Baseline: import demand elasticities estimated by Broda and Weinstein (2006) for HS10 product categories
  - Also pursue refinements that restrict construction of demand elasticities to consumption and/or capital goods (UN BEC classification)
- Start with a median cutoff: $\beta_1 \mathbf{1}(\rho_j > \rho_{med})$.
  - Theory suggests: $\beta_1 < 0$.

    Propensity to integrate upstream inputs lower for high demand elasticity industries. (Prediction P.1)
- Later use a set of quintile dummies: $\sum_{n=2}^{5} \beta_n \mathbf{1}(\rho_j \in Quint_n(\rho))$

Cross-Firm Analysis

$$\log R_{jpc} = \beta_0 + \beta_1 \mathbf{1}(\rho_j > \rho_{med}) + \beta_X X_j + \beta_W W_p + D_c + \epsilon_{jpc}$$

- X_j: Vector of industry controls ▸ Details
  - Log Nonproduction emp., Equipment capital, Plant capital, Materials (all in per worker terms) from NBER-CES
  - Log (0.001 + R&D expenditures/Sales) from Nunn and Trefler (2013)
- W_p: Vector of firm controls
  - Log number of subsidiaries, Indicator for MNC status, Year started
  - Log total employment, Log sales in USD
- D_c: Parent country fixed effects
- Cluster standard errors by output industry j
- Later introduce interactions with "Upstream Contractibility"

Plan of Talk

1. Introduction and Motivation
2. Theory
   - Baseline model
   - The role of contractibility
3. Empirical setting
   - Data and measures
   - Regression specifications
4. **Findings**
   - From cross-firm variation
   - From within-firm, cross-input variation
5. Conclusions

Median Cutoff: Negative Coefficient on $\mathbf{1}(\rho_j > \rho_{med})$

Table 1

Upstreamness of Integrated vs Non-Integrated Inputs: Median Elasticity Cutoff

Dependent variable:	**Log Ratio-Upstreamness**				
	(1)	(2)	(3)	(4)	(5)
Ind.(Elas_j > Median)	-0.0354*	-0.0612***	-0.0604***	-0.0593***	-0.1138***
	[0.0204]	[0.0188]	[0.0185]	[0.0215]	[0.0261]
Log (Skilled Emp./Worker)_j		0.0100	0.0091	0.0112	-0.0219
		[0.0243]	[0.0245]	[0.0278]	[0.0360]
Log (Equip. Capital / Worker)_j		0.1139***	0.1121***	0.0809***	0.0835***
		[0.0206]	[0.0202]	[0.0207]	[0.0254]
Log (Plant Capital / Worker)_j		-0.0405*	-0.0397*	-0.0175	-0.0320
		[0.0229]	[0.0225]	[0.0274]	[0.0322]
Log (Materials / Worker)_j		-0.0279	-0.0289	-0.0393*	-0.0059
		[0.0222]	[0.0222]	[0.0230]	[0.0296]
R&D intensity_j		0.0049	0.0039	0.0103	0.0058
		[0.0058]	[0.0058]	[0.0074]	[0.0085]
(Value-added / Shipments)_j		-0.1050	-0.1142	-0.0706	0.1683
		[0.1278]	[0.1286]	[0.1295]	[0.1587]
Elasticity based on:	All goods	All goods	All goods	BEC cons. & cap. goods	BEC cons. goods
Parent firm controls?	N	N	Y	Y	Y
Parent country dummies?	Y	Y	Y	Y	Y
Observations	316,977	316,977	286,072	206,490	144,107
No. of industries	459	459	459	305	219
R^2	0.0334	0.1372	0.1447	0.1511	0.2052

Quintile Cutoff: Stronger Effect in Higher Quintiles of ρ_j

Table 2
Upstreamness of Integrated vs Non-Integrated Inputs: Elasticity Quintiles

Dependent variable:	Log Ratio-Upstreamness				
	(1)	(2)	(3)	(4)	(5)
Ind.(Quintile 2 Elas_j)	-0.0209	-0.0290	-0.0278	-0.0590	-0.0802*
	[0.0345]	[0.0319]	[0.0313]	[0.0447]	[0.0474]
Ind.(Quintile 3 Elas_j)	-0.0742**	-0.0802**	-0.0783**	-0.0569	-0.0982**
	[0.0336]	[0.0316]	[0.0309]	[0.0454]	[0.0429]
Ind.(Quintile 4 Elas_j)	-0.0480	-0.0893***	-0.0881***	-0.1068**	-0.1685***
	[0.0365]	[0.0337]	[0.0331]	[0.0459]	[0.0457]
Ind.(Quintile 5 Elas_j)	-0.0588	-0.0955***	-0.0947***	-0.1156***	-0.1850***
	[0.0377]	[0.0325]	[0.0318]	[0.0420]	[0.0459]
Log (Skilled Emp./Worker)_j		0.0080	0.0069	0.0073	-0.0290
		[0.0238]	[0.0239]	[0.0290]	[0.0379]
Log (Equip. Capital / Worker)_j		0.1127***	0.1112***	0.0732***	0.0768***
		[0.0195]	[0.0192]	[0.0183]	[0.0205]
Log (Plant Capital / Worker)_j		-0.0331	-0.0325	-0.0088	-0.0240
		[0.0210]	[0.0207]	[0.0228]	[0.0276]
Log (Materials / Worker)_j		-0.0311	-0.0322	-0.0397*	-0.0099
		[0.0222]	[0.0222]	[0.0238]	[0.0290]
R&D intensity_ j		0.0053	0.0044	0.0113	0.0048
		[0.0058]	[0.0057]	[0.0070]	[0.0086]
(Value-added / Shipments)_j		-0.1270	-0.1357	-0.0841	0.1725
		[0.1295]	[0.1301]	[0.1324]	[0.1699]
Elasticity based on:	All goods	All goods	All goods	BEC cons. & cap. goods	BEC cons. goods
Parent firm controls?	N	N	Y	Y	Y
Parent country dummies?	Y	Y	Y	Y	Y
Observations	316,977	316,977	286,072	206,490	144,107
No. of industries	459	459	459	305	219
R^2	0.0449	0.1504	0.1580	0.1770	0.2333

Baseline with Quintile Cutoff (cont.)

