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ABSTRACT

We use broad-based yet detailed data from the economy's goods-producing sectors to investigate firms' ownership of production chains. It does not appear that vertical ownership is primarily used to facilitate transfers of goods along the production chain, as is often presumed: Roughly one-half of upstream plants report no shipments to their firms' downstream units. We propose an alternative explanation for vertical ownership, namely that it promotes efficient intra-firm transfers of intangible inputs. We show evidence consistent with this hypothesis, including the fact that upon a change of ownership, an acquired plant begins to resemble the acquiring firm along multiple dimensions.

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Many firms own links of production chains. That is, they operate both upstream and downstream plants, where the upstream industry produces an input used by the downstream industry. We explore the reasons for such ownership using two detailed and comprehensive data sets on ownership structure, production, and shipment patterns throughout broad swaths of the U.S. economy.

We find that most vertical ownership does *not* appear to be primarily concerned with facilitating physical goods movements along a production chain within the firm, as is commonly presumed. Upstream units ship surprisingly small shares of their output to their firms' downstream plants. One-half of upstream plants do not report making shipments inside their firm. The median internal shipments share across upstream plants in vertical production chains is 0.4 percent, if shipments are counted equally, and less than 0.1 percent in terms of total dollar values or weight. Even the 90th percentile internal shippers are hardly dedicated makers of inputs for their firms' downstream operations, with 38 percent of the value of their shipments sent outside the firm. (However, a small fraction of upstream plants—slightly more than 1 percent—*are* operated as dedicated producers of inputs for their firms' downstream operations, and these plants tend to be quite large. We will discuss this further below.) These small shares are robust to a number of choices we made about the sample, how vertical links are defined, and whether we measure internal shares as a percentage of the firm's upstream production or its downstream use of the product.

This result raises a puzzle. If firms don't own upstream and downstream units so the former can provide intermediate materials inputs for the latter, why do they? Certainly, much of the literature on vertical integration—stretching back to the landmark paper by Coase (1937), with other notable later contributions like Stigler (1951), and Grossman and Hart (1986)—couches firms' motives for integrating in terms of facilitating movement of products along a production chain.[1] (Of course, in some contexts like hotel or business services franchising, vertical integration often does not involve transfers of physical goods. Our paper, however, focuses on vertically integration and shipments in the *goods-producing* sectors of the economy,

[1] The size of the literature precludes comprehensive citation. Surveys include Perry (1989), Salop (1998), Joskow (2005), and Lafontaine and Slade (2007). Much of the recent industrial organization research on integration has focused on foreclosure (market power) implications. Examples of recent theoretical and empirical work with broader views of the determinants of integration within and across industries include Antras (2003), Acemoğlu, Johnson, and Mitton (2005) and Acemoğlu, Aghion, Griffith, and Zilibotti (2010).

like manufacturing. Our view is that a fair reading of the parables and case studies in the vertical integration literature would imply that many, if not most, researchers would consider moderating physical goods transactions a key motive for vertical ownership.)

We propose an alternative explanation that is consistent with small amounts of shipments within vertically structured firms, and even with an absence of internal shipments altogether. Namely, that the primary purpose of ownership is to mediate efficient transfers of *intangible* inputs within firms. Managerial oversight and planning strike us as important types of such intangibles, but these need not be involved. Other possibilities include marketing know-how, intellectual property, and R&D capital, but any information-based input might be transferred readily across upstream and downstream units.[2]

That vertical integration is often about transfers of intangible inputs rather than physical ones may seem unusual at first glance. However, as observed by Arrow (1975) and Teece (1982), it is precisely in the transfer of nonphysical knowledge inputs that the market, with its associated contractual framework, is mostly likely to fail to be a viable substitute for the firm. This, of course, does not preclude integration from also involving physical input transfers in some cases. As noted above, we find a small number of plants that are clearly dedicated producers for their firms' downstream production units. However, these are the exception rather than the rule. Thus it appears that the "make-or-buy" decision (at least referring to physical inputs) can explain only a fraction of the vertical ownership structures in the economy.

We find additional patterns in the data that are consistent with the intangible inputs explanation. First, we show that plants in vertical ownership structures have higher productivity levels, are larger, and are more capital intensive than other plants in their industries. These disparities, which we interpret as embodying fundamental differences in plant "type," mostly reflect persistent differences in plants started by or brought into vertically structured firms. In other words, while there are some modest changes in plants' type measures upon integration, the cross sectional differences primarily reflect selection on pre-existing heterogeneity. Controlling for firm size explains most of these type differences; plants of similarly-sized firms have similar types, regardless of whether their firm is structured vertically, horizontally, or as a conglomerate.

Second, by studying how establishments' behavior changes upon changes of ownership,

[2] These inputs might be just as likely to be transferred from the firm's "downstream" units to its "upstream" ones as vice versa. The names reflect the flow of the physical production process, not necessarily the actual flow of inputs within the firm.

we provide suggestive evidence of flows of intangible inputs within vertically structured firms. Acquired establishments begin to resemble existing establishments in their acquiring firms along two key dimensions: the acquired plants start shipping their outputs to locations that their acquirers had already been shipping to, and begin producing products that their acquirers had already been manufacturing.

These patterns evoke the equilibrium assignment view of firm organization advanced by Lucas (1978), Rosen (1982), and more recently by Garicano and Rossi-Hansberg (2006) and Garicano and Hubbard (2007). To the extent that intangibles are complementary to the physical inputs involved in making vertically linked products, equilibrium assignment typically entails the allocation of higher-type intangible inputs to higher-type plants in each product category. If plant size is restricted by physical scale constraints, better intangible inputs will also be shared across a larger number of plants. Simply put, higher-quality intangible inputs (e.g., the best managers) are spread across a greater set of productive assets. Some of these assets can be vertically linked plants, but their vertical linkage need not necessarily imply the transfer of physical goods among them.

Furthermore, there may not be anything special about vertical structures per se. The evidence below suggests that firm size, not structure, is the primary reflection of input quality. Larger firms just happen to be more likely to contain vertically linked plants. In this way, vertical expansion by a firm may not be altogether different than horizontal expansion. A typical horizontal expansion involves the firm starting operations in markets that are new but still near to its current line(s) of business, under the expectation that its current abilities can be carried over into the new markets. Physical goods transfers among the firm's establishments are not automatically expected in such expansions, but inputs like management and marketing are expected to flow to units in the new markets. Vertical expansions may operate similarly. Industries immediately upstream and downstream of a firm's current operations are obviously related lines of business. Firms will occasionally expand into these lines, expecting their current capabilities to prove useful in the new markets. And, just as with horizontal expansions, transfers of managerial or other non-tangible inputs will be made to the new establishments. Yet no physical good transfers from upstream to downstream establishments need occur.

The upshot is that the assignment view of the firm is consistent with large firms composed of high-type plants operating (often) in several lines of business. Common ownership allows the firm to efficiently move intangible inputs across its production units. Many of these units will be vertically related, making these segments "vertical" in that the firm owns each end of a link in a production chain. But the chain need not exist for the purpose of moderating the flow of physical products along it.

This scenario is consistent with the evidence we document here, and in particular with our primary result about the lack of goods shipments within vertically structured firms. The remainder of the paper lays out the evidence and tests the hypothesis in more detail. It is organized as follows. The next section describes our data sources. We then explain in Section III how we use them to measure vertical integration and shipments internal and external to vertical chains within firms. Section IV reports the empirical results. Section V discusses flows of intangible inputs across establishments, within firms. We conclude in Section VI.

I. Data

We use microdata from two sources, the U.S. Economic Census and the Commodity Flow Survey, and aggregate data from the Annual Wholesale Trade Survey and the Annual Retail Trade Survey. We discuss each dataset in turn.

Economic Census. The Economic Census (EC) is an establishment-level census that is conducted every five years, in years ending in either a "2" or a "7". Establishments are unique locations where economic activity takes place, like stores in the retail sector, warehouses in wholesale, offices in business services, and factories in manufacturing. Our sample uses establishments from the 1977, 1982, 1987, 1992, and 1997 censuses. We specifically use those establishments in the Longitudinal Business Database, which includes the universe of all U.S. business establishments with paid employees.[3] The data has been reviewed by Census staff to ensure that establishments can be accurately linked across time and that their entry and exit have been measured correctly.

Critically, the Economic Census contains the owning-firm indicators necessary for us to identify which plants are vertically integrated. (We discuss in Section III how we make this classification.) Additionally, the Census of Manufactures portion of the EC also contains

[3] Plant-level data from before 1977 is almost exclusively for the manufacturing sector, precluding proper classification of vertical ownership for manufacturing plants owned by firms that are in fact vertically structured, but only into non-manufacturing sectors (e.g., firms that own a manufacturing plant and a retail store selling the product the plant makes).

considerable data on plants' production activities. This includes information on their annual value of shipments, production and nonproduction worker employment, capital stocks, and purchases of intermediate materials and energy. We use this production data to construct plant-specific output, productivity, and factor intensity measures; details are discussed further below and in the Appendix. In some cases, we augment the base production data with microdata from the Census of Manufactures materials supplement, which contains, by plant, six-digit SIC product-level information on intermediate materials expenditures.[4]

Commodity Flow Survey. The Commodity Flow Survey (CFS) collects data on shipments originating from mining, manufacturing, wholesale, and catalog and mail-order retail establishments.[5] The survey defines shipments as "an individual movement of commodities from an establishment to a customer or to another location in the originating company." The CFS takes a random sample of an establishment's shipments in each of four weeks during the year, one in each quarter. The sample generally includes 20-40 shipments per week, though establishments with fewer than 40 shipments during the survey week simply report all of them.

For each shipment, the originating establishment is observed, as well as the shipment's destination zip code (exports report the port of exit along with a separate entry indicating the shipment as an export), the commodity, the mode(s) of transportation, and the dollar value and weight of the shipment.

We use the microdata from the 1993 and 1997 CFS; the former contains roughly 120,000 establishments and 11 million shipments, and the latter 60,000 establishments and 5.5 million shipments. As with the Economic Census, each establishment has an identification number denoting the firm that owns it. Both the establishment and the firm numbers are comparable to those in the EC, so we can merge data from the two sources. We match the 1993 CFS to the 1992 EC; this will inevitably lead to some mismeasurement of ownership patterns, but we expect this will be small given the modest annual rates at which plants are bought and sold by firms.

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[4] For very small EC plants, typically those with less than five employees, the Census Bureau does not elicit detailed production data from the plants themselves. It instead relies on tax records to obtain information on plant revenues and employment and then imputes all other production data. We exclude such plants—called Administrative Records (AR) plants—from those analyses below that use plant-level measures constructed from the Census of Manufactures (e.g., productivity). While roughly one-third of plants in the Census of Manufactures are AR plants, their small size means they comprise a much smaller share of industry-level output and employment aggregates.

[5] Hillberry and Hummels (2003, 2008) and Holmes and Stevens (2010, 2012) use the CFS microdata to investigate various affects of distance on trade patterns. They do not make the within- and between-firm distinctions that we do here. These are the only other studies using the CFS microdata that we are aware of.

Annual Wholesale Trade Survey and Annual Retail Trade Survey. These datasets provide information on sales and purchases of 4-digit retail and wholesale industries. We use these datasets to help determine whether two industries are vertically linked.

II. Measuring Vertical Ownership and Shipments within Firms' Production Chains

This section explains how we use our data to determine which businesses are vertically integrated and whether the CFS shipments we observe are internal or external to the firm.

Determining Which Industries Are Vertically Linked to One Another

We define vertically linked industries as *I-J* industry pairs for which a substantial fraction—1% in the baseline specification—of industry *I*'s sales are sent to establishments in industry *J*.[6] To compute the fraction of sales of industry *I* output that are sent to industry *J*, we use information from the 1992 Bureau of Economic Analysis Input-Output Tables, the 1992 Economic Census, the 1993 Commodity Flow Survey, the1993 Annual Wholesale Trade Survey, and the 1993 Annual Retail Trade Survey. We define industries by their 4-digit SIC code. We apply the classification of vertically linked industries implied by this data to our entire sample.[7]

To measure the value of shipments sent by industry-*I* establishments to industry-*J* establishments, we first compute the shipments of commodity *C* sent to industry *J* using the 1993 CFS. Commodities are defined by their Standard Transportation Commodity Code (STCC).[8] We then sum over all commodities that each industry *I* ships to determine the share of *I*'s sales going to *J*, thereby indicating which *I-J* industry pairs are vertically linked.

For most industries, we rely primarily on the Input-Output Tables, which track quantities of inter-industry flows of goods and services, to perform these calculations. However, the I-O Tables treat the entire wholesale sector as a single, monolithic industry, with no distinction as to the types of products its establishments distribute. They treat the retail sector in the same way.

[6] The one-percent cutoff used to define substantial vertical links is of course arbitrary. We have checked our major findings using a five-percent cutoff and found few differences. (The overall level of integration is of course lower in this more stringent case.)

[7] Applying one vertical structure to the entire sample is made necessary by the lack of CFS microdata before 1993 and changes in the way the CFS records commodities between 1993 and 1997. Given that the input-output structure of the economy is fairly stable over time, we do not expect a large impact on our results.

[8] A list of STCC codes can be found in pages 117 to 167 of "Reference Guide for the 2008 Surface Transportation Board Carload Waybill Sample," published by Railinc.

Additionally, they do not keep track of shipments by manufacturers to (or through) wholesalers or retailers, instead measuring only those inputs directly used by wholesalers and retailers in the production of wholesale and retail services (e.g., in the I-O Tables, cardboard boxes are a major input used by the wholesale sector, but the actual products the sector distributes are not). To achieve better measurement of the flow of goods through the wholesale and retail sector, we use a different algorithm that incorporates additional data from the Annual Wholesale Trade Survey and the Annual Retail Trade Survey. All these calculations are detailed in the Appendix.[9]

Classifying Shipments as Internal or External to the Firm

To classify shipments from vertically integrated establishments in the Commodity Flow Survey as internal or external to the firm, we first must merge the CFS and EC data. This can be done straightforwardly using the two datasets' common establishment and firm identifiers. Of critical importance is the fact that the Commodity Flow Survey contains the destination zip code of each shipment, while the Economic Census records establishments' zip codes.

We identify a shipment as internal if the shipping establishment's firm also owns an establishment that is both in the destination zip code and in a 4-digit SIC industry that is a downstream vertical link (as defined above) of the sending establishment's industry.[10] The CFS contains shipment-specific sample weights that indicate how many actual shipments in the population each sampled shipment represents. We use these weights when computing the shares of internal shipments, be it by count, dollar value, or weight.

III. Shipments within Firms' Vertical Links

We begin by looking at the patterns of shipments within firms' vertical links. We focus on establishments in the Commodity Flow Survey that are a) in vertical ownership structures and b) upstream links within those structures.

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[9] In a previous draft, we employed a cruder methodology to identify pairs of vertically linked industries, defining industry *I* as upstream of industry *J* provided either a) *J* buys at least five percent of its intermediate materials from *I*, or b) *I* sells at least five percent of its own output to industry *J*. We furthermore did not attempt to make any distinction among wholesale or retail industries. While we prefer the current methodology for its increased accuracy, we reproduce our main analysis using the old methodology in the Appendix and find similar results.

[10] Every establishment is assigned to a unique industry. For establishments that produce products that fall under multiple 4-digit SIC industries, the Census Bureau classifies such plants based on their primary product, which is almost always the product accounting for the largest share of revenue.

A. Vertically Integrated Establishments' Shipments—Benchmark Sample

The combined 1993 and 1997 CFS yield a core sample of about 67,500 plant-year observations of upstream establishments in firms' production chains. These establishments report a total of roughly 6.3 million shipments in the CFS. Panel A of Table 1 shows the prevalence of internal shipments within this sample. It reports quantiles of the distribution of internal shipment shares across our sample plants, measured as the fraction of the total number, dollar value, and weight of the establishment's shipments.[11]

Overall, only a small share vertically integrated upstream establishments' shipments are to downstream units in the same firm. Across the 67,500 establishments, the median fraction of internal shipments is 0.4 percent. The median internal shares by dollar value and weight are even smaller, at less than 0.1 percent. Almost half of the plants report no internal shipments at all. Even the 90th-percentile plant ships over 60 percent of its output outside the firm.

The exception to this general pattern is the small set of establishments that are clearly dedicated to serving the downstream needs of their firm, the 1.2 percent of the sample that reports exclusively internal shipments. The unusualness of this specialization is even more apparent in the histogram of plants' internal shipment shares shown in Figure 1, panel A. The histogram echoes the quantiles reported above: the vast majority of upstream plants make few internal transfers. The fractions of establishments fall essentially monotonically as internal shipment shares rise—until the cluster of internally dedicated establishments. Another factor in the unusualness of these internal specialist plants that is not apparent in the histogram is that they are larger on average. This, along with the internal share distribution being highly skewed, explains why the aggregate internal share of upstream plants' shipments (the across-plant sum of internal shipments divided by the across-plant sum of total shipments) is 16 percent. This is well above the median share across plants. Thus internal shipments are more important on a dollar-weighted than an ownership-decision-weighted basis, but are the exception in either case.

These results imply the traditional view that firms choose to own plants in upstream industries to control input supplies may be off target. Clearly other motivations for ownership *must* apply for those plants making no internal shipments. Even for those that do serve their own

[11] For data confidentiality reasons, the reported quantiles are actually averages of the immediately surrounding percentiles; e.g., the median is the average of the 49th and 51st percentiles, the 75th percentile is the average of the 74th and 76th percentiles, and so on.

firm, though, their typically small internal shipments suggest that this role may not be primary.[12]

B. Robustness Checks

The disconnect between the upstream plants and their downstream partners, at least in terms of physical goods transfers, is stark and perhaps surprising. We conduct several robustness checks to verify our benchmark results.

First, it is appropriate to review some details of how the Commodity Flow Survey is conducted, specifically with regard to its ability to capture intra-firm shipments. The CFS definitely seeks to measure them, and it makes no distinction between intra- and inter-firm transfers in its definition of "shipment." In fact, the survey instructions (U.S. Census Bureau (1997)) state explicitly that respondents should report shipments "to another location of your company," save for incidental items like "inter-office memos, payroll checks, business correspondence, etc."

There are several reasons to believe the implied shipments totals are accurate. First, the Census Bureau audits responses by comparing the establishment's implied annual value of shipments from the CFS with that from other sources. If the disparity is well beyond statistical variance, the Bureau contacts the respondent and reviews the responses for accuracy. If integrated establishments were systematically underreporting internal shipments because of confusion or by not following directions, the auditing process would help catch this.

Second, most establishments do report *some* internal shipments, indicating that they have not interpreted the definition of shipments as precluding intra-firm transfers. This is also reflected in the small share of establishments that report nothing but internal shipments. Moreover, there is no mechanical reason why we should find the bump up in internal shipment shares near one, as seen in Figure 1. We take this as further evidence that respondents understand the CFS instructions.

Third, for plants in the manufacturing sector, there is an independent measure of internal shipments. The Census of Manufacturers collects data on what it terms plants' Interplant Transfers, shipments that are sent to other plants in the same firm for further assembly. These interplant transfers represent part, but not all, of our internal shipments measure—for example,

[12] It is possible in some production chains that an upstream plant could completely serve its firm's downstream needs with only a small fraction of its output. We show that this possibility is not driving our results in Appendix B3, however.

shipments to wholesalers or retailers are not included in CM Interplant Transfers.[13] In addition to the difference in definition, these measures are collected using separate survey instruments (often likely to have been filled out by different individuals at the plant). Despite these differences, we find a strong correlation between the two measures. The correlation coefficient between plants' logged interplant transfers and our CFS-based estimate of internal shipments is 0.52 across our matched sample of about 37,000 plant-years, and a regression of the latter on the former yields a coefficient of 0.470 (s.e. = 0.011).

B.1. Robustness: Sample

In our first series of robustness checks, we consider the impact of modifications to our core sample of upstream vertically integrated plants. The corresponding distributions of establishments' internal shipments are shown in Table 3, panel B. Each row is a separate check. We show only the distributions of the dollar value shares for the sake of brevity; similar patterns are observed in the shares by shipment counts or total weight.

The robustness check in the first row of panel B uses only establishments reporting at least the median number of shipments across all establishments in the sample. The point is to exclude those for which sampling error could be higher and for whom extreme values like zero are more likely. This leaves us with a sample of about 34,000 establishment-years making just over 4.2 million shipments. (This is greater than half the establishment-years in the benchmark sample because several plants report exactly the median number of shipments.) Extreme values are in fact rarer in this sample: 45.5 percent report making no internal shipments, down from 49 percent in the full sample, and 0.3 percent report exclusively internal shipments, down from 1.2 percent. The remainder of the distribution is not much different, however. The median fraction of internal shipments is 0.2 percent, and the 90th percentile establishment is less likely to ship internally than that in the full sample, with just under half of shipments being intra-firm.

The second check drops any establishment that reports any shipments for export. In the CFS, the destination zip code of shipments for export is for the port of exit, with a separate note indicating the shipment's export status and its destination country. Thus internal shipments to a firm's overseas locations would be misclassified as outside the firm, unless by chance the firm

[13] Restricting shipments to those that are sent for further assembly has a substantial impact on the estimate of plants' internal shipments. We estimate in Appendix B1 that half of our measured internal shipments from manufacturing plants are sent to plants outside of the manufacturing sector (and, thus, are not for further assembly).

has a downstream establishment in the port's zip code. Focusing on the roughly 47,000 establishments reporting no exports among their roughly 4.3 million shipments avoids this potential mismeasurement. The results are in the second row of panel B of Table 3. The entire distribution is close to the benchmark results above, with the median internal share being less than 0.1 percent and 49.7 percent of establishments reporting zero intra-firm shipments. Missing export destinations are not the source of our results.[14]

The next check counts shipments destined for the zip code of *any* plant in the same firm as internal, not just those going to locations of downstream links of vertical chains. It is possible that some vertical production may occur outside those chains we identify using the Input-Output Tables. Some may even occur within a given industry, when a particularly complex production process is broken up across multiple establishments. Here, we are taking the broadest possible view toward defining intra-firm transfers of physical goods along a production chain. As seen in the third row of panel B, all quantiles have internal shipment fractions higher than the benchmark, as they must. Still, the median internal share is only 4.9 percent, and the 90th percentile 67.5 percent. About 23 percent of establishments still have no shipments to a zip code of any plant in their firm, and exclusively internal establishments number 2.7 percent.

In the fourth check we make the generous assumption that a shipment is internal if it goes to any *county* in which the firm has a downstream establishment. While unrealistic, this approach accounts for almost any problems with zip code reporting errors or missing zip codes. The results of this exercise are in row 4 of panel B. Not surprisingly, the shares of shipments considered intra-firm are considerably higher, given the easier criterion for being defined as internal. There are more internal specialists or near-specialists: the 90th percentile internal share is 87 percent, and 4.2 percent of establishments have all of their reported shipments being internal. Even so, a substantial fraction of establishments—25 percent, more than five times the number of internal specialists—report no shipments to counties where downstream plants in their firms are located. The median internal share across plants is 7.2 percent.

The fifth check restricts the sample to plants in the twenty-five manufacturing industries with the least amount of product differentiation, as measured by the Gollop and Monahan (1991) product differentiation index. The concern is that even our detailed industry classification

[14] We will discuss below how the fraction of international trade that is within firms could be so much larger than the intra-firm domestic trade we document here.

scheme may be too coarse to capture the true extant vertical links. For instance, it might be that while two industries are substantially linked at an aggregate level, this actually reflects the presence of (say) two separate vertical links within a four-digit SIC industry. In this case, we would not expect many shipments to go from upstream plants in one link to downstream plants in another, even though we might infer the two are vertically linked just from comparing the industry-level trade patterns. Selecting industries with undifferentiated products should reduce product heterogeneity within detailed industries and raise the probability that the industry links we identify as described above hold at a disaggregate level. There are about 2200 plant-years in this subset of industries in the CFS. We find that internal shares are actually lower for plants in the less differentiated industries. The median plant has no internal shipments, while the 90th percentile plant's internal share is 20 percent

The remaining robustness checks in the panel explore the impact of varying the definition of vertical links. Row 6 of the table shows the results using a 5 percent cutoff, while Row 7 keeps the 1 percent cutoff, but removes the possibility that an industry can be vertically linked with itself. Both of these robustness checks reduce the number of plants that are defined to be vertically linked from the benchmark. The 5 percent cutoff sample contains about 53,000 plant-years and 5.0 million shipments, while the "No $I \rightarrow I$" rule produces a sample with about 43,000 plant-years and 4.0 million shipments. In both these subsamples, the median and 90th percentile internal shares are slightly smaller than in the benchmark.

All in all, our benchmark results appear robust to several sample and variable definition changes. Additional robustness checks along these lines are provided in Appendix B1.

B.2. Robustness: Accounting for Actual Downstream Use

We measure internal shipments above as an upstream plant's internal shipments as a share of its total shipments. There are cases where this ratio might be misleading as to the extent of intra-firm product movements. Consider a hypothetical copper products company with two plants: an upstream mill that produces copper billets, and a downstream plant that processes billets into pipe. Suppose the downstream plant needs $10 million of billets to operate at capacity. Now say the upstream mill produced $100 million of billets in a year. If the mill shipped $10 million of billets to the pipe-making plant and the remaining $90 million elsewhere, we would compute its internal shipment share as 10 percent. Yet the firm would be completely supplying its downstream needs internally. The difference in the scales of operations upstream and downstream creates this misleading internal share.

While this may raise the question of why the firm wouldn't own enough pipe plants to use its upstream production, in this section we create an alternative measure of internal shipment shares that can account for inherent differences in operating scales across industries. Instead of using upstream plants' total shipments as the denominator in the internal shipment share measure, we instead calculate firms' downstream use of products they make upstream. We then construct internal shipments shares as intra-firm shipments of upstream plants divided by the *minimum* of two values, either the firm's total upstream shipments as above, or the firm's reported downstream use of the upstream product. Hence the internal share of the hypothetical copper firm above would be 100%, rather than 10% as before, because the firm provides all the copper it uses downstream.

While the CFS offers a random sample of establishments' shipments, we unfortunately do not have a random sample of establishments' incoming materials. This precludes us from directly measuring "internal purchase shares" in the same way we measure internal shipment shares. But for a subset of firms we can construct internal shipments as a fraction of downstream use. To do so, we must first restrict our CFS sample to those where we observe *all* the upstream shipments of a firm, at least for a given product. If firms served downstream needs from upstream plants not in the CFS, we would not observe their non-CFS plants' shipments, and therefore would not know they are internal. Hence we look here only at CFS plants where we observe all the firm's plants in a particular industry. We use the Economic Census to find this subset of establishments, which ends up being about 11,000 plant-years. If we calculate these shares as before, this subsample looks similar to the entire sample. For example, 53.8 percent of these plants report making no internal shipments, and the 90^{th} percentile plant ships 36.5 percent of its output internally.

We then match these upstream plants' shipments to downstream usage within the firm. We construct three downstream usage measures. The first simply aggregates the materials purchases of all the firm's downstream manufacturing plants. These purchases are reported by every plant in the Census of Manufactures. The firm's downstream use of upstream products is simply the sum of all its intermediate materials purchases. We can compute these downstream use measures for 4438 firm-year observations. To compute internal shares, we add up the internal shipments of the firms' upstream plants to use as the numerator.[15]

The second measure of downstream usage matches upstream shipments to downstream usage by product. We use the detailed materials purchase information from the Census of Manufactures materials supplement, which collects plants' materials purchases by detailed product. We compute firm's upstream shipments by product using the shipment commodity codes available in the CFS. Product-specific shipments are computed at the 2-digit level. (We use only 1993 CFS data here because a change in the commodity coding scheme made it difficult to match the 1997 CFS commodity codes with the materials codes in the Census of Manufactures.) We sum the same firm's reported downstream use of that 2-digit product from the Census of Manufactures. The internal shipment share is the ratio of the firm's internal shipments of the product divided by its reported downstream use of that product. We are able to match 5491 firm-material combinations.

The third and final measure of downstream materials usage repeats the procedure above, except matches at the more detailed 4-digit product level. Because the greater detail makes finding matches less likely, we have a sample of 2351 such firm-product combinations.

The results from these exercises are shown in Table 2. Recall that we now compute internal shipments as their share of the *smaller* of a) the firm's (or firm-product's) total upstream shipments or b) the firm's downstream usage. Again, only the dollar-value shares are shown for brevity. The first row shows shares computed using the firm-level match where internal materials usage is aggregated across all materials. The second row shows results from the sample of matched firm-products at the 2-digit level; the third shows the firm-product match sample at the 4-digit level.

All three measures downstream usage still imply that most vertical ownership structures are not about serving the downstream material needs of the firm. The median share across plants

[15] There are two measurement problems with this first approach that will tend to bias our internal shares measures in opposite directions. First, because we only required that we observe all of a firm's plants making *a particular product* in the CFS, we might be missing internal shipments from firms' other upstream plants (this is much less of a problem in our other two downstream use measures below, since they are matched by firm-product, rather than just by firm). This will cause us to understate the true internal shipment share. The second measurement issue arises because we can only observe materials purchases for downstream establishments in the manufacturing sector. If some upstream products are used in the firms' non-manufacturing establishments, we will not include these in our downstream usage measures. This will lead us to overstate internal shipment shares. As a practical matter, both of these measurement concerns are probably second-order. Our restricted sample has a large fraction of firms with only a few establishments, so if a firm's upstream plant(s) is in the CFS and its downstream plant(s) in manufacturing, chances are those are all the plants the firm owns.

of internal shipments as a fraction of the smaller of the firm's upstream shipments and its downstream use is 0.3% in the first (firm-wide) downstream use measure. The share of this subsample reporting zero internal shipments is 44.4 percent. For the second measure of internal usage (firm-product matching at the 2-digit level), 60.2 percent of the firms report no internal shipments. For the third measure (firm-product matching at the 4-digit level), 65.3 percent of the sample report no internal shipments.

One thing to note about the results is that some shares are above one. It is possible that this reflects in part the fact that some of the upstream plants' shipments that we classified as internal because their destination zip code was where the firm owned a downstream plant in fact went to a plant outside the firm in the same zip code. But probably some of these shares reflect measurement error in firms' downstream materials use (it is outside the manufacturing sector and we can't observe it, for instance). A summary measure of the extent of such measurement error is the fraction of observations with implied internal usage ratios above one. For the three downstream use measures above, these shares are 6.7, 11.7, and 12.5 percent, respectively.

Thus the small internal shares we were finding before do not seem to be simply reflecting the fact that most integrated structures have considerably larger upstream plant scales than downstream. In fact, we still find a large number of cases (slightly under one-half of the sample) without any intra-firm shipments. In other words, we know a firm makes a particular product upstream, uses that same product as an input downstream, but does not ship any of its own upstream output to its downstream units.

B.3. Shipments of Plants that Make Firms Become Vertically Structured

We next look at the internal shipment patterns for a very select subset of establishment-years in our sample. These observations have two properties. First, they correspond to newly vertically integrated establishments on the upstream end of a production chain (they were single-unit firms in the previous Economic Census). Additionally, these establishments have been acquired by firms that, concurrent with the purchase, begin owning plants in a vertical production chain for the first time. In other words, these are the establishments that *make* these firms vertically structured. These establishments might provide one of the clearest windows into any connection between why firms expand vertically and internal shipment patterns. Because of the narrow selection criteria, the subsample is small—a total of just over 300 establishment-years in the CFS, reporting about 28,000 shipments—but this still offers enough leverage to make a meaningful comparison to the overall patterns discussed above.

This subsample exhibits an even lower prevalence of internal shipments than in the benchmark. 68 percent of these plants report no internal shipments at all, and the 90^{th} percentile of internal shipments is only 10.1 percent. Because the small sample raises questions of whether these differences are statistically significant, we also estimate regressions that project plants' intra-firm shipment shares on an indicator for these new-VI establishment/firm units and full set of industry-year dummies. The estimated coefficient on the subsample indicator in the dollar-value-share regressions is -0.057 (s.e. = 0.009). (The coefficient is also significantly negative when shares of shipment counts or weights are used as the dependent variable.) These establishments do in fact have significantly lower internal shipments shares.

Thus even for establishments acquired expressly as part of a firm's move to build a vertically integrated ownership structure, internal sourcing of physical inputs is unusual.

B.4. Other Robustness Checks

We conducted additional, detailed robustness checks on the benchmark results that, for the sake of brevity, we detail in the Appendix. One explores whether the observed small internal shipment shares reflect the fact that plants in vertical ownership structures are spaced further apart geographically than typical. We show this is not the case; in fact, even vertically structured firms with all their plants in a single metro have internal shares similar to those in the broader sample. A second robustness check asks whether our definition of vertical ownership, which by necessity requires a firm to operate the upstream and downstream stages of production in separate plants, misses vertically integrated production practices occurring within a single plant (and therefore undercounting the within-plant "shipments" that accompany them). We find no evidence that this is driving our result.

IV. Explanations for Vertical Ownership

The lack of movement of goods along production chains within most vertically structured firms appears to be a robust feature of the data. As mentioned above, we propose that vertical ownership is instead typically used to facilitate movements of intangible inputs like management oversight across a firm's production units. In this section we document additional facts that are consistent with this theory.

A. Firms as Outcomes of an Assignment Mechanism

We first show evidence that plants' vertical ownership structures are systematically related to persistent differences in plant "types"—combinations of idiosyncratic demand and supply fundamentals that affect plant profitability in equilibrium. Further, these type differences primarily reflect "selection" on pre-existing differences rather than "treatment" effects of becoming part of a vertical ownership structure. At the same time, we find that these type differences aren't much tied to vertical ownership itself, but rather to being in large firms of any structure. We discuss below how these patterns are all consistent with theories of the firm as the outcome of an assignment mechanism that allocates tangible and intangible assets among heterogeneous firms. Models of such mechanisms—which include Lucas (1978), Rosen (1982), and more recently by Garicano and Rossi-Hansberg (2006) and Garicano and Hubbard (2007)[16]—offer an explanation for why we might not see many internal shipments within vertical ownership structures while at the same time pointing us toward an alternative explanation for such ownership patterns: namely, facilitating the flow of intangible inputs within the firm.

A.1. Plants in Vertical Ownership Structures are High "Type" Plants

We first focus on the patterns of plant-level measures of "type" across vertically integrated and unintegrated plants. We use four measures to proxy for plant type.[17] They are not independent, but they differ enough in construction to allow us to gauge the consistency, or lack thereof, of our results. Two are productivity measures that differ in their measure of inputs: output per worker-hour and total factor productivity (TFP). (Both are expressed as the log of the plant's output-input ratio.) Our third type measure is simply the plant's logged real revenue. The fourth metric is the plant's logged capital-labor ratio (capital stock per worker-hour). Further details on the construction of these measures are in the Appendix. Because of data limitations, we can only construct these measures for the roughly 350,000 plants in each Census of Manufactures.

[16] These models are in turn built on foundations laid out earlier by Koopmans' (1951) and Becker (1973).

[17] Foster, Haltiwanger, and Syverson (2008) present a model of industry equilibrium where producers differ along both demand and cost dimensions, and show that plant type can be summarized as a single-dimensional index of demand, productivity, and factor price fundamentals.

These empirical type measures have been shown in various empirical studies to be correlated with plant survival. Survival probabilities reflect plant type in many models of industry dynamics with heterogeneous producers, like Jovanovic (1982), Hopenhayn (1992), Ericson and Pakes (1995), and Melitz (2003). The productivity-survival link has perhaps been the most extensively studied empirically; see Syverson (2011) for a recent literature review. Plant scale and survival was the subject of much of Dunne, Roberts, and Samuelson (1989), and capital intensity's connection to survival was explored in Doms, Dunne, and Roberts (1995). Hence they capture the connection between plants' supply and demand fundamentals and the plants' profit and survival prospects.

We first compare plant type measures across integrated an unintegrated producers by regressing plant types on an indicator for plants' integration status and a set of industry-by-year fixed effects. The coefficient on the indicator captures the average difference between plants in and out of vertical ownership structures. By including fixed effects, we are identifying type differences across plants in the same industry-year, avoiding confounding productivity, scale, or factor intensity differences across industries and time. We estimate this specification for each of the four plant type proxies and report the results in Table 3, panel A.[18]

It is clear that plants in vertical ownership structures have higher types. They are more productive, larger, and more capital intensive. Their labor productivity levels are on average 40 percent higher ($e^{0.336} = 1.399$) than their unintegrated industry cohorts. These are sizeable differences; Syverson (2004) found average within-industry-year interquartile logged labor productivity ranges of roughly 0.65; the gaps here are almost half of this. TFP differences, while still positive and statistically significant, are much smaller, at 1.4 percent. Vertical plants are much larger—4.2 times larger—than other plants in their industry in terms of real output. Capital intensities are substantially higher in integrated plants as well, explaining why their labor productivity advantage is so much bigger than the average TFP difference.

A natural question that follows from these results is the causal nature of vertically linked plants' type differences. There are three possibilities, and they are not mutually exclusive. The gaps could reflect the fact that newly built plants under vertical ownership are different than newly built plants in other ownership structures, and because types are persistent, this is reflected

[18] Sample sizes differ across the specifications because not all the necessary variables for construction of each are available for each proxy measure for every plant-year observation. Below, we will focus on differences among the set of plants with each of the plant-level production measures (except TFP) available.

in the broader population. Or it may be that high-type firms that seek to merge new plants into their internal production chains choose plants that already have high types to add to the firm. Finally, becoming part of a vertical ownership structure might be associated with a change in an existing plant's type.

We can separately investigate these possibilities. To see if new vertically structured plants are different than newly built plants in other ownership structures, we re-estimate the type specification above on a subsample that includes only new plants.[19] To test if firms already comprised of high-type vertically linked plants expand by purchasing unintegrated plants that already have systematically higher types, we regress unintegrated plants' type proxies on a dummy indicating if a plant will *become* vertically integrated by the next Economic Census. (Again industry-year fixed effects are included.) The estimated coefficient on the dummy captures how to-be-vertically-owned plants compare *before integration* to other plants in their industry that will not become integrated during the period. Finally, to test if becoming part of a vertical ownership structure is associated with systematic changes in a plant's type, we regress the inter-census growth in plants' type measures on an indicator for plants that become part of integrated production chains during the period. All these specifications include industry-year fixed effects, so we are always comparing plants within the same industry and time period.

Panels B-D of Table 3 show the results, with panel B comparing new plants, panel C comparing the types of unintegrated plants before integration, and panel D comparing plant type changes. Comparing the type disparities in these panels to those in panel A suggests that much of the heterogeneity between plants in and out of vertical ownership structures reflects differences in the assignment of plant types to integration status. As panels B and C show, most of vertically integrated plants' higher productivity levels, scale of operations, and capital intensities already existed either when they were born into integrated structures or before they were merged into integrated structures. For example, labor productivity and capital intensity are on average about 30 percent higher for new plants in vertically integrated structures firms than for other new plants. This is about three-fourths of the analogous gaps observed among all

[19] New plants are defined as those appearing for the first time in the Economic Census, which is associated with the start of economic activity at its particular locations. In other words, these plants are greenfield entrants. Existing plants that merely change industries between ECs are not counted as entrants in our sample. New plants are an important part of the formation of vertically integrated structures in the economy: entering integrated plants account for roughly two-fifths of the employment, and three-fifths of the capital stock, of all new plants in a given EC. This specification excludes observations from the 1977 EC because of censored entry.

plants. Similarly, unintegrated plants that will soon become part of vertical ownership chains are already considerably more productive, larger, and capital intensive than unintegrated plants that will remain so. Thus most of the differences observed in panel A of the table reflect "selection" effects. At the same time, the results in panel D make clear that, for labor productivity and capital intensity in particular, those gaps not accounted for by pre-existing differences in type are closed due to the faster growth in experienced by existing plants when they become integrated. Thus we cannot ignore the possibility that integration has some direct effects on plant types.[20]

A.2. Firm Size, Not Structure, Explains Most Plant Type Differences

The fact that plants in vertical ownership structures are different naturally leads to the question of whether *firms* with vertical structures are different. And indeed, as we show in the Appendix, firms with vertical ownership structures are larger on average (whether measured by total employment or revenues) than other firms with multi-unit organizational structures, be it those that own multiple plants in a single industry or that own establishments in multiple industries, but none of which comprise substantial vertical links as defined above.

Given that firms with vertical structures tend to be the largest, it's natural to ask whether the differences in plant types seen above simply reflect underlying differences in firms. That is, if large firms tend to own systematically larger (and more productive, etc.) plants, this might explain the distinctive type patterns of plants in vertical structures, rather than their vertical ownership linkages per se. Perhaps the high types of plants in vertical ownership structures are a function of firm size rather than firm structure.

To see if this is the case, we rerun the plant type regressions above while including controls for firm size. We regress plant type measures on an indicator for vertically integrated plants and industry-year dummies as above, while now adding flexible controls for firm size. These controls are quintics of logged firm employment, logged number of establishments, and the logged number of industries in which the firm operates. We restrict the sample to plants owned by multi-unit firms, but few differences are seen if single-establishment firms are also included. This specification lets us compare plants that are in firms of the same size, regardless

[20] These are of course general patterns across the hundreds of manufacturing industries in our sample. They do not imply that the relative importance of these sources of type differences doesn't vary across individual industries. It is possible that in certain industries most of the type differences reflect changes that occur when plants become integrated rather than pre-existing type dissimilarities.

of the firms' internal structures.

Table 4 shows the results of these regressions. Much of the correlation between a plant's type and its vertical ownership structure goes away once we control fully for firm size. The point estimate for plants' TFP differences is now half as large and is one-eighth as large for revenue differences. The labor productivity and capital intensity "premia" for vertically integrated plants are now roughly 4 percent, much smaller than the initial 35 to 45 percent differences reported in panel A of Table 3.

Hence, much of what makes plants in vertical ownership structures different isn't really related to vertical ownership itself. Instead, the largest plants tend to be in the largest firms, and the largest firms tend to own vertically linked plants. Accounting for this fully explains the TFP and size differences and most of the labor productivity and capital intensity gaps.[21]

A.3. Discussion

The results in this subsection are consistent with theories of the firm as the outcome of an assignment mechanism that spreads higher-quality intangible inputs (e.g., better managers) across better and/or a greater number of production units. The highest-quality intangible inputs are allocated to multiple establishments in distinct product categories (each among the highest types within their industry), some of which are vertically linked. The end result is what we document in the data: vertically integrated production chains are found in the largest firms composed of the highest-type plants. This firm matching/sorting implication is also supported by our results that plants that will become parts of vertical ownership structures *already* have considerably higher type measures than other plants in the industries. Firms with high-type plants seek out other high-type plants to bring into the fold. It's also consistent with the fact that (not reported here for space reasons) plants' types within firms are positively correlated; firm's with high-type plants in one industry tend to have high-type plants in their other industries.

Note that if the intangible inputs mediation explanation for vertical ownership is correct, the distinction between "downstream" and "upstream" becomes one of convenience rather than

[21] This evokes the result in Hortaçsu and Syverson (2007) that vertically integrated ready-mixed concrete plants' productivity and survival advantages don't reflect their vertical structure per se, but rather that these plants tend to be owned by firms with clusters of ready-mixed plants in local markets. (The clusters allow them to harness logistical efficiencies.) Once we compared vertically integrated concrete plants to non-integrated plants that were also in clusters, many of the differences seen between integrated and nonintegrated plants disappeared.

an accurate depiction of intra-firm transfers. Managerial, marketing, knowledge capital, or other similar inputs are just as likely to be transferred from a firm's downstream units to its upstream ones as the reverse. The names reflect the flow of goods through the physical production process, which may be nonexistent or otherwise very small; they do not necessarily indicate the flow of inputs within the firm. Further, verticality itself need not be an important distinction under this alternative explanation. Vertical firm expansions are simply a particular way in which a firm applies its intangible capital to new but related lines of business. No flows of goods between the firms' vertically related establishments are necessary, just as with a typical horizontal expansion. This is consistent with the result above that firm size rather than structure explains most of the average type differences seen across plants.

B. Some Evidence that Vertical Structures Facilitate Intangible Input Transfers

It is difficult to directly test our "intangible input" explanation for vertical ownership structures because such inputs are by definition hard to measure. Ideally, we would have information on the application of managerial or other intangible inputs (like managers' time-use patterns across the different business units of the firm) across firm structures. Such data does not exist for the breadth of industries which we are looking at here, however. That said, we compile some suggestive evidence for an intangible input mechanism in this section.

Our first test digs deeper into the changes seen in plants that become vertically integrated, as with those observed in panel D of Table 4. We saw there that the only significant changes in type measures observed for such plants were in labor productivity and capital intensity.[22] We decompose these changes into their respective components by repeating the exercises, but this time running the specifications separately for plants' capital stocks and labor inputs. To allow exact decomposition of these changes, we restrict the sample to plants for which we observe each of the production measures, ensuring that the changes in the ratios' (logged) components add up to the change in ratios. Furthermore, for reasons that will become clear momentarily, we look at the individual changes in two types of labor inputs: production and nonproduction workers. The results are shown in Table 5.

[22] These are also the only two significant differences that remain between integrated and nonintegrated plants in the cross section once we fully control for firm size. It's not surprising that these two measures are positively correlated; higher capital intensity implies more output per unit labor in any production technology where capital and labor are complements.

The 3.0 percent average labor productivity change in this sample is driven both by a marginally significant 1.2 percent increase in output (unlike in the whole sample, which saw no significant change) and by 1.8 percent decline in hours. The 2.9 percent increase in capital intensity mostly reflects the same decrease in labor inputs, but the (albeit insignificant) point estimate suggests investment may have been higher at these newly integrated plants than their nonintegrated counterparts, as capital stocks grew 1.1 percent faster in the former.

The most interesting feature of observed drop in labor inputs is the labor composition shift that accompanies it. The percentage drop in nonproduction workers is more than four times that in production workers. This is also reflected in the drop in nonproduction workers' share of total employment at the plant.

These changes in capital intensity and labor composition are consistent with an intangible inputs motive for vertical ownership. Capital intensity would rise upon a plant becoming part of a vertical link if skilled managerial or other intangible inputs have stronger complementarities with capital than labor, for example.[23] The relative decline in nonproduction workers upon integration is consistent with some of the plant's former management, marketing, R&D, or any other staff associated with providing intangible inputs being replaced with the new intangible inputs of the vertically integrated structure. Fewer workers are needed to provide these new inputs in the integrated structure because of centralization and scale returns or greater efficacy. Both of these changes are consistent with the allocation mechanism we discuss above.

Our next tests look for further circumstantial evidence for intangible input movements by examining changes in the behavior of acquired plants once they are brought into their new firm. We investigate two practices: the products the plants manufacture and, taking further advantage of our CFS shipments data, the locations to which plants send their output.

To explore changes in acquired plants' product mixes, for each acquired plant we partition the universe of products into four groups, according to the acquiring and acquired firms' production patterns in the previous Census of Manufactures. Group 1 consists of products that were produced neither by any plant in the acquiring firm nor by any other plant in the

[23] Firms with vertical ownership structures might also face lower effective capital costs, which would shift their optimal factor allocation toward a more capital-intensive orientation. Since we know vertical firms are larger on average, and there is evidence that larger firms might be less credit constrained (e.g., Fazzari, Hubbard, and Petersen (1988) and Eisfeldt and Rampini (2009)), this is a plausible alternative.

acquired firm.[24] Group 2 are products that were produced by the acquired firm but not the acquiring firm. Group 3 are products made by the acquiring firm but not the acquired firm, and Group 4 includes products made by both the acquired and the acquiring firms. We then compute the sales of the acquired plants in each of these four groups in the CMs both preceding and following the ownership change of ownership.[25] A shift in acquired plants' product mixes away from Groups 2 and 4 and toward Group 3 would indicate that the acquiring firms reorient the plants toward the firms' existing operations. This reorientation is likely to require some intangible capital of the acquiring firms, be it production knowledge, product design, customer lists, or the like. As such, the reorientation would be circumstantial evidence for the flow of intangibles.

The results are in panel A of Table 6. There is a marked shift in the acquired plants' product mix away from what it did before. While the dollar value of production in these groups drops only slightly, because the acquired plants' sales grew on average (by 18 percent), the combined share of the acquired plants' products in these two groups falls from 36.6 to 30.7 percent. Also consistent with this reorientation is the fact that the plants' value of sales of Group 3 products increases by 11 percent. (Although here the share drops slightly because most of the acquired plants' production growth was in Group 1 products—those made by neither the acquiring firm nor the other plants of the acquired firm in the previous CM.)[26]

We show in the Appendix that these basic data patterns remain present in more structured tests. Specifically, we estimate a logit specification for the probability that an acquired plant will produce a specific 7-digit product after acquisition as a function of the product mix of the acquiring and acquired firms in the previous CM. The probability an acquired plant produces a given 7-digit product is significantly and economically larger if the product was made by the acquiring firm in the prior CM.

[24] We do not classify products based on those made by the acquired plant in question itself, as we are comparing production patterns before and after acquisition. If we grouped products based on the acquired plant's production, the plant's sales of any product in Groups 2 or 4—those groups that include products not made by the acquired firm in the prior CM—would be zero by definition. We similarly exclude the plant's own shipment destinations in the analogous zip code classifications below.

[25] We define products at the 7-digit SIC level. The sample consists of all manufacturing plants that are part of a merger or acquisition between 1987 and 1997 and for which we have detailed production data from the Census of Manufacturers Product Supplement.

[26] Bernard, Redding, and Schott (2010) report substantial turnover in the products that firms produce.

We conduct a similar exercise looking changes in the locations to which acquired plants ship their output before and after acquisition.[27] Again, we partition the acquired plants' sales into four groups. But here, they are based on the locations to which the acquiring and acquired firms shipped prior to the acquisition. Group 1 contains zip codes to which neither the acquiring firm nor any other plant in the acquired firm shipped before the acquisition. Group 2 contains zip codes where other plants in the acquired firm shipped but no establishments in the acquiring firm did. Group 3 contains zip codes to where the acquiring firm shipped but not the other plants in the acquired firm, and Group 4 includes zip codes to which both firms shipped output. A shift in acquired plants' shipping locations away from Groups 2 and 4 and toward Group 3 again suggests a reorientation toward the acquiring firms' existing operations and any intangible capital flows associated with it.

The results are in panel B of Table 6. The patterns line up with the reorientation story. Both the level and fraction of shipments to zip codes in groups 2 and 4 fall after acquisition. Combined shipment levels across these two groups fall by 20 percent, and the share going to these two groups drops from 23.1 to 15.2 percent. Concomitant with these drops is an increase in shipments to Group 3 zip codes. Here, shipment levels increase by about 40 percent while their share rises from 17.4 to 20.1 percent. (As with the product mix results, there is an overall increase in reported shipments, mostly coming in Group 1 zip codes.)

We again show using logit regressions in the Appendix that these basic patterns hold up to more formal testing.[28]

Thus we have seen that acquired plants see increases in capital intensity driven in large part by reductions in their number of nonproduction workers, a reorientation in their product mix away from their old firm's products and toward their acquiring firms' preexisting product mix, and similar shifts in the destinations of their shipments (and presumably, the identity of their customers as well) away from their old firm's orientation and toward the acquirers'. These patterns are all circumstantial evidence for the flows in intangible inputs that occur within integrated firms. We note, however, that these results are only suggestive—we cannot observe

[27] Our sample consists of establishments in both the 1993 and 1997 CFS that experienced a change of ownership during that period. The construction of this sample is detailed in the Appendix.

[28] Our results on the reorientation of acquired plants' operations complement those in Maksimovic, Phillips, and Prabhala (2011). That paper argues that, following a merger or acquisition, the acquiring firm shuts down or sells off establishments outside of the firm's core business segments while keeping acquired plants that operate in segments in which the firm already has a large presence or is particularly productive.

workers' positions within the firm at any finer level than the production/nonproduction worker dichotomy, and we would need much more detailed information on managerial or other intangible inputs to test the theory convincingly. Still, we find the results an intriguing starting point for continued work.

V. Conclusion

We have used data on hundreds of thousands of plants, the organizational structure of firms that own them, and their shipments, to explore production behavior in vertical ownership structures. We find that the common view of vertical ownership supporting efficient intra-firm transfers of goods along a production chain may not be its primary purpose. Firms' upstream plants ship only a fraction (and often none) of their output to downstream units inside the firm. This finding is robust to a number of measurement methods. Thus, outside of some exceptional plants that we find are clearly dedicated to internal production, most vertical ownership appears to have a different motive.

Motivated by patterns we document in plants' "types" within and across firms, we propose an alternative explanation for vertical integration. Namely, that it facilitates efficient transfers of *intangible* inputs (e.g., managerial oversight) within firms. It is plausible that the market would have a more difficult time mediating transfers of knowledge inputs than of physical goods. We provide suggestive evidence in favor of the intangible inputs hypothesis: Acquired establishments begin to resemble—both in terms of their shipment destinations and products produced—establishments from the acquiring firm.

Note that if this explanation is correct, there may not be anything particular about vertical structure within firms; intangible inputs can flow in any direction across a firm's production units. Vertical firm structures and expansions may not be fundamentally different from horizontal structures and expansions. Instead, a more generalized view of firm organization, like the firm as an outcome of an assignment mechanism that matches heterogeneous tangible and intangible inputs, may be warranted, and is consistent with some of the other patterns we document in the data.

One interesting point of comparison between our findings and the existing literature is with regard to international trade flows. For countries where such data is available, intra-firm trade accounts for roughly one-third of international goods shipments (see, e.g., Bernard, Jensen, Redding, and Schott (2007)). This is clearly substantially larger than the modest, domestic within-firm shipment volume we document here. A possible explanation might be that multinational firms are more likely to be comprised of the types of plants at the right tail of our Figure 1: large, dedicated producers to the firms downstream plants. Why multinationals would choose to structure themselves in a way so different than domestic shippers is less clear; we see this question as a good launching point for further research.

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Table 1. Plant-Level Shares of Internal Shipments

A. Benchmark

Internal share of:	Percentile 25th	50th	75th	90th	95th	Fraction = 0	Fraction = 1
Plant shipment counts	0.0%	0.4%	7.3%	32.2%	62.7%	49.7%	1.2%
Plant dollar value of shipments	0.0%	<0.1%	7.0%	37.6%	69.5%	49.7%	1.2%
Plant total weight of shipments	0.0%	<0.1%	7.1%	38.4%	69.9%	49.7%	1.2%

Notes: These tables report shares upstream plants' shipments that are internal to their firm. The sample consists of 67,500 plant-years aggregated from about 6.3 million shipments. For data confidentiality reasons, the reported percentiles are averages of immediately surrounding percentiles; e.g., the median = 0.5*(49th percentile + 51st percentile).

B. Robustness Checks (Share of Dollar Value Shown)

Specification/Sample	Percentile 25th	50th	75th	90th	95th	Frac. = 0	Frac. = 1	Approx. N
1. At least median number of shipments	0.0%	0.2%	6.9%	31.7%	59.5%	45.5%	0.3%	34,000
2. No exporters	0.0%	<0.1%	8.6%	46.5%	78.3%	49.7%	1.6%	47,000
3. Shipments to any plant in firm are internal	0.1%	4.9%	25.1%	67.5%	90.6%	22.8%	2.6%	67,500
4. County, not zip, determines internal	0.0%	7.2%	39.8%	87.1%	98.8%	25.3%	4.2%	67,500
5. 25 least differentiated industries	0.0%	0.0%	2.5%	20.0%	48.6%	61.4%	0.6%	2,200
6. 5% cutoff definition for VI	0.0%	0.0%	5.1%	32.1%	63.3%	53.9%	0.9%	53,000
7. Remove I→I as a potential vertical link	0.0%	0.0%	3.9%	30.8%	60.7%	58.7%	1.0%	43,000

Notes: Each row shows for a different subsample the distributions of the shares (by dollar value) of upstream integrated establishments' shipments that are internal to the firm. The criteria for inclusion in and size of each subsample is discussed in the text. For data confidentiality reasons, the reported percentiles are averages of immediately surrounding percentiles; e.g., the median = 0.5*(49th percentile + 51st percentile).

Table 2. Internal Shipments as Share of Smaller of Upstream Shipments or Downstream Usage

	Value share of shipments percentiles				
Downstream usage measure	25^{th}	50^{th}	75^{th}	90^{th}	95^{th}
Firm's total downstream manufacturing materials purchases	0.0%	0.3%	13.8%	67.4%	134.3%
Firm's downstream use of 2-digit product	0.0%	0.0%	15.4%	118.8%	403.2%
Firm's downstream use of 4-digit product	0.0%	0.0%	18.5%	125.4%	687.0%

Notes: These tables report shares upstream plants' shipments that are internal to their firm, as a fraction of the smaller of a) the total shipments of a firm's upstream plants or b) the firm's downstream use of a product. Sample construction and sizes are detailed in the text. For data confidentiality reasons, the reported percentiles are averages of immediately surrounding percentiles; e.g., the median = 0.5*(49^{th} percentile + 51^{st} percentile).

Table 3. Plant Attributes by Vertical Ownership Structure

	Output per hour	TFP	Output	Capital-labor ratio
A. Within-industry differences				
Approximate N	966,000	876,000	987,000	933,000
Indicator for vertical plants	0.336*	0.014*	1.441*	0.424*
	(0.002)	(0.001)	(0.004)	(0.003)
B. Differences among new plants				
Approximate N	237,000	211,000	245,000	230,000
Indicator for vertical plants	0.280*	0.033*	1.224*	0.329*
	(0.004)	(0.003)	(0.009)	(0.006)
C. Comparing unintegrated plants: to-be-vertical vs. remaining non-vertical				
Approximate N	403,000	367,000	410,000	389,000
Indicator for to-be-vertical plants	0.194*	0.002	1.254*	0.247*
	(0.005)	(0.003)	(0.010)	(0.007)
D. Changes upon entering vertical ownership				
Approximate N	347,000	299,000	356,000	327,000
Newly vertical indicator	0.035*	-0.010*	0.019*	0.032*
	(0.005)	(0.004)	(0.007)	(0.008)

Notes: This table shows plant "type" comparisons between plants in (or to-be-in) vertical ownership structures and their non-vertical counterparts. Panel A compares across all plants for which type measures are available. Panel B compares new plants. Panel C compares *prior period* types among non-vertical plants that will become part of vertical ownership structures by next period to those remaining non-vertical. Panel D compares changes in type for plants that become part of vertical ownership structures to changes for unintegrated plants that remain so. All regressions include industry-year fixed effects. Samples are comprised of non-AR manufacturing plants. See text and appendix on construction of type measures and additional details. An asterisk denotes significance at a five percent level.

Table 4. Plant Type Differences Controlling for Firm Size

	Output per hour	TFP	Output	Capital-labor ratio
Multi-unit firm dummy				
Approximate N	966,000	876,000	987,000	933,000
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				
Approximate N	947,000	862,000	965,000	915,000
VI indicator	0.040*	0.007*	0.154*	0.034*
	(0.003)	(0.002)	(0.006)	(0.005)

Notes: This table shows the results from regressing plant-level type measures on an indicator for vertically integrated plants, a set of industry-year fixed effects, and controls for firm size. The firm size controls are a dummy for single-industry firms and quintics of several measures of the plant's owning-firm size: employment, the number of establishments, and number of industries.

Table 5. Changes in Plant Attributes Upon Integration

	Change upon VI
Output per hour	0.030* (0.005)
Output	0.012 (0.006)
Hours	-0.018* (0.006)
Capital-labor ratio	0.029* (0.009)
Capital	0.011 (0.009)
Production workers	-0.011 (0.006)
Nonproduction workers	-0.048* (0.007)
Nonproduction worker share	-0.006* (0.001)

Notes: The table repeats panel D of Table 3, but with additional plant production measures. The sample consists of only of the approximately 285,000 newly integrated plants that have nonmissing data for all production measures. See text for details. Regressions include industry-year fixed effects. An asterisk denotes significance at a five percent level.

Table 6. Allocation of Sales/Shipments across Products and Locations for Acquired Establishments

A. Product Mix

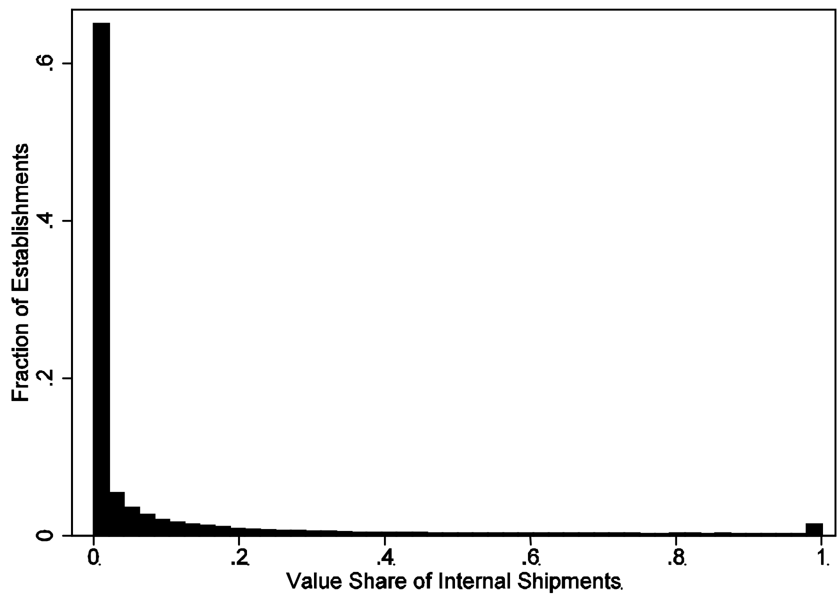
	Group 1	Group 2	Group 3	Group 4
Average sales, CM prior to acquisition (millions)	$10.1	$5.5	$7.0	$4.4
Average sales, CM after acquisition (millions)	$14.3	$5.5	$7.8	$4.3
Fraction of establishment sales, CM prior to acquisition (%)	37.4	20.5	26.0	16.1
Fraction of establishment sales, CM after acquisition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

B. Shipment Locations

	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

Notes: This table presents, for acquired establishments, the average dollar amounts and shares of sales accounted for by products (shipment locations in panel B) in four different groups based on the behavior of the acquiring and acquired firms' establishments in the CM prior to acquisition. Shares are weighted according to the revenue of the acquired establishment. Group 1 contains products (locations in panel B) that neither the acquiring firm's establishments nor the establishments in the acquired firm (other than the establishment in question) produced (shipped to in panel B) in the prior CM. Group 2 contains products (locations in panel B) that the acquired firm's other establishments produced (shipped to in panel B) but the acquiring firm's establishments did not. Group 3 contains products (locations) that the acquiring firm's establishments produced (shipped to) but the acquired firm's other establishments did not. Group 4 contains products (locations) that both the acquiring and the acquired firms' establishments produced (shipped to). Dollar figures are stated in terms of real 1987 dollars using industry-level price indices from the NBER Productivity database. See text for details.

Figure 1. Share of Intra-firm Shipments by Upstream Vertically Integrated Establishments



APPENDIX – NOT FOR PUBLICATION

A. Construction of Production Variables

We describe here details on the construction of our production variables.

Output. Plant output is its inventory-adjusted total value of shipments, deflated to 1987 dollars using industry-specific price indexes from the NBER Productivity Database.

Labor Hours. Production worker hours are reported directly in the CM microdata. To get total plant hours, we multiply this value by the plant's ratio of total salaries and wages to production worker wages. This, in essence, imputes the hours of non-production workers by assuming that average non-production worker hours equal average production worker hours within plants.

Labor Productivity. We measure labor productivity in terms of plant output per worker-hour, where output and total hours are measured as described above.

Total Factor Productivity. We measure productivity using a standard total factor productivity index. Plant TFP is its logged output minus a weighted sum of its logged labor, capital, materials, and energy inputs. That is,

$$TFP_{it} = y_{it} - \alpha_{lt} l_{it} - \alpha_{kt} k_{it} - \alpha_{mt} m_{it} - \alpha_{et} e_{it},$$

where the weights α_j are the input elasticities of input $j \in \{l, k, m, e\}$. Output is the plant's inventory-adjusted total value of shipments deflated to 1987 dollars. While inputs are plant-specific, we use industry-level input cost shares to measure the input elastiticies. These cost shares are computed using reported industry-level labor, materials, and energy expenditures from the NBER Productivity Database (which is itself constructed from the CM). Capital expenditures are constructed as the reported industry equipment and building stocks multiplied by their respective BLS capital rental rates in the corresponding two-digit industry.

Real Materials and Energy Use. Materials and energy inputs are plants' reported expenditures on each divided by their respective industry-level deflators from the National Bureau of Economic Research Productivity Database.

Capital-Labor Ratio. Equipment and building capital stocks are plants' reported book values of each capital type deflated by the book-to-real value ratio for the corresponding three-digit industry. (These industry-level equipment and structures stocks are from published Bureau of Economic Analysis data.) Any reported machinery or building rentals by the plant are inflated to stocks by dividing by a type-specific rental rate.[29] The total productive capital stock k_{it} is the sum of the equipment and structures stocks. This is divided by the plants' number of labor hours to obtain the capital-intensity measure used in the empirical tests.

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[29] Capital rental rates are from unpublished data constructed by the Bureau of Labor Statistics for use in computing their Multifactor Productivity series. Formulas, related methodology, and data sources are described in U.S. Bureau of Labor Statistics (1983) and Harper, Berndt, and Wood (1989).

Nonproduction Worker Ratio. Plants directly report both their number of production and nonproduction employees. Nonproduction workers are defined by the Census Bureau as those engaged in "supervision above line-supervisor level, sales (including a driver salesperson), sales delivery (truck drivers and helpers), advertising, credit, collection, installation, and servicing of own products, clerical and routine office functions, executive, purchasing, finance, legal, personnel (including cafeteria, etc.), professional and technical [employees]. Exclude proprietors and partners." The nonproduction worker ratio is simply such employees' share of total plant employment.

B. Measuring the Flow of Goods through the Wholesale and Retail Sectors

The Input-Output Tables treat both the entire wholesale and retail sectors as single industries. Further, they do not keep track of shipments by manufacturers to or through wholesalers or retailers, