Vertical Integration and Input Flows

(formerly "Why Do Firms Own Production Chains?")

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Overview

Huge literature on the causes and effects of vertical integration (VI)

- Efficiency reasons for integrating
- Market power reasons for integrating
- Models built around transfers of inputs—"make or buy" decision

But little systematic evidence on how firms with VI structure are systematically different along these and other measurable lines

- Not just hard-to-measure things: capital specificity, transaction costs, etc.—even basics

We use two large datasets to document behavior and attributes in VI structures, with a particular focus on goods transfers along chain

- Economic Census—all establishments in non-farm private sector
- Commodity Flow Survey—random sample of plants and shipments

Overview

Main empirical finding: vast majority of upstream VI plants' shipments NOT to other units in firm

- Mode is zero, median share of intra-firm shipments is about 3%
- Pattern is ubiquitous across industries
- Result is robust to a number of alternative measurement approaches

What explains these patterns?

- Shipments data indicates reasons to VI not necessarily (or even usually) about physical goods passed down production chains in firms
- Ubiquity implies explanation can't rely on specific technologies, product market attributes, etc.

Overview

Our take:

- VI is typically used to facilitate intra-firm transfers of *intangible*, rather than tangible, inputs
  - E.g., managerial oversight, sales and marketing know-how, intellectual property, organizational capital, etc.
  - Information-based inputs like these may be types where market is poorest substitute for within-firm provision

- Equilibrium assortative matching in assignment of complementary intangible and tangible inputs creates "type" patterns
  - Consistent with our other findings:
    - VI plants have higher "types" in their industry
    - Plants' types correlated within firms

- Indirect evidence of intangible input transfers: acquired plants start to "act like" acquiring firms—product mix and shipment locations

Data

Economic Census (1977, 82, 87, 92, 97)

- Quinennial census of establishments of non-farm private economy
  - Establishment: unique location where economic activity occurs
- Firm IDs let us observe ownership structure of every establishment (Census makes real efforts to ensure "firms" are *firms*)
- Combine with Input-Output Tables to find vertical chains within firms
- For establishments in Census of Manufactures (about 350K per EC), we see revenues, labor inputs, capital stocks, materials inputs

Data

Commodity Flow Survey (1993, 97)

- Random sample of establishments and their shipments
- Shipments sampled in one week of each quarter
- About 100 shipments observed per establishment on average
  - Origin and destination ZIP, distance, dollar value, weight, & more
- Establishment ID numbers allow merge with EC
  - 1993 CFS ⇔ 1992 EC
- We focus on upstream firms in VI structures: 67,500 establishments with 6.3 million shipments

Measuring Vertical Integration

1. Use firm IDs in Economic Census microdata to group establishments (plants) by firm

2. Find all industries in which each firm operates

3. Determine "substantial vertical links"
   - A "substantial link" exists between Industries *I* and *J* if at least 1% of *I*'s sales are sent to establishments in Industry *J*
     - For most industries, the Input-Output Table shows us these values
     - For wholesale and retail sectors (which the I-O Table treats mostly as pass-through monoliths) we use data from Annual Wholesale (Retail) Trade Surveys and CFS info on establishments' industry classifications to impute shipments and purchases by *I*-*J* pair

4. All plants whose firm owns at least one other plant in an upstream or downstream in substantial link are considered vertically integrated
   - Not all plants in a firm need be vertically integrated

Classifying Shipments as Internal or External to Firm

1. Merge EC with CFS data

2. Determine which CFS establishments are VI *and* are on upstream side of vertical link

3. Use EC to find ZIP codes of all downstream plants in the same firm

4. Compare shipments' destination ZIPs to downstream plant ZIPs; matches are considered intra-firm shipments

- Note shipment to *any* downstream plant is considered internal, not just downstream of upstream CFS plant's industry
- Shipment to downstream ZIP code is assumed to go to firm's own establishment rather than one outside the firm
- Only observe just over 90 percent of ZIP codes
- Will conduct several robustness checks

Establishment-Level Shares of Intra-Firm Shipments

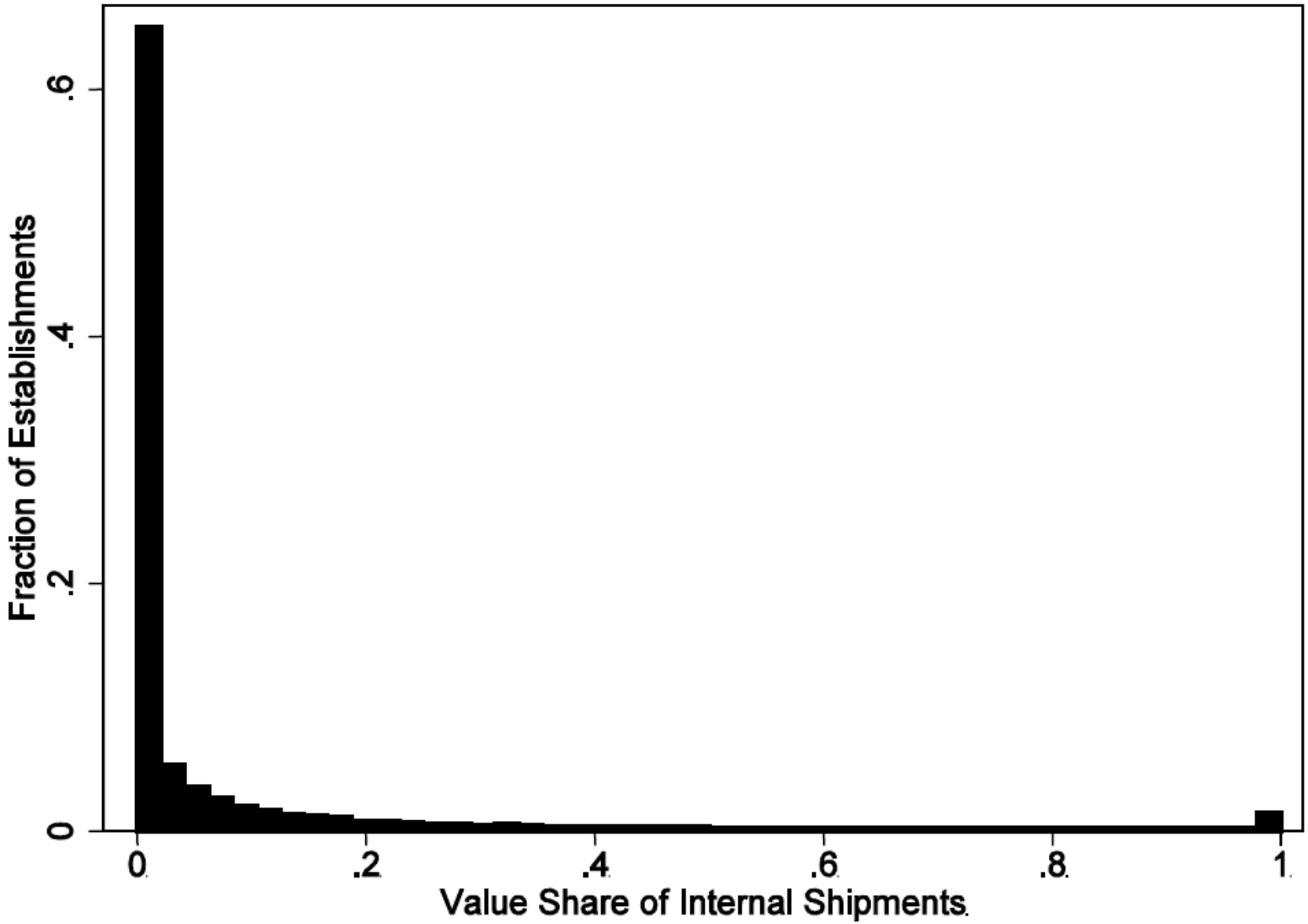
For each upstream VI establishment in CFS, compute fractions of shipments (by count, dollar value, and weight) are sent to any downstream establishment(s) in its firm

Quantiles of internal share distribution across 67,500 upstream VI estabs:

	Percentile				
Internal share of:	25th	50th	75th	90th	95th
Plant shipment count	0%	0.4%	7.3%	32.2%	62.7%
Plant dollar value of shipments	0	<0.1	7.0	37.6	69.5
Plant total weight of shipments	0	<0.1	7.1	38.4	69.9

Fraction of plants with internal shares equal to zero = 49.7%
Fraction of plants with internal shares equal to one = 1.2%

Establishment-Level Shares of Intra-Firm Shipments



Robustness

Basic survey measurement issue: Are firms reporting internal shipments?

- CFS instructions explicitly state that respondents should report shipments "to another location of your company"
  - (Save for incidental items like "inter-office memos, payroll checks, business correspondence, etc.")

- Majority of establishments report *some* internal shipments

- Census has auditing process that compares implied total shipments from CFS to shipments data from other sources (e.g., CM)

- In MFG, CM collects data on dollar value of "interplant transfers": shipments to other establishments in firm for further assembly
  - Correlation is 0.52 across matched sample of 37K plant-years; regression yields coefficient of 0.470 (s.e. = 0.011)

Robustness

Specification/Sample	Percentile					Frac. = 0	Frac. = 1	Appx. N
	25th	50th	75th	90th	95th			
At least median number of shipments	0.0%	0.2%	6.9%	31.7%	59.5%	45.5%	0.3%	34K
No exporters	0.0	<0.1	8.6	46.5	78.3	49.7	1.6	47K
Shipments to any plant in firm are internal	0.1	4.9	25.1	67.5	90.6	22.8	2.6	67.5K
County, not ZIP, determines internal	0.0	7.2	39.8	87.1	98.8	25.3	4.2	67.5K
25 least differentiated industries	0.0	0.0	2.5	20.0	48.6	61.4	0.6	2.2K
5% cutoff definition for VI	0.0	0.0	5.1	32.1	63.3	53.9	0.9	53K
Remove I→I as a potential vertical link	0.0	0.0	3.9	30.8	60.7	58.7	1.0	43K

Lafontaine and Slade (JEL 2007) VI Case Studies

We also checked internal shipments in industries covered by L-S (JEL 2007) survey on vertical integration.

12 industries passed Census disclosure threshold: surface mining of coal, underground mining of coal, soft drink bottling, crude oil refining, cyclic crudes and intermediates, other industrial organic chemicals, men's footwear, cement, auto parts, aerospace parts, bulk petroleum wholeseale, nonbulk petroleum wholesale

50^{th} and 75^{th} percentile internal shipment shares were 4.9 and 33.8% (compared to 0.1 and 7.0% in larger sample).

While internal shipment share is higher (as expected), bulk of shipments still sent outside firm.

Robustness: Shipments as Fraction of Usage

We compute internal shipments as a fraction of all upstream shipments

Measurement issue: Conceivably, firm could fully supply its downstream needs, but still make a lot of shipments outside firm. E.g.:

- U plant makes $100 million of copper ingots
- D plant makes copper pipes, using $10 million of ingots from U
- Firm fully internally sourced, but still ships 90% outside of firm
    - Still an issue of why firm doesn't own more downstream plants…

Check—Measure "absorption rate" of internal shipments: fraction of firm's *downstream* use (rather than fraction of upstream shipments)

- Use subsample where CFS has *all* of firm's U plants in an industry
    - 11K plant-years (54% report no internal shipments, 90 percentile is 36.5% internal)
- Three different measures of downstream usage
- Use **min**{**upstream shipments, downstream use**} as denominator

Robustness: Shipments as Fraction of Usage

- Absorption rate #1: total internal shipments across all upstream plants ÷ materials purchases reported in core CM for firm's downstream mfg plants (N = 4400 firm-years)
- Absorption rate #2: internal shipments by 2-digit product ÷ matching 2-digit materials purchases (from 1992 CM materials supplement) for firm's downstream mfg plants (N = 5500 firm-products)
- Absorption rate #3: same as #2, except at 4-digit level (N = 2350 firm-materials)

	Value share of shipments percentiles				
Absorption rate	25th	50th	75th	90th	95th
#1	0%	0.3%	13.8%	67.4%	134.3%
#2	0	0	15.4	118.8	403.2
#3	0	0	18.5	125.4	687.0

Robustness: Shipments of "Marginal VI Plants"

Sample: CFS establishments that a) are newly VI on upstream end of chain, b) were single-unit firms in previous EC, and c) were acquired by a firm that became integrated because of acquisition

- I.e., these are the "marginal VI plants"—the establishments that *make* these firms VI for the first time
- 300 plant-years and 28K shipments

Shipment patterns:

- Reporting zero internal shipments: 68%
- 90^{th} percentile: 10.1%
- Coefficient of regression of all plants' internal shipment shares on indicator for these marginal plants and industry-year dummies: -0.057 (s.e. = 0.009)

Robustness: Vertical Integration "Under One Roof"

Measurement issue: Our VI definition requires a firm to own at least two plants, but what if some VI is within-plant?

Example

Firm 1:

- Upstream plant makes fan assemblies (from, e.g., ball bearings)
- Downstream plant makes freezers using fans from upstream plant

Firm 2:

- One plant makes fan assemblies on one side of factory, which are then used in freezers made on other side

How could we tell whether Firm 2 types are common?

CM materials supplement—plants' mat'ls purchases by 6-digit product

Compare freezer plants:

Do some buy fans, while others buy ball bearings?

Do those we call VI purchase systematically different materials than others?

Robustness: Vertical Integration "Under One Roof"

Robustness checks using CM materials supplement for 1977-97

1. Regress share of raw materials (defined as products of ag, forestry, fisheries, or mining sectors) in plants' materials purchases on VI indicator (with industry-year dummies)

    All plants (N = 450K plant-years, average raw mat'ls share 8.2%):

        VI coeff = 0.47% (s.e. = 0.05%)

    Only plants reporting positive raw materials purchases (N = 85K, avg. raw mat'ls share 44.0%):

        VI coeff = -1.8% (s.e. = 0.19%)

2. Mean difference between VI and non-VI plants' raw materials shares at 4-digit industry level (n = 1867 industry-years): 0.08% (0.22%)

Robustness: Vertical Integration "Under One Roof"

Robustness checks using CM materials supplement, continued

3. Correlation between materials intensity ranks of VI and non-VI plants in industry (N = 87K, rank correlation coefficient is 0.74):

		Material's intensity rank in non-VI plants				
		1	2	3	4	5
Material's intensity rank in VI plants	1	50.5%	13.7%	8.0%	4.5%	3.3%
	2	14.7%	26.1%	15.4%	10.1%	6.0%
	3	8.1%	14.7%	19.1%	13.2%	9.8%
	4	5.6%	10.6%	12.1%	14.8%	11.8%
	5	3.1%	6.5%	9.6%	11.2%	11.3%
	6	3.2%	5.1%	6.5%	7.9%	10.4%
	7	2.2%	4.3%	5.9%	6.4%	7.3%

Robustness: Is Geographic Closeness Important?

- Distance definitely matters…if firm's downstream plants are a long ways away, shipments less likely
  - This can be a sign of intangible inputs transfer VI rather (otherwise, why own plants far away?)
  - Many plants make shipments that go further than nearest within-firm downstream plant
    - Avg. median shipment distance is 256 miles, avg. distance to nearest downstream plant is 242 miles—VI firms "bypass" their own downstream units often

- For 2254 plant-years (200K shipments), *all* plants in VI firm are in same county
  - 46.7% report no internal shipments
  - 90^{th} percentile of internal share is 49.0%
  - 2.4% report only internal shipments

VI Plants Are High "Type" within Their Industries

"Type"—idiosyncratic demand and supply fundamentals affecting plant profitability

We use four proxies for type:

1. Labor productivity (output per hour)
2. Total factor productivity
3. Real output
4. Capital intensity

All have been shown to be empirically related to survival

- E.g., Dunne, Roberts, and Samuelson (1989); Doms, Dunne, and Roberts (1995); and Bartelsman and Doms (2000)

Type and survival are theoretically linked in industry models

- E.g., Jovanovic (1982), Hopenhayn (1992), Ericson and Pakes (1995), and Melitz (2003)

VI Plants Are High "Type" within Their Industries

Regress type measure on VI indicator and industry-year fixed effects:

$$y_{eit} = \gamma_{it} + \alpha_{VI} I[\text{VI}] + \varepsilon_{eit}$$

	Output per hour	TFP	Output	Capital-labor ratio
Approx. N	970,000	879,000	991,000	937,000
VI indicator	0.337*	0.013*	1.443*	0.424*
	(0.002)	(0.001)	(0.004)	(0.003)

VI Plants as High-Type Plants

Do VI plants' higher types reflect pre-existing differences or effects of becoming VI?

Differences among new plants within industry-years

Using all new plants:

$$y_{eit} = \gamma_{it} + \alpha_{VI} I[\text{VI}] + \varepsilon_{eit}$$

	Output per hour	TFP	Output	Capital-labor ratio
Approx. N	240,000	213,000	248,000	233,000
VI Indicator	0.281*	0.032*	1.228*	0.330*
	(0.004)	(0.003)	(0.009)	(0.006)

VI Plants as High-Type Plants

Pre-existing differences or effects of becoming VI (continued)?

Are plants that are sought out for VI different?

Using all unintegrated plants:

$$y_{eit} = \gamma_{it} + \alpha_{VI} I[\text{VI by next CM}] + \varepsilon_{eit}$$

	Output per hour	TFP	Output	Capital-labor ratio
Approx. N	403,000	367,000	410,000	390,000
VI Indicator	0.197*	0.002	1.258*	0.246*
	(0.005)	(0.003)	(0.010)	(0.007)

VI Plants as High-Type Plants

Pre-existing differences or effects of becoming VI (continued)?

<u>Changes upon integration</u>

Using all surviving unintegrated plants:

$$\Delta y_{eit} = \gamma_{it} + \alpha_{VI} I[\text{become VI}] + \varepsilon_{eit}$$

	Output per hour	TFP	Output	Capital-labor ratio
N	348,000	300,000	356,000	327,000
VI Indicator	0.034*	-0.009*	0.015*	0.033*
	(0.005)	(0.004)	(0.007)	(0.009)

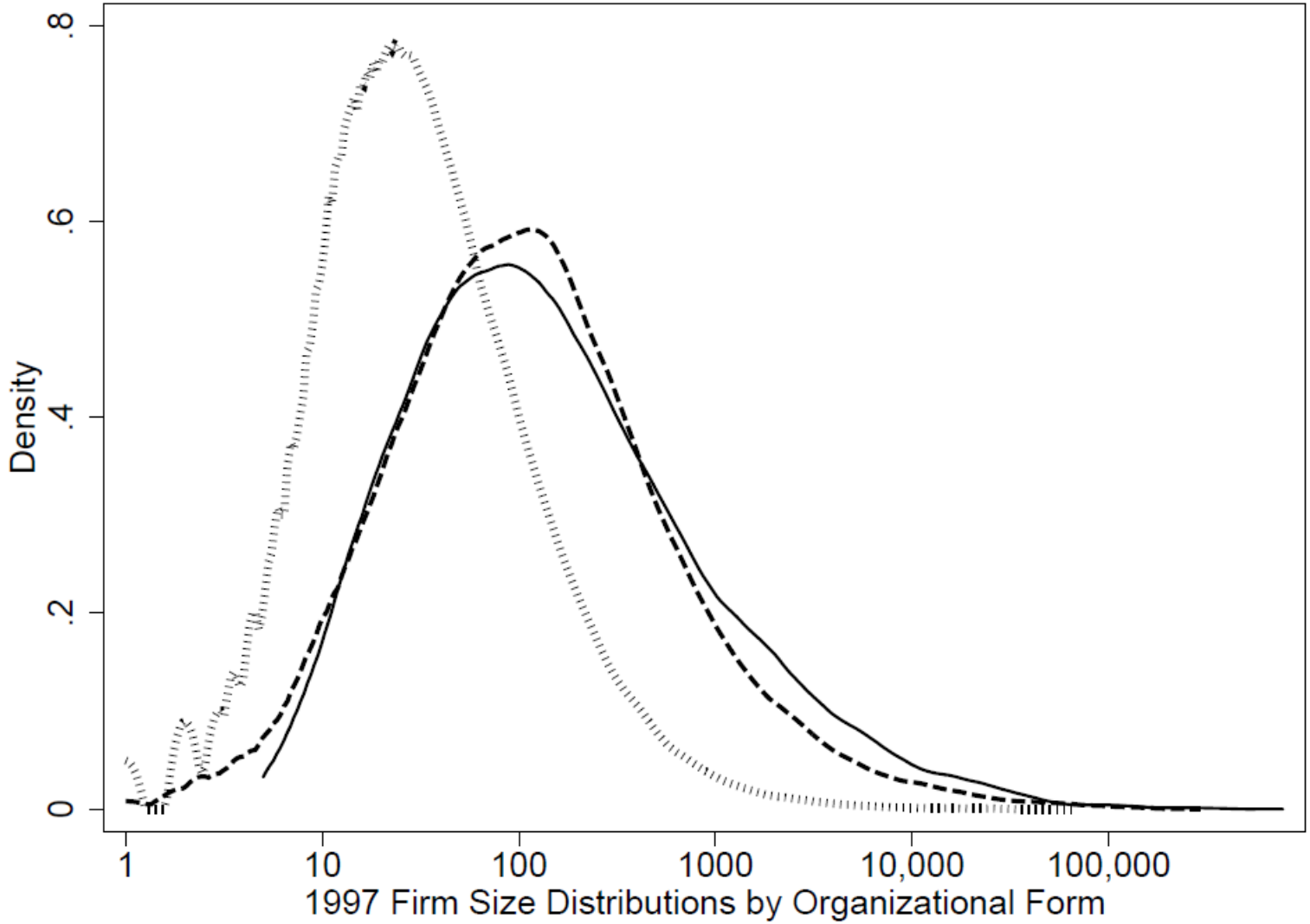
VI Plants as High-Type Plants

Results: type gaps between VI and non-VI plants in the same industry mostly reflect differences in assignment of plant types to VI status

- Present at birth for entrants
- Present before merge into VI structure for newly VI plants

Remaining gaps closed by changes seen at time of integration

Firms with VI Structures Are Larger



Firms with VI Structures Are Larger

Plant Type Differences Controlling for Firm Size

	Output per hour	TFP	Output	K/L ratio
Multi-unit firm dummy				
N	966,305	875,791	986,881	933,423
VI indicator	0.179*	0.016*	0.698*	0.218*
	(0.003)	(0.002)	(0.006)	(0.004)
Multi-industry indicator	0.197*	-0.003	0.935*	0.260*
	(0.002)	(0.002)	(0.005)	(0.004)
Flexible controls for firm size				
N	947,342	861,835	965,338	915,230
VI indicator	0.040*	0.007*	0.154*	0.034*
	(0.003)	(0.002)	(0.006)	(0.005)

Discussion

Is there an explanation consistent with all these patterns (and that can apply across very different industries)?

VI facilitates intra-firm transfers of *intangible*, rather than tangible, inputs

- Managerial oversight likely candidate for such an input, but sales and marketing know-how, etc. also possibilities

- Information-based inputs like management may be kinds where market offers poorest substitute for within-firm provision

Discussion

- Intangible inputs can easily flow from "downstream" to "upstream" units
  - Distinction becomes one of convenience rather than reflecting intra-firm input transfers
- Vertical expansions are similar to horizontal expansions
  - H expansion—firm begins operating in markets typically related to current business, but no physical goods transfers are implied
  - V expansion—upstream and downstream business are related to firm's current business, and no physical goods transfers need occur

Discussion

Results about VI plants being high type and correlation of types within firms are consistent with intangible inputs being complements to physical inputs in production

Complementarities imply assortative matching in equilibrium

- Equilibrium assignment view of firm organization: Lucas (1978), Rosen (1982), Garicano and Rossi-Hansberg (2006) and Garicano and Hubbard (2007)

Higher-quality intangible inputs (e.g., better managers) are spread across larger and/or a greater number of production units

Highest-quality inputs are allocated across multiple establishments, some of which are vertically linked

- VI production chains are found in largest firms with highest-type plants

Testing the Intangible Inputs Motive

Look at what happens to plants when they are acquired by a firm and placed into vertical links

- Decompose changes upon VI observed above
  - Labor productivity change into output and input changes
  - Capital intensity change into capital and labor changes
  - Labor composition changes
- See whether and how shipment patterns change
- See whether and how product choice patterns change

Revisiting Plant Changes upon Integration

	Change upon VI
Output per hour	0.025*
	(0.005)
Output	0.008
	(0.006)
Hours	-0.017*
	(0.006)
Capital-labor ratio	0.030*
	(0.009)
Capital	0.013
	(0.009)
Production workers	-0.010
	(0.006)
Nonproduction workers	-0.047*
	(0.007)
Nonproduction worker share	-0.006*
	(0.001)

Testing the Intangible Inputs Motive: Product Mix and Shipment Changes upon Acquisition

For each CM plant we observe before and after acquisition by another firm, we partition universe of products (shipment locations) into 4 groups:

- Group 1—Products produced (locations shipped to) by neither any plant in acquiring firm nor any *other* plants in acquired firm
  - I.e., plant's idiosyncratic activity
- Group 2—Products produced (locations shipped to) by acquired firm but not acquiring firm
- Group 3—Products produced (locations shipped to) by acquiring firm but not acquired firm
- Group 4—Products produced (locations shipped to) by both acquired and acquiring firms

We then compute sales of the acquired plants in each of these groups in the CMs preceding and following the ownership change

Testing the Intangible Inputs Motive: Product Mix and Shipment Changes upon Acquisition

A shift in acquired plants' product mixes (shipment locations) away from Groups 2 and 4 and toward Group 3 indicates acquiring firms reorient the plants toward the acquiring firms' existing operations.

Reorientation likely requires intangible capital of acquiring firms

- E.g., production knowledge, product design, customer lists, etc.
- Reorientation is circumstantial evidence for the flow of intangibles

Testing the Intangible Inputs Motive: Product Mix Changes upon Acquisition

	Group 1	Group 2	Group 3	Group 4
Average sales, CM prior to acquisition (millions)	$10.1	$5.5	$7.0	$4.4
Average sales, CM after acquisition (millions)	$14.3	$5.5	$7.8	$4.3
Fraction of establishment sales, CM prior to acquisition (%)	37.4	20.5	26.0	16.1
Fraction of establishment sales, CM after acquisition (%)	44.7	17.2	24.6	13.5

Sales: Groups 2 + 4 decline 1%, Group 3 increase 11%.
Share of Sales: Groups 2 + 4 decrease 16%, Group 3 decrease 5%
Share of non-idiosyncratic sales: Groups 2 + 4 decline 5%, Group 3 increase 7%

Testing the Intangible Inputs Motive: Shipment Location Changes upon Acquisition

	Group 1	Group 2	Group 3	Group 4
Average sales, CM prior to acquisition (millions)	$61.5	$15.0	$17.9	$8.8
Average sales, CM after acquisition (millions)	$86.3	$13.7	$25.0	$5.2
Fraction of establishment sales, CM prior to acquisition (%)	59.6	14.5	17.4	8.6
Fraction of establishment sales, CM after acquisition (%)	69.3	11.0	20.1	4.2

Sales: Groups 2 + 4 decline 13%, Group 3 increase 16%.
Share of Sales: Groups 2 + 4 decrease 34%, Group 3 increase 16%
Share of non-idiosyncratic sales: Groups 2 + 4 decline 25%, Group 3 increase 32%

Conclusion

Few intra-firm shipments by upstream VI plants

High plant "types" are correlated with VI, and highly correlated in firms with VI structures

Explanation:

- VI typically facilitates intra-firm transfers of *intangible* inputs (e.g., management) instead of physical goods down a production chain
- Equilibrium assignment with complementarities between intangible and tangible inputs yields plant type patterns, within-firm correlations
- Vertical expansions not unlike horizontal expansions—a move into a related business to expand scope of managerial oversight, etc.

Circumstantial evidence for transfers of intangible inputs to newly acquired manufacturing plants

Does Vertical Ownership = Vertical Integration?

Does it start with an asset governance structure and then look for transactions? Or, does definition start with a transaction and investigate governance structure around it?

The literature has been ambiguous about any separation:

- "We define integration in terms of the ownership of assets and develop a model to explain when one firm will desire to acquire the assets of another firm." — Grossman and Hart (1986)
- "A VI firm controls a number of different operations in the production and/or marketing of similar commodities on successive levels; and its management pursues a unified profit policy." — "Toward a Definition of Integration," Hirsch (1950)
- "VI describes the ownership or control by a firm of different stages of the production process, e.g., petroleum refining firms owning 'downstream' the terminal storage and retail gasoline distribution facilities and 'upstream' the crude oil field wells and transportation pipelines." — OECD's Glossary of Statistical Terms

Does Vertical Ownership = Vertical Integration?

- "[Industry guide] was searched for additional information on utility ownership of mines. Then, the entries for the 25 largest utility consumers of coal in Moody's were reviewed in an effort to identify additional utility-owned mines. Finally, the ownership of all suppliers identified in the contracts with mine-mouth plants was determined from another listing in the Keystone Coal Manual." — Joskow (1985)

- Stigler (1951) cites empirical VI studies that count VI as firms with "two or more establishments making successive products."

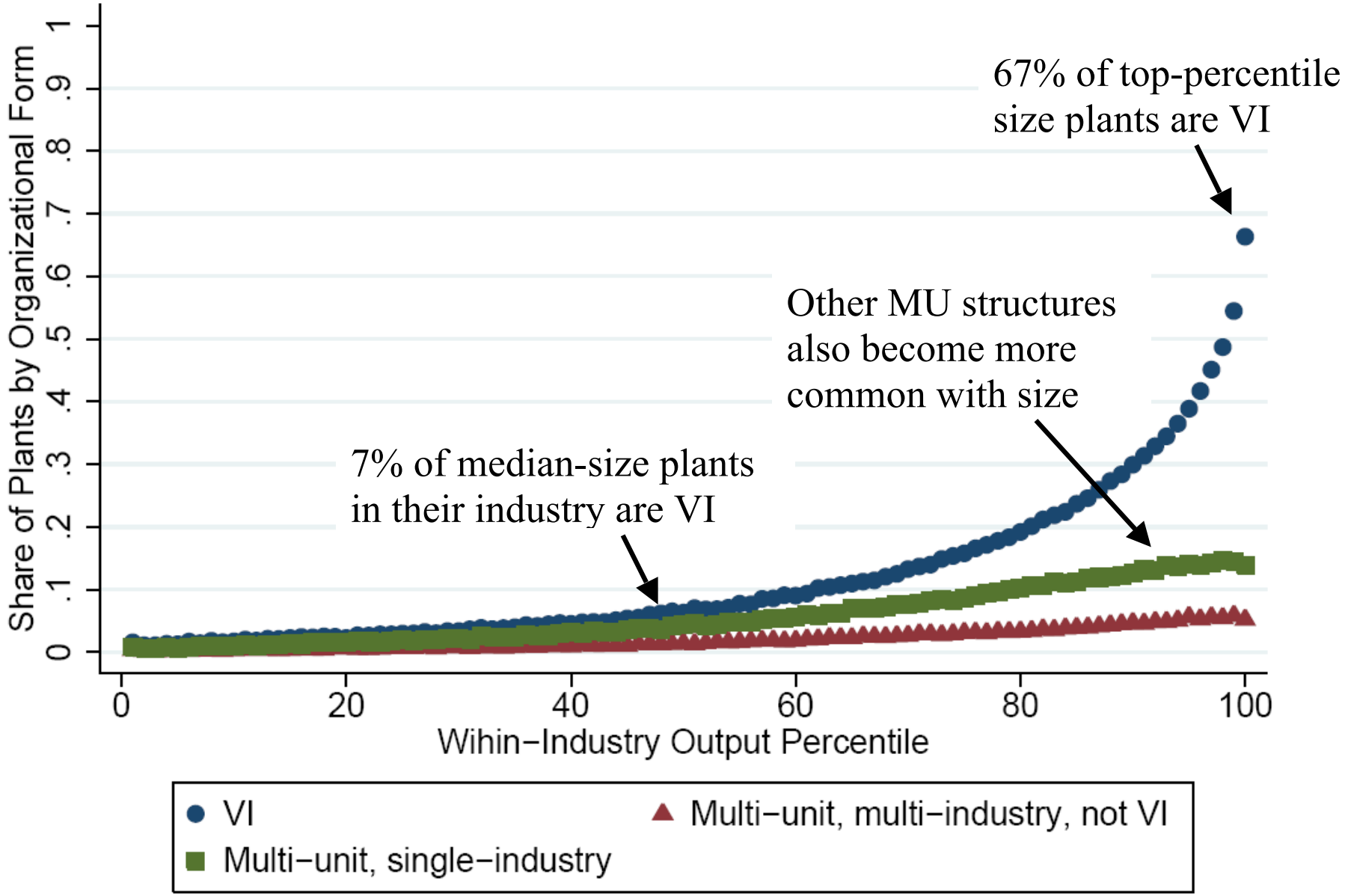
- VI exists whenever a company transmits from one of its departments to another a good or service which could, without major adaptation, be sold in the market. — Adelman (1955)

- Harmonizing the otherwise divergent interests of the two parties by internalizing the transaction through vertical merger promises to overcome the haggling costs… — Williamson (1971)

Aggregate Patterns

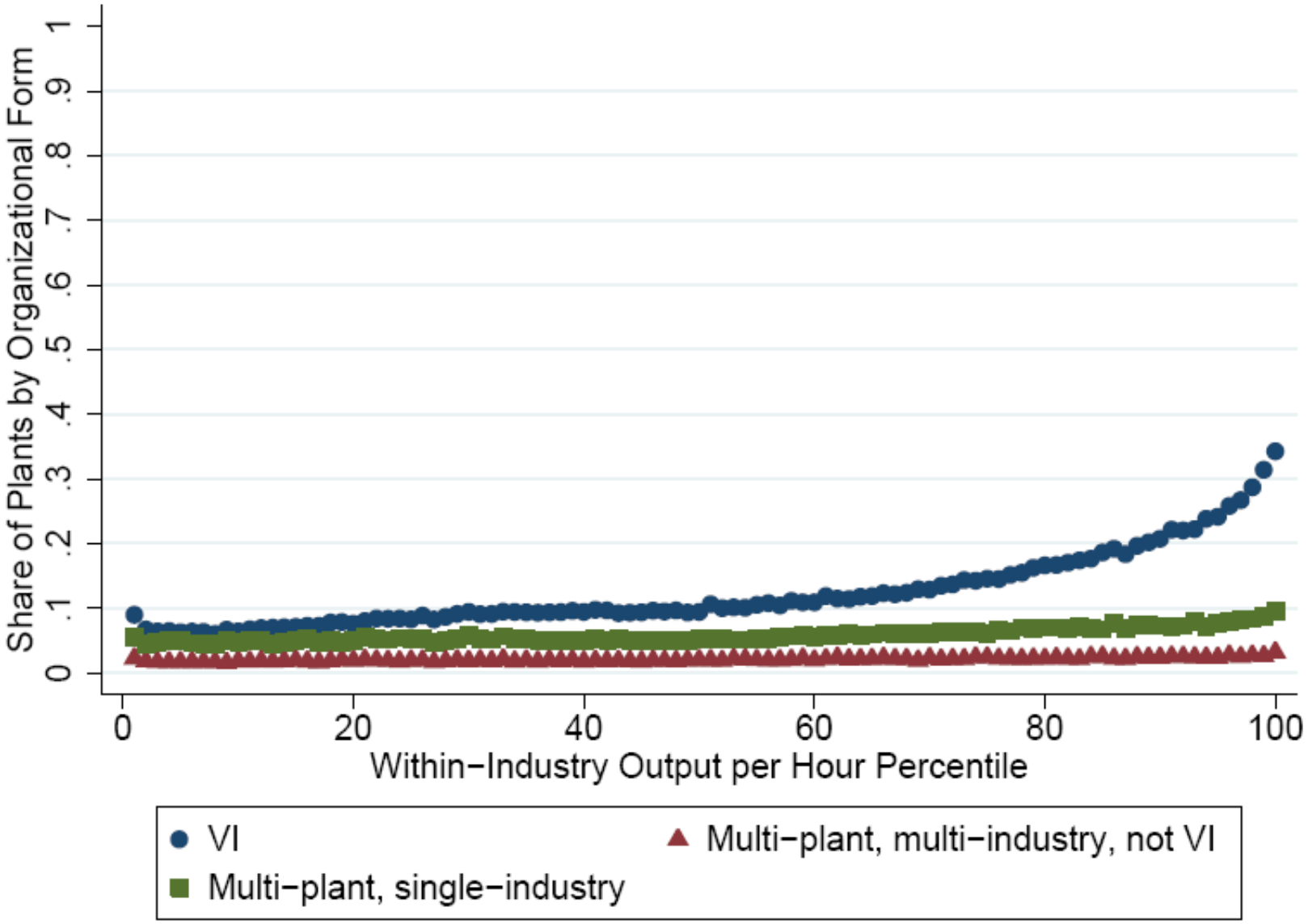
	1977	1982	1987	1992	1997
A. Non-farm Private Economy					
Total establishments (thousands)	4862.2	5049.8	5855.5	6253.2	6831.1
VI establishment share (percent)	**7.9**	**8.4**	**9.4**	**8.3**	**8.0**
Total employment (millions)	68.1	75.7	87.7	93.6	106.1
VI employment share (percent)	**29.8**	**28.4**	**30.7**	**28.3**	**26.7**
B. Manufacturing					
Total establishments (thousands)	350.6	348.4	358.9	371	375.9
VI establishment share (percent)	**12.5**	**12.5**	**12.6**	**11.4**	**11.1**
Total employment (millions)	18.5	17.8	17.7	17.0	17.5
VI employment share (percent)	**57.0**	**52.9**	**57.0**	**53.2**	**50.3**
Total revenue ($ billions, nominal)	1358.3	1960.2	2475.9	3005.0	3961.8
VI revenue share (percent)	**70.9**	**68.7**	**72.5**	**70.8**	**69.4**

VI Plants Are Larger

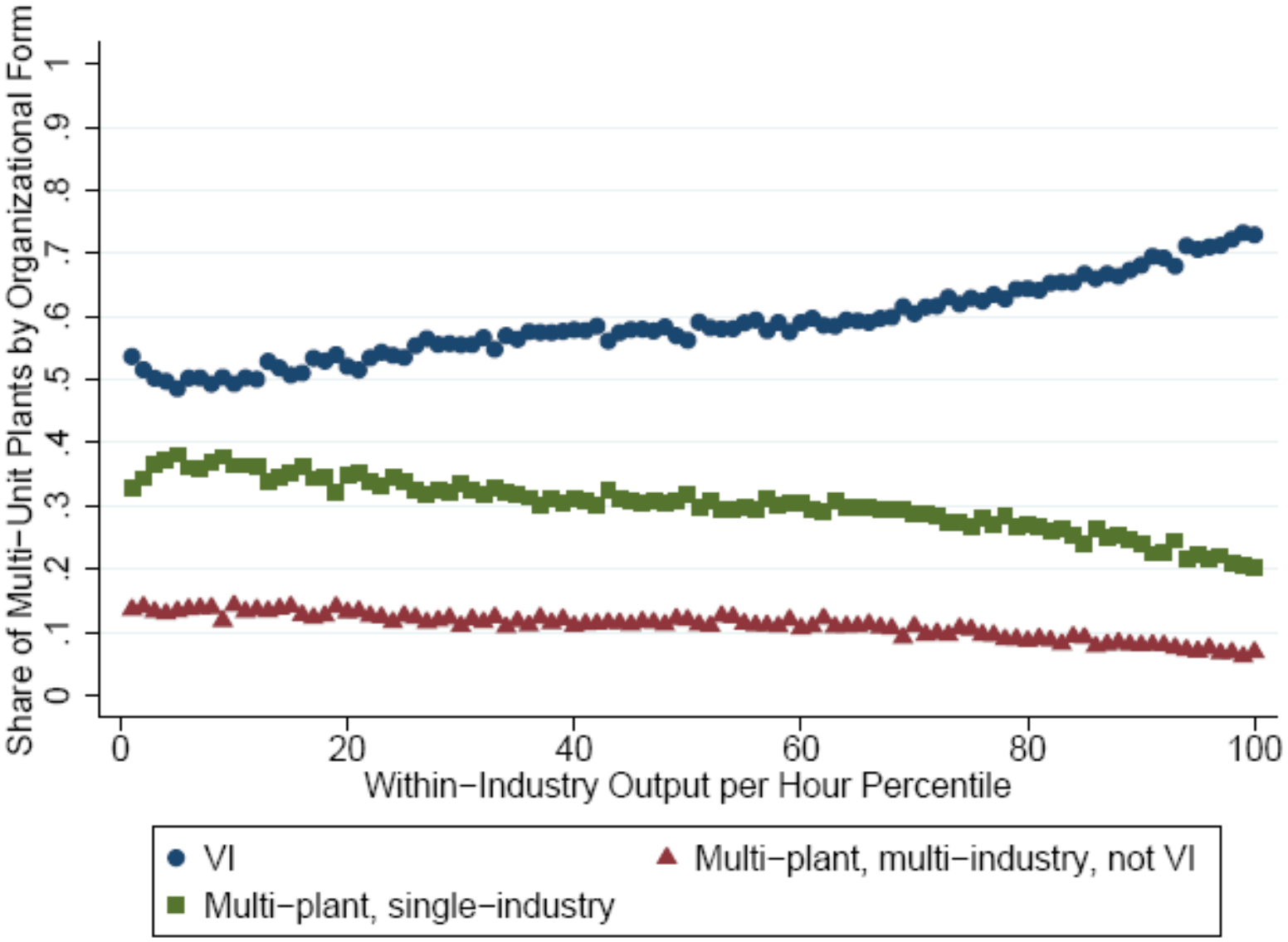


VI Plants Are Larger among Plants in Multi-Unit Firms

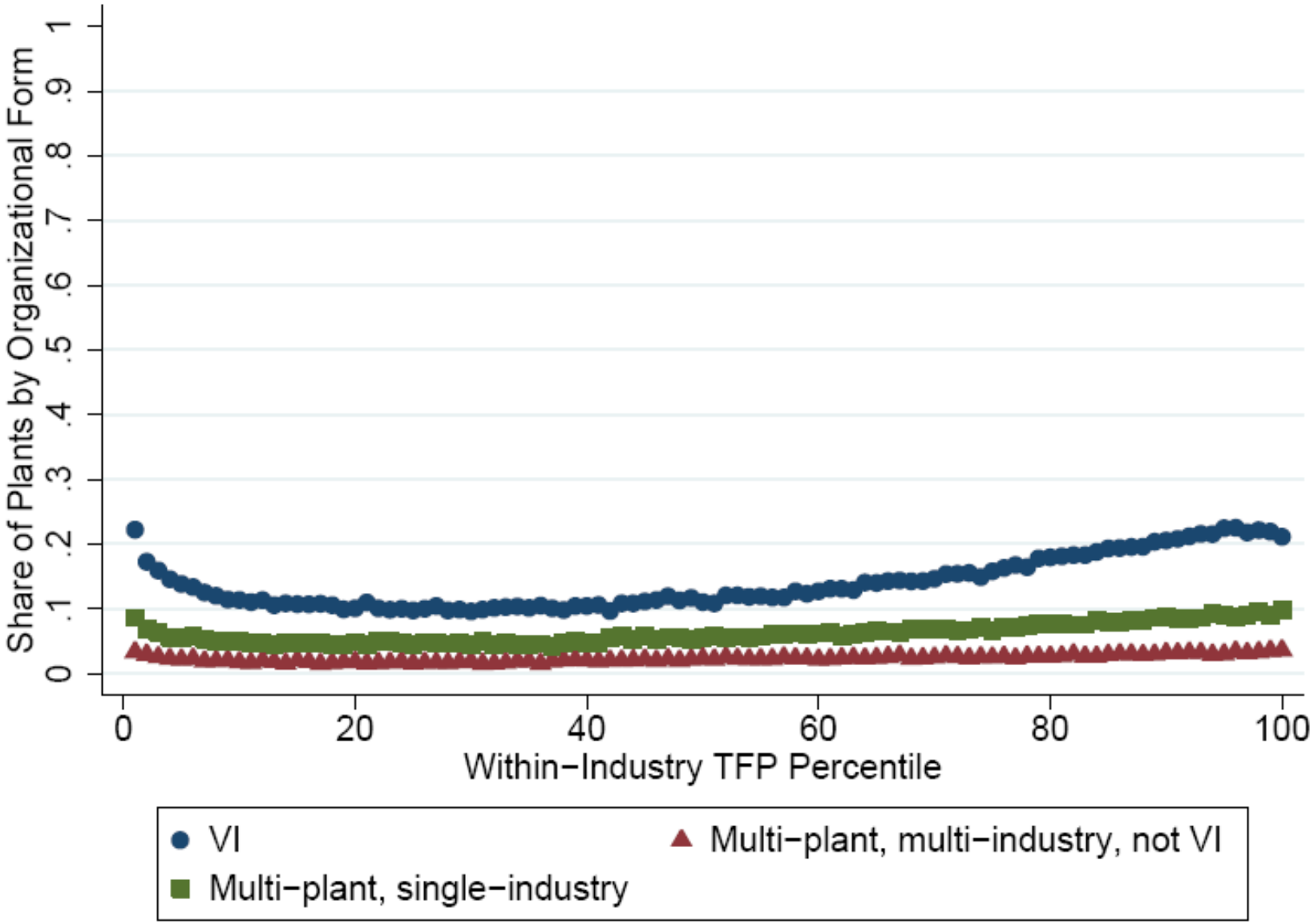
VI Plants Are High Type: Output per Hour



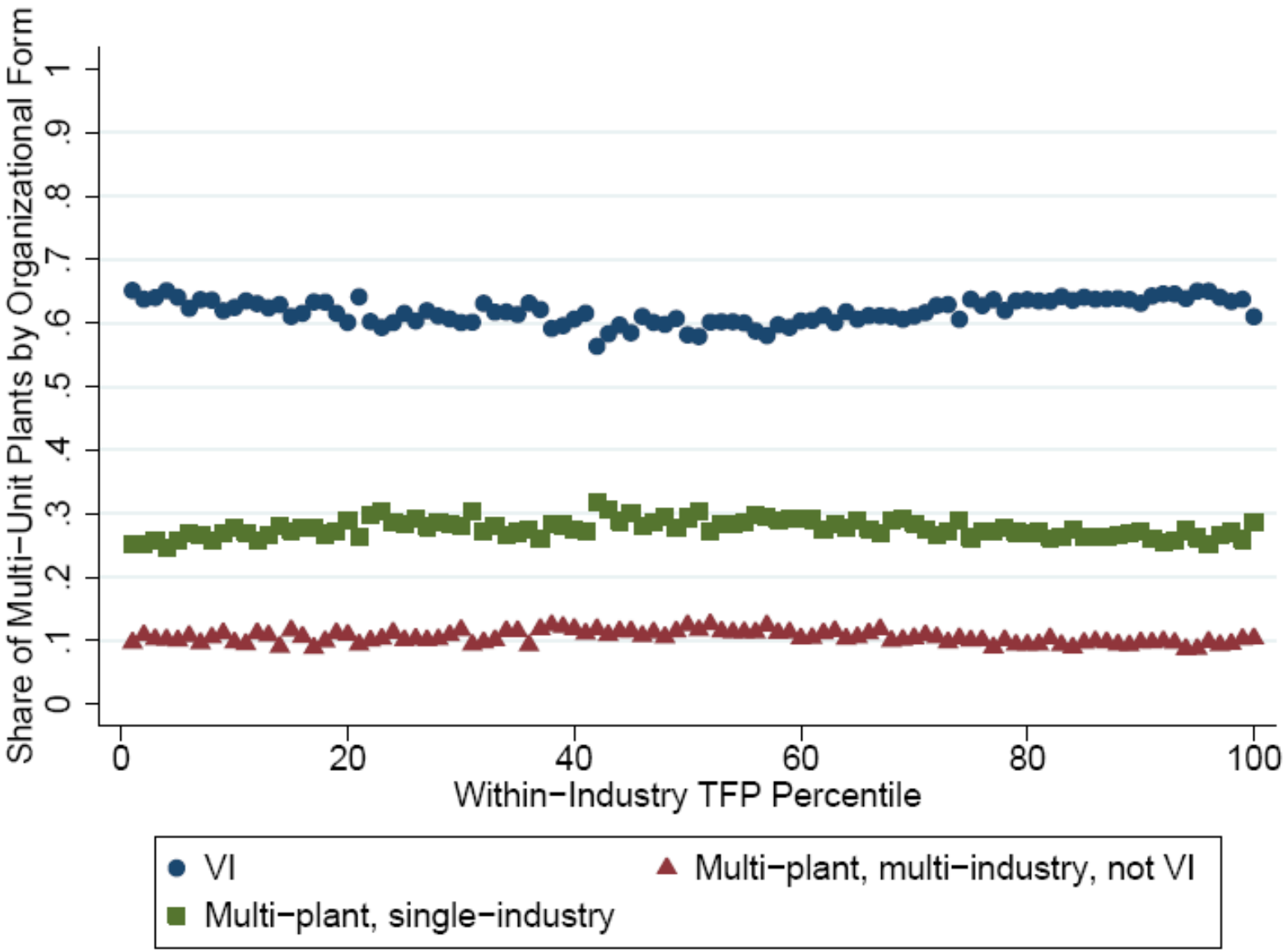
VI Plants Are High Type among Multi-Unit Firms: Output per Hour



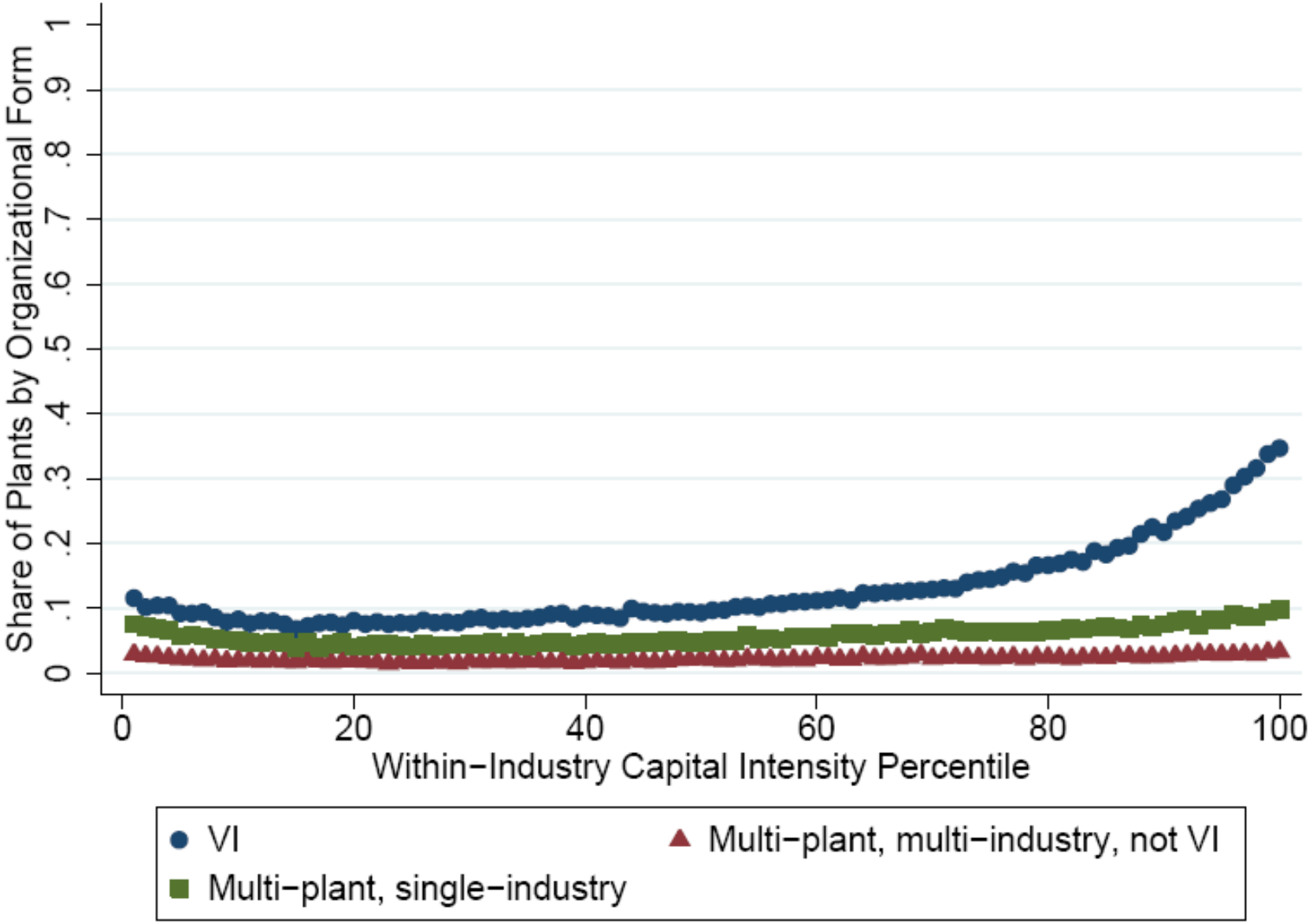
VI Plants Are High Type: TFP



VI Plants Are High Type among Multi-Unit Firms: TFP



VI Plants Are High Type: Capital-Labor Ratio



VI Plants Are High Type among Multi-Unit Firms: Capital-Labor Ratio