Remarks:

- Magnitude of effects larger as we refine the ρ proxy to include information only on final good demand elasticities (UN BEC)
- Coefficient of $\mathbf{1}(\rho_j \in Quint_5(\rho))$: Corresponds to a decrease in the propensity to integrate upstream vs downstream stages of about one standard deviation (Column 5), when moving from Q1 to Q5
- Robust to controlling further for:
  - VI index used in Acemoglu et al. (2009), Alfaro et al. (2013)
  - Share of tr_{ij} that can be obtained from integrated foreign suppliers
  - Country dummy variables for establishment presence
  - Double marginalization motive: Weighted-average demand elasticity of inputs used

Effect of Upstream Contractibility: Empirical Specification

$$\begin{aligned}\log R_{jpc} &= \beta_0 + \beta_1 \mathbf{1}(\rho_j > \rho_{med}) + \beta_{U1} \mathbf{1}(\rho_j < \rho_{med}) \times UpstCont_j \\ &\quad + \beta_{U2} \mathbf{1}(\rho_j > \rho_{med}) \times UpstCont_j + \beta_X X_j + \beta_W W_p + D_c + \epsilon_{jpc}, \text{ and} \\ \log R_{jpc} &= \beta_0 + \sum_{n=2}^{5} \beta_n \mathbf{1}(\rho_j \in Quint_n(\rho)) + \sum_{n=1}^{5} \beta_{Un} \mathbf{1}(\rho_j \in Quint_n(\rho)) \times UpstCont_j \\ &\quad + \beta_X X_j + \beta_W W_p + D_c + \epsilon_{jpc}.\end{aligned}$$

- Constructing $UpstCont_j$:
  - Contractibility follows Nunn (2007): Extent to which production involves the use of HS products classified as homogenous (Rauch 1999).
  - Then take the total requirements weighted-covariance between the upstreamness and contractibility of manufacturing inputs:

$$UpstCont_j = \sum_{i \in S^m(j)} \theta^m_{ij} \left(upst_{ij} - \overline{upst}_{ij}\right)\left(cont_i - \overline{cont}_i\right)$$

($S^m(j)$ is the set of manufacturing inputs used by j, i.e., $tr_{ij} > 0$.)

Effect of Upstream Contractibility: Empirical Specification

$$\log R_{jpc} = \beta_0 + \beta_1 \mathbf{1}(\rho_j > \rho_{med}) + \beta_{U1} \mathbf{1}(\rho_j < \rho_{med}) \times UpstCont_j + \beta_{U2} \mathbf{1}(\rho_j > \rho_{med}) \times UpstCont_j + \beta_X X_j + \beta_W W_p + D_c + \epsilon_{jpc}, \text{ and}$$

$$\log R_{jpc} = \beta_0 + \sum_{n=2}^{5} \beta_n \mathbf{1}(\rho_j \in Quint_n(\rho)) + \sum_{n=1}^{5} \beta_{Un} \mathbf{1}(\rho_j \in Quint_n(\rho)) \times UpstCont_j + \beta_X X_j + \beta_W W_p + D_c + \epsilon_{jpc}.$$

- In median cutoff regressions, expect:
  - $\beta_{U1} < 0$ and $\beta_{U2} > 0$. Upstream contractibility:

    Raises the propensity to integrate upstream in the complements case...

    ... but lowers it in the substitutes case! (Prediction P.2)

Effect of Upstream Contractibility

Table 3
Effect of Upstream Contractibility: Median Elasticity Cutoff

Dependent variable:	**Log Ratio-Upstreamness**		
	(1)	(2)	(3)
Ind.(Elas_j > Median)	-0.0910***	-0.1306***	-0.1433***
	[0.0210]	[0.0256]	[0.0263]
"Upstream Contractibility"			
X Ind.(Elas_j < Median)	-0.8944***	-1.1150***	-1.2398***
	[0.2868]	[0.3837]	[0.4345]
X Ind.(Elas_j > Median)	0.5043***	1.0228***	0.8876***
	[0.1717]	[0.1571]	[0.1505]
p-value: Q5 at median Upst. Cont.	[0.0001]	[0.0004]	[0.0000]
Elasticity based on:	All goods	BEC cons. & cap. goods	BEC cons. goods
Industry controls?	Y	Y	Y
Firm controls?	Y	Y	Y
Parent country dummies?	Y	Y	Y
Observations	286,072	206,490	144,107
No. of industries	459	305	219
R^2	0.1882	0.2610	0.2910

Effect of Upstream Contractibility

Table 4
Effect of Upstream Contractibility: Elasticity Quintiles

Dependent variable:	Log Ratio-Upstreamness		
	(1)	(2)	(3)
Ind.(Quintile 2 Elas_j)	-0.0350	-0.0611	-0.0490
	[0.0300]	[0.0396]	[0.0429]
Ind.(Quintile 3 Elas_j)	-0.1104***	-0.0566	-0.0684**
	[0.0288]	[0.0405]	[0.0328]
Ind.(Quintile 4 Elas_j)	-0.1207***	-0.1605***	-0.1612***
	[0.0304]	[0.0292]	[0.0277]
Ind.(Quintile 5 Elas_j)	-0.1409***	-0.1760***	-0.1643***
	[0.0297]	[0.0306]	[0.0292]
"Upstream Contractibility"			
X Ind.(Quintile 1 Elas_j)	-1.5538***	-1.5490***	-1.8558***
	[0.4934]	[0.4176]	[0.4446]
X Ind.(Quintile 2 Elas_j)	-0.9812***	-0.5727	-0.6889
	[0.3166]	[0.5972]	[0.7620]
X Ind.(Quintile 3 Elas_j)	0.3269	-0.3233	-0.4177
	[0.2408]	[0.3743]	[0.3855]
X Ind.(Quintile 4 Elas_j)	0.3846	1.0664***	0.6855***
	[0.2866]	[0.2319]	[0.2105]
X Ind.(Quintile 5 Elas_j)	0.7107***	1.0534***	1.1180***
	[0.2148]	[0.2148]	[0.2273]
p-value: Q5 at median Upst. Cont.	[0.0000]	[0.0000]	[0.0000]
Elasticity based on:	All goods	BEC cons. & cap. goods	BEC cons. goods
Industry controls?	Y	Y	Y
Firm controls?	Y	Y	Y
Parent country dummies?	Y	Y	Y
Observations	286,072	206,490	144,107
No. of industries	459	305	219
R^2	0.2204	0.2793	0.3064

Robustness:

- Different samples:

  Single-establishment firms; Small firms (emp. $\geq$ 10); MNCs ▸ Details
- Alternative constructions of ratio-upstreamness ▸ Details
- Additional firm and industry controls ▸ Details
- Alternative contractibility measures ▸ Details
- Multi-industry parents ▸ Details

Within-Firm Analysis: Empirical Specification

Start with:

$$D\_INT_{ijp} = \gamma_0 + \sum_{n=1}^{5} \gamma_n \mathbf{1}(\rho_j \in Quint_n(\rho)) \times upst_{ij} + \gamma_S \mathbf{1}(i = j) + D_i + D_p + \epsilon_{ijp}$$

- Expand the dataset to the parent firm by SIC input level
- LHS: Indicator variable, D_INT_{ijp}, for whether parent firm p with output industry j has input i within firm boundaries
- Estimate as a linear probability model
- To make sure LHS variable not too sparse:
  - Focus on parents that have integrated at least one manufacturing SIC input $i \neq j$
  - For each p, include the top 100 manufacturing inputs i by tr value

    (Covers between 88-98% of the tr value of the output industry)

Within-Firm Analysis: Empirical Specification

Start with:

$$D\_INT_{ijp} = \gamma_0 + \sum_{n=1}^{5} \gamma_n \mathbf{1}(\rho_j \in Quint_n(\rho)) \times upst_{ij} + \gamma_S \mathbf{1}(i = j) + D_i + D_p + \epsilon_{ijp}$$

- $\mathbf{1}(i = j)$: Self-SIC dummy
- D_p: Parent firm fixed effects
- D_i: SIC input fixed effects
- Cluster standard errors by i-j pair
- Theory would strictly say: $\gamma_1 > 0$ and $\gamma_5 < 0$.

  A weaker form of this prediction: Propensity to integrate would be decreasing with $upst_{ij}$ most strongly in the complements case.

Within-Firm Regression Results

Dependent variable:	Indicator variable: Input Integrated?			
	(1)	(2)	(3)	(4)
Upstreamness_ij				
X Ind.(Quintile 1 Elas_j)	-0.0056***	0.0005	-0.0006	-0.0036**
	[0.0009]	[0.0014]	[0.0013]	[0.0015]
X Ind.(Quintile 2 Elas_j)	-0.0085***	-0.0001	0.0001	-0.0032
	[0.0019]	[0.0035]	[0.0036]	[0.0036]
X Ind.(Quintile 3 Elas_j)	-0.0100***	-0.0001	0.0002	-0.0014
	[0.0012]	[0.0027]	[0.0027]	[0.0026]
X Ind.(Quintile 4 Elas_j)	-0.0098***	0.0084***	0.0083***	0.0022
	[0.0021]	[0.0024]	[0.0025]	[0.0017]
X Ind.(Quintile 5 Elas_j)	-0.0113***	0.0054*	0.0045	0.0014
	[0.0021]	[0.0028]	[0.0029]	[0.0019]
"Contractibility up to i" (in prod. of j)				
X Ind.(Quintile 1 Elas_j)		0.0234***	0.0165***	0.0166***
		[0.0052]	[0.0049]	[0.0045]
X Ind.(Quintile 2 Elas_j)		0.0339***	0.0357**	0.0260**
		[0.0128]	[0.0147]	[0.0103]
X Ind.(Quintile 3 Elas_j)		0.0365***	0.0392***	0.0280***
		[0.0082]	[0.0084]	[0.0084]
X Ind.(Quintile 4 Elas_j)		0.0669***	0.0666***	0.0318***
		[0.0157]	[0.0174]	[0.0095]
X Ind.(Quintile 5 Elas_j)		0.0685***	0.0591***	0.0299***
		[0.0134]	[0.0144]	[0.0096]
"Contractibility at i" (in prod. Of j)				
X Ind.(Quintile 1 Elas_j)			0.0809***	0.0707***
			[0.0247]	[0.0241]
X Ind.(Quintile 2 Elas_j)			-0.0305	0.0024
			[0.0422]	[0.0311]
X Ind.(Quintile 3 Elas_j)			-0.0546*	0.0129
			[0.0299]	[0.0294]
X Ind.(Quintile 4 Elas_j)			0.0093	0.1297**
			[0.0794]	[0.0532]
X Ind.(Quintile 5 Elas_j)			0.1985	0.2823**
			[0.1471]	[0.1396]
Dummy: Self-SIC	0.9794***	0.9699***	0.9699***	0.9335***
	[0.0018]	[0.0028]	[0.0029]	[0.0086]
p-value: Quintile 5 - Quintile 1 effect of "Contractibility up to i"	---	[0.0015]	[0.0049]	[0.2010]
Observations	4,707,722	4,707,722	4,707,722	4,707,722
No. of parent firms	46,992	46,992	46,992	46,992
No. of i-j pairs	21,836	21,836	21,836	21,836
R^2	0.5342	0.5359	0.5362	0.5599

- Effect of $upst_{ij}$:

  Propensity to integrate upstream inputs falls for higher elasticity quintiles

Within-Firm Analysis: Empirical Specification (cont.)

Specification with Contractibility up to i:

$$\begin{aligned} D\_INT_{ijp} &= \gamma_0 + \sum_{n=1}^{5} \gamma_n \mathbf{1}(\rho_j \in Quint_n(\rho)) \times upst_{ij} \\ &\quad + \sum_{n=1}^{5} \delta_n \mathbf{1}(\rho_j \in Quint_n(\rho)) \times ContUpToi_{ij} + \gamma_S \mathbf{1}(i = j) + D_i + D_p + \epsilon_{ijp} \end{aligned}$$

- Recall: $\beta^*(i) = 1 - \alpha \left(\dfrac{\int_0^i (\psi(k)/c(k))^{\frac{\alpha}{1-\alpha}} dk}{\int_0^1 (\psi(k)/c(k))^{\frac{\alpha}{1-\alpha}} dk} \right)^{\frac{\alpha-\rho}{\alpha}}$
- "Contractibility up to i in prod. of j"

$$ContUpToi_{ij} = \frac{\sum_{k \in S_i^m(j)} tr_{kj} cont_k}{\sum_{k \in S^m(j)} tr_{kj} cont_k}$$

where $S_i^m(j) = \{k : upst_{kj} \geq upst_{ij}\}$ is the set of manufacturing inputs used by j upstream of and including i.

Within-Firm Analysis: Empirical Specification (cont.)

Specification with Contractibility up to i:

$$\begin{aligned} D\_INT_{ijp} &= \gamma_0 + \sum_{n=1}^{5} \gamma_n \mathbf{1}(\rho_j \in Quint_n(\rho)) \times upst_{ij} \\ &\quad + \sum_{n=1}^{5} \delta_n \mathbf{1}(\rho_j \in Quint_n(\rho)) \times ContUpToi_{ij} + \gamma_S \mathbf{1}(i = j) + D_i + D_p + \epsilon_{ijp} \end{aligned}$$

- Recall: $\beta^*(i) = 1 - \alpha \left(\frac{\int_0^i (\psi(k)/c(k))^{\frac{\alpha}{1-\alpha}} dk}{\int_0^1 (\psi(k)/c(k))^{\frac{\alpha}{1-\alpha}} dk} \right)^{\frac{\alpha-\rho}{\alpha}}$
- Expect that: Having controlled for $ContUpToi_{ij}$, $upst_{ij}$ itself should not matter for explaining integration
- Also: $\delta_1 < 0$ and $\delta_5 > 0$. $ContUpToi_{ij}$ would raise the propensity to integrate any given stage in the complements case

  ... but would reduce it in the substitutes case

Within-Firm Regression Results

Dependent variable:	Indicator variable: Input Integrated?			
	(1)	(2)	(3)	(4)
Upstreamness_ij				
X Ind.(Quintile 1 Elas_j)	-0.0056***	0.0005	-0.0006	-0.0036**
	[0.0009]	[0.0014]	[0.0013]	[0.0015]
X Ind.(Quintile 2 Elas_j)	-0.0085***	-0.0001	0.0001	-0.0032
	[0.0019]	[0.0035]	[0.0036]	[0.0036]
X Ind.(Quintile 3 Elas_j)	-0.0100***	-0.0001	0.0002	-0.0014
	[0.0012]	[0.0027]	[0.0027]	[0.0026]
X Ind.(Quintile 4 Elas_j)	-0.0098***	0.0084***	0.0083***	0.0022
	[0.0021]	[0.0024]	[0.0025]	[0.0017]
X Ind.(Quintile 5 Elas_j)	-0.0113***	0.0054*	0.0045	0.0014
	[0.0021]	[0.0028]	[0.0029]	[0.0019]
"Contractibility up to i" (in prod. of j)				
X Ind.(Quintile 1 Elas_j)		0.0234***	0.0165***	0.0166***
		[0.0052]	[0.0049]	[0.0045]
X Ind.(Quintile 2 Elas_j)		0.0339***	0.0357**	0.0260**
		[0.0128]	[0.0147]	[0.0103]
X Ind.(Quintile 3 Elas_j)		0.0365***	0.0392***	0.0280***
		[0.0082]	[0.0084]	[0.0084]
X Ind.(Quintile 4 Elas_j)		0.0669***	0.0666***	0.0318***
		[0.0157]	[0.0174]	[0.0095]
X Ind.(Quintile 5 Elas_j)		0.0685***	0.0591***	0.0299***
		[0.0134]	[0.0144]	[0.0096]
"Contractibility at i" (in prod. Of j)				
X Ind.(Quintile 1 Elas_j)			0.0809***	0.0707***
			[0.0247]	[0.0241]
X Ind.(Quintile 2 Elas_j)			-0.0305	0.0024
			[0.0422]	[0.0311]
X Ind.(Quintile 3 Elas_j)			-0.0546*	0.0129
			[0.0299]	[0.0294]
X Ind.(Quintile 4 Elas_j)			0.0093	0.1297**
			[0.0794]	[0.0532]
X Ind.(Quintile 5 Elas_j)			0.1985	0.2823**
			[0.1471]	[0.1396]
Dummy: Self-SIC	0.9794***	0.9699***	0.9699***	0.9335***
	[0.0018]	[0.0028]	[0.0029]	[0.0086]
p-value: Quintile 5 - Quintile 1 effect of "Contractibility up to i"	---	[0.0015]	[0.0049]	[0.2010]
Observations	4,707,722	4,707,722	4,707,722	4,707,722
No. of parent firms	46,992	46,992	46,992	46,992
No. of i-j pairs	21,836	21,836	21,836	21,836
R^2	0.5342	0.5359	0.5362	0.5599

- *ContUpToi* matters:

(i) Raises propensity to integrate in the complements case

(ii) Also does in the substitutes case, but more weakly so

- Similar results with more flexible quintile-by-quintile estimation ▸ Details

Plan of Talk

1. Introduction and Motivation
2. Theory
   - Baseline model
   - The role of contractibility
3. Empirical Setting
   - Data and measures
   - Regression specifications
4. Findings
   - From cross-firm variation
   - From within-firm, cross-input variation
5. **Conclusions**

Conclusion

- Production line position matters for firm organizational decisions.
- Available data on the production activities of firms operating in many countries and industries can be combined with information from I-O tables to study the organization of firms along global value chains.
- Evidence from WorldBase confirms that firms are less inclined to integrate upstream production stages as their demand elasticity increases.
- Above patterns are moderated in industries that exhibit greater "upstream contractibility".
  - Importantly: Entire profile of upstream inputs matters, not just the contractibility of the input itself.
  - Upstream contractibility reduces the need to rely on organizational mode to elicit desired effort levels from upstream suppliers to mediate downstream spillovers.

Back-Up Slides

Summary Statistics (Firm-level) Return

Table A.1
Summary Statistics

	10th	Median	90th	Mean	Std Dev
A: Firm variables					
Number of Establishments (incl. self)	1	1	1	1.22	3.44
Number of countries (incl. self)	1	1	1	1.05	0.62
Number of integrated SIC codes	1	2	3	1.95	2.21
Year started	1948	1984	1999	1976.84	24.68
Log (Total employment)	3.045	3.807	5.557	4.088	1.080
Log (Sales in USD), 288,627 obs	12.522	15.202	17.059	14.803	2.573
MNCs only, 6,370 obs:					
Number of Establishments (incl. self)	2	3	17	8.48	22.74
Number of countries (incl. self)	2	2	6	3.47	3.64
Number of integrated SIC codes	2	5	17	8.10	11.88
Year started	1917	1968	1995	1960.29	33.88
Log (Total employment)	3.912	5.737	8.522	6.031	1.788
Log (Sales in USD), 5,891 obs	15.895	17.997	20.934	18.208	1.978

Relevance

First-pass evidence that the information in D&B is relevant in terms of input-output linkages:

- 98.0% of the observed (i, j) pairs in the D&B data have $tr_{ij} > 0$.
- 85.6% of these pairs exceed the median positive tr_{ij} value.
- Similar summary statistics if:
    - restrict to distinct (i, j) pairs within each parent firm.
    - restrict to manufacturing inputs.
    - drop pairs where $i = j$.

Return

Measuring Upstreamness ▸ Return

$$upst_{ij} = \frac{d_{ij} + 2\sum_{k=1}^{N} d_{ik} d_{kj} + 3\sum_{k=1}^{N}\sum_{l=1}^{N} d_{ik} d_{kl} d_{lj} + \dots}{d_{ij} + \sum_{k=1}^{N} d_{ik} d_{kj} + \sum_{k=1}^{N}\sum_{l=1}^{N} d_{ik} d_{kl} d_{lj} + \dots}$$

Straightforward to show that:

- $upst_{ij} \geq 1$;
- Numerator of $upst_{ij}$ is the (i,j)-th entry of $[I - D]^{-2} D$; and
- Denominator of $upst_{ij}$ is the (i,j)-th entry of $[I - D]^{-1} D$;

where D is the matrix of d_{ij}'s, and I is the identity matrix.

Use the above properties to compute both $upst_{ij}$ and tr_{ij} from the 1992 U.S. Benchmark Input-Output Tables.

Measuring Upstreamness: Practical Implementation Issues ▸ Return

- Applying the open-economy and net-inventories correction to D; see Antràs et al. 2012.)
- Original industry categories: IO1992
- Compute $upst_{ij}$ and tr_{ij} first for IO1992 codes, and then map to SIC.
- For manufacturing: Each SIC is mapped into by a unique IO1992
- For non-manufacturing: Can have multiple IO1992's mapping to an SIC.
- We focus on global parents whose primary output j is in manufacturing, so the mapping issue matters for non-manufacturing inputs.

  Different treatments considered: (pairwise correlation > 0.98)

  (i) Simple average of $upst_{ij}$ over constituent IO1992 input categories
  (ii) Simple median
  (iii) Random pick
  (iv) tr_{ij} weighted-average

- Separate issue: If an IO1992 input maps into multiple SICs, divide up the tr_{ij} coefficient using a simple average.

Ratio-Upstreamness Measures: Summary statistics

B: <u>From Input-Output Tables</u>					
Total Requirements coefficient	0.000006	0.000163	0.002322	0.001311	0.008026
Baseline Upstreamness measure (mean)	1.838	3.094	4.285	3.097	0.955
C: <u>Ratio-Upstreamness measures</u>					
Baseline (mean)	0.494	0.561	0.691	0.590	0.141
Baseline (random pick)	0.495	0.561	0.692	0.590	0.141
Manufacturing inputs only	0.548	0.633	0.798	0.657	0.174
Ever-integrated inputs only (mean)	0.583	0.656	0.803	0.692	0.179
Exclude parent sic (mean)	0.569	0.934	1.663	1.048	0.429
Exclude parent sic, manufacturing only	0.590	1.100	2.128	1.269	0.625

- R_{jp} values tend to be < 1, but this appears to be driven by the parent SIC.
- Correlation between variants is high (typically > 0.8).

  Key exception: When excluding parent SIC, correlation with baseline measures drops to about 0.15.

Return

Summary Statistics (Industry Controls) ▸ Return

Table A.2
Summary Statistics: Industry Characteristics

	10th	Median	90th	Mean	Std Dev
SIC characteristics (459 industries)					
Import demand elasticity (all codes)	2.300	4.820	20.032	8.569	10.181
Import demand elasticity (BEC cons.+cap.)	1.983	4.500	20.289	8.819	11.722
Import demand elasticity (BEC cons. only)	2.000	4.639	15.992	8.366	11.881
Log (Skilled Emp./Worker)	-1.750	-1.363	-0.778	-1.308	0.377
Log (Equip. Capital / Worker)	2.869	4.043	5.163	4.039	0.867
Log (Plant Capital / Worker)	2.517	3.302	4.524	3.426	0.755
Log (Materials / Worker)	3.898	4.596	5.681	4.702	0.726
R&D intensity: Log (0.001+ R&D/Sales)	-6.908	-6.097	-3.426	-5.506	1.463
Value-added / Shipments	0.357	0.518	0.660	0.514	0.119
Contractibility (Rauch cons., homog.+ref.priced)	0.091	0.362	0.816	0.410	0.265
Upst. contractibility (Rauch cons., homog.+ref.priced)	-0.069	0.018	0.101	0.015	0.069

Further Robustness Tests [Return]

1. Alternative Samples (single establishment, Global ultimate, MNCs, empl.$>=$10). [Details]

2. Alternative constructions of ratio-upstreamness [Details]

3. Additional contractibility measures: [Details]

   - Contractibility of j
   - To confirm that it is variation in production line position matters: $\mathbf{1}(\rho_j \in Quint_n(\rho))$ interacted with a tr-weighted variance of the contractibility of inputs used.

4. Secondary manufacturing SIC codes: [Details]

   - Restrict to parents with a single SIC output industry
   - Alternatively: Construct R_{jpc} for each output industry j.

     Run a regression with two-way clustering of standard errors by parent firm and by output industry j (Cameron, Gelbach and Miller 2011).

Robustness: Alternative Samples

Return

Dependent variable:	Log Ratio-Upstreamness			
	Emp.>=20 & Single Estab.	Emp.>=20 & Global Ultimate	Emp.>=20 & MNC	Emp.>=10
	(1)	(2)	(3)	(4)
Ind.(Quintile 2 Elas_j)	-0.0461	-0.0632*	-0.0865***	-0.0403
	[0.0445]	[0.0361]	[0.0288]	[0.0447]
Ind.(Quintile 3 Elas_j)	-0.0630*	-0.0918***	-0.0787***	-0.0709**
	[0.0338]	[0.0295]	[0.0280]	[0.0326]
Ind.(Quintile 4 Elas_j)	-0.1625***	-0.1560***	-0.1107***	-0.1595***
	[0.0284]	[0.0256]	[0.0269]	[0.0281]
Ind.(Quintile 5 Elas_j)	-0.1639***	-0.1667***	-0.1209***	-0.1614***
	[0.0299]	[0.0271]	[0.0330]	[0.0296]
"Upstream Contractibility"				
X Ind.(Quintile 1 Elas_j)	-1.8620***	-1.8024***	-1.5062***	-1.8660***
	[0.4611]	[0.3851]	[0.3701]	[0.4557]
X Ind.(Quintile 2 Elas_j)	-0.7404	-0.4480	0.2335	-0.8862
	[0.8056]	[0.5864]	[0.3986]	[0.8253]
X Ind.(Quintile 3 Elas_j)	-0.4970	-0.0665	0.2514	-0.3783
	[0.3920]	[0.3785]	[0.2844]	[0.3781]
X Ind.(Quintile 4 Elas_j)	0.6749***	0.7644***	0.5719**	0.6231***
	[0.2162]	[0.2118]	[0.2485]	[0.2068]
X Ind.(Quintile 5 Elas_j)	1.1030***	1.1925***	0.9989***	1.1139***
	[0.2322]	[0.2253]	[0.2952]	[0.2364]
p-value: Q5 at median Upst. Cont.	[0.0000]	[0.0000]	[0.0030]	[0.0000]
Elasticity based on:	BEC cons.	BEC cons.	BEC cons.	BEC cons.
Industry controls?	Y	Y	Y	Y
Firm controls?	Y	Y	Y	Y
Parent country dummies?	Y	Y	Y	Y
Observations	117,956	26,151	2,490	239,355
No. of industries	219	219	199	219
R^2	0.2990	0.3376	0.2473	0.2982

Robustness: Alternative R_{jpc}'s

Return

Dependent variable:	Random pick (1)	"Ever-Integrated" inputs (2)	Mfg. inputs only (3)	Mfg. inputs and drop parent SIC (4)
Ind.(Quintile 2 Elas_j)	-0.0481	-0.0239	-0.0385	-0.0262
	[0.0428]	[0.0413]	[0.0497]	[0.0925]
Ind.(Quintile 3 Elas_j)	-0.0687**	-0.0402	-0.0786**	-0.0642
	[0.0329]	[0.0341]	[0.0394]	[0.0514]
Ind.(Quintile 4 Elas_j)	-0.1574***	-0.1294***	-0.1825***	-0.1390**
	[0.0277]	[0.0307]	[0.0320]	[0.0661]
Ind.(Quintile 5 Elas_j)	-0.1652***	-0.1314***	-0.1762***	-0.2959***
	[0.0303]	[0.0261]	[0.0396]	[0.0934]
"Upstream Contractibility"				
X Ind.(Quintile 1 Elas_j)	-1.8580***	-0.8334***	-2.1693***	-1.1099*
	[0.4454]	[0.3137]	[0.4818]	[0.5751]
X Ind.(Quintile 2 Elas_j)	-0.6963	-0.8882	-0.9344	0.0011
	[0.7601]	[0.7959]	[0.9046]	[0.8379]
X Ind.(Quintile 3 Elas_j)	-0.4199	0.0370	-0.2729	-1.8117*
	[0.3873]	[0.4978]	[0.4890]	[0.9845]
X Ind.(Quintile 4 Elas_j)	0.6473***	0.9039***	0.8981***	-2.5364***
	[0.2126]	[0.3313]	[0.2503]	[0.7378]
X Ind.(Quintile 5 Elas_j)	1.1824***	1.3673***	1.1377***	-0.0741
	[0.2803]	[0.2992]	[0.3823]	[1.1156]
p-value: Q5 at median Upst. Cont.	[0.0000]	[0.0000]	[0.0000]	[0.0013]
Elasticity based on:	BEC cons.	BEC cons.	BEC cons.	BEC cons.
Industry controls?	Y	Y	Y	Y
Firm controls?	Y	Y	Y	Y
Parent country dummies?	Y	Y	Y	Y
Observations	144,107	144,107	143,846	46,992
No. of industries	219	219	219	218
R^2	0.3059	0.1950	0.3311	0.1217

Robustness: Additional Firm and Industry Controls ▸ Return

Dependent variable:	Log Ratio-Upstreamness					
	(1)	(2)	(3)	(4)	(5)	(6)
Ind.(Quintile 2 Elas_j)	-0.0429	-0.0491	-0.0425	-0.0584	-0.0489	-0.0477
	[0.0414]	[0.0429]	[0.0449]	[0.0489]	[0.0430]	[0.0424]
Ind.(Quintile 3 Elas_j)	-0.0549*	-0.0684**	-0.0613**	-0.0732**	-0.0683**	-0.0345
	[0.0305]	[0.0327]	[0.0309]	[0.0316]	[0.0328]	[0.0283]
Ind.(Quintile 4 Elas_j)	-0.1602***	-0.1614***	-0.1577***	-0.1605***	-0.1612***	-0.1343***
	[0.0253]	[0.0277]	[0.0252]	[0.0288]	[0.0277]	[0.0193]
Ind.(Quintile 5 Elas_j)	-0.1547***	-0.1643***	-0.1596***	-0.1654***	-0.1643***	-0.1301***
	[0.0269]	[0.0292]	[0.0268]	[0.0296]	[0.0292]	[0.0207]
"Upstream Contractibility"						
X Ind.(Quintile 1 Elas_j)	-1.6823***	-1.8551***	-1.8407***	-1.8143***	-1.8546***	-1.3938***
	[0.4082]	[0.4444]	[0.4041]	[0.4768]	[0.4450]	[0.3022]
X Ind.(Quintile 2 Elas_j)	-0.6777	-0.6871	-0.8194	-0.4520	-0.6888	-0.3596
	[0.7338]	[0.7621]	[0.8638]	[0.9331]	[0.7626]	[0.8585]
X Ind.(Quintile 3 Elas_j)	-0.5881	-0.4174	-0.4967	-0.3226	-0.4181	-0.6177
	[0.3682]	[0.3851]	[0.4096]	[0.3604]	[0.3859]	[0.3840]
X Ind.(Quintile 4 Elas_j)	0.5891***	0.6848***	0.6249**	0.7377***	0.6867***	0.4608**
	[0.1714]	[0.2104]	[0.2463]	[0.2200]	[0.2107]	[0.2039]
X Ind.(Quintile 5 Elas_j)	0.9590***	1.1190***	1.0486***	1.1428***	1.1195***	0.6453***
	[0.2165]	[0.2269]	[0.2397]	[0.2206]	[0.2276]	[0.2175]
Vertical Integration Index, j	-1.1296***					-1.0273***
	[0.2065]					[0.1969]
Foreign integrated tr share, j		-0.9241***				-0.2539**
		[0.1244]				[0.1208]
Log Input Elasticity, j			-0.0440			-0.2862***
			[0.0542]			[0.0644]
Wtd. Covariance of input elasticity and upstreamness, j				-0.0091		-0.0447***
				[0.0088]		[0.0105]
p-value: Q5 at median Upst. Cont.	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]	[0.0000]
Elasticity based on:	BEC cons.	BEC cons.	BEC cons.	BEC cons.	BEC cons.	BEC cons.
Industry controls?	Y	Y	Y	Y	Y	Y
Firm controls?	Y	Y	Y	Y	Y	Y
Parent country dummies?	Y	Y	Y	Y	Y	Y
Subsidiary country dummies?	N	N	N	N	Y	Y
Observations	144,107	144,107	144,107	144,107	144,107	144,107
No. of industries	219	219	219	219	219	219
R^2	0.3526	0.3075	0.3085	0.3096	0.3069	0.3785

Robustness: Additional Controls (Related to Contractibility) ▸ Return

Dependent variable:	Log Ratio-Upstreamness			
	(1)	(2)	(3)	(4)
Ind.(Quintile 2 Elas_j)	-0.0407	-0.0509	-0.1187	-0.0939
	[0.0443]	[0.0438]	[0.1322]	[0.1350]
Ind.(Quintile 3 Elas_j)	-0.0626**	-0.0695**	-0.4769***	-0.4544***
	[0.0310]	[0.0327]	[0.1176]	[0.1156]
Ind.(Quintile 4 Elas_j)	-0.1576***	-0.1612***	-0.3214***	-0.3214***
	[0.0245]	[0.0278]	[0.1201]	[0.1169]
Ind.(Quintile 5 Elas_j)	-0.1576***	-0.1667***	-0.4507***	-0.4370***
	[0.0268]	[0.0290]	[0.1235]	[0.1221]
"Upstream Contractibility"				
X Ind.(Quintile 1 Elas_j)	-2.3570***	-2.0402***	-1.1739**	-1.6284**
	[0.5742]	[0.5299]	[0.5681]	[0.7426]
X Ind.(Quintile 2 Elas_j)	-1.1561	-0.8466	-0.3054	-0.6615
	[0.9567]	[0.7616]	[0.7066]	[0.8772]
X Ind.(Quintile 3 Elas_j)	-0.8615*	-0.5602	-0.9148**	-1.2697***
	[0.5148]	[0.4718]	[0.3602]	[0.4821]
X Ind.(Quintile 4 Elas_j)	0.2387	0.5423	0.5971**	0.1825
	[0.3747]	[0.3434]	[0.2828]	[0.4461]
X Ind.(Quintile 5 Elas_j)	0.6403*	0.9620***	0.7837***	0.3838
	[0.3713]	[0.3660]	[0.2736]	[0.4025]
Output SIC contractibility, j	-0.1376			-0.1243
	[0.0946]			[0.0932]
Wtd. Avg. input contractibility, j		-0.0973		0.0291
		[0.1706]		[0.1722]
Var. Input contractibility, j X Ind. (Quintile n Elas_j)	N	N	Y	Y
p-value: Q5 at median Upst. Cont.	[0.0000]	[0.0000]	[0.0006]	[0.0006]
Elasticity based on:	BEC cons.	BEC cons.	BEC cons.	BEC cons.
Industry controls?	Y	Y	Y	Y
Firm controls?	Y	Y	Y	Y
Parent country dummies?	Y	Y	Y	Y
Observations	144,107	144,107	144,107	144,107
No. of industries	219	219	219	219
R^2	0.3111	0.3068	0.3405	0.3442

Multi-industry Parents

Return

Dependent variable:	Log Ratio-Upstreamness					
	Single mfg output SIC		Most downstream mfg output SIC		Parent firm by SIC mfg output (two-way cluster)	
	(1)	(2)	(3)	(4)	(5)	(6)
Ind.(Quintile 2 Elas_j)	-0.0779	-0.0419	-0.0585	-0.0386	-0.0744*	-0.0476
	[0.0527]	[0.0464]	[0.0445]	[0.0414]	[0.0426]	[0.0428]
Ind.(Quintile 3 Elas_j)	-0.1148**	-0.1021***	-0.0586	-0.0217	-0.0794*	-0.0362
	[0.0465]	[0.0292]	[0.0446]	[0.0459]	[0.0412]	[0.0398]
Ind.(Quintile 4 Elas_j)	-0.1671***	-0.1522***	-0.1420***	-0.1453***	-0.1646***	-0.1642***
	[0.0503]	[0.0305]	[0.0444]	[0.0292]	[0.0412]	[0.0257]
Ind.(Quintile 5 Elas_j)	-0.1789***	-0.1522***	-0.1557***	-0.1479***	-0.1835***	-0.1680***
	[0.0493]	[0.0306]	[0.0462]	[0.0315]	[0.0431]	[0.0286]
"Upstream Contractibility"						
X Ind.(Quintile 1 Elas_j)		-1.9121***		-1.5447***		-1.7763***
		[0.4691]		[0.4565]		[0.4149]
X Ind.(Quintile 2 Elas_j)		-0.7893		-0.4459		-0.5591
		[0.7721]		[0.6295]		[0.7887]
X Ind.(Quintile 3 Elas_j)		0.1054		-0.8797		-0.8420
		[0.2069]		[0.6102]		[0.5438]
X Ind.(Quintile 4 Elas_j)		0.6618***		0.6971***		0.6806***
		[0.2346]		[0.2113]		[0.2039]
X Ind.(Quintile 5 Elas_j)		1.1177***		1.2295***		1.1643***
		[0.2104]		[0.2643]		[0.2544]
p-value: Q5 at median Upst. Cont.		[0.0000]		[0.0001]		[0.0000]
Elasticity based on:	BEC cons.	BEC cons.	BEC cons.	BEC cons.	BEC cons.	BEC cons.
Industry controls?	Y	Y	Y	Y	Y	Y
Firm controls?	Y	Y	Y	Y	Y	Y
Parent country dummies?	Y	Y	Y	Y	Y	Y
Observations	97,174	97,174	146,851	146,851	211,238	211,238
No. of industries	219	219	219	219	---	---
R^2	0.2468	0.3308	0.1948	0.2647	0.2205	0.2881

Within-Firm Regressions (Cont.) ▸ Return

Similar results with more flexible quintile-by-quintile estimation.

- "Contractibility up to *i*" matters for integration decisions (particularly in Q5), even when controlling for $upst_{ij}$ at the same time.

Table 8
Integration Decisions over the Top 100 Inputs: By Elasticity Quintile

Dependent variable:	**Indicator variable: Input Integrated?**				
BEC cons. Elas_j:	Quintile 1 (1)	Quintile 2 (2)	Quintile 3 (3)	Quintile 4 (4)	Quintile 5 (5)
Contractibility up to i (in prod. of j)	0.0284***	0.0217***	0.0264***	0.0353***	0.0473***
	[0.0047]	[0.0061]	[0.0084]	[0.0101]	[0.0130]
Upstreamness_ij	0.0002	-0.0069*	-0.0013	0.0036*	0.0007
	[0.0013]	[0.0041]	[0.0032]	[0.0021]	[0.0025]
Dummy: Self-SIC	0.9401***	0.9316***	0.9529***	0.7983***	0.8812***
	[0.0087]	[0.0237]	[0.0107]	[0.0530]	[0.0418]
Firm fixed effects?	Y	Y	Y	Y	Y
Input industry (i) fixed effects?	Y	Y	Y	Y	Y
Observations	1,064,215	1,423,826	817,651	786,015	616,015
No. of parent firms	10626	14205	8149	7860	6152
No. of input-output (ij) industry pairs	4306	4411	4405	4401	4313
R^2	0.5463	0.5849	0.5108	0.6178	0.6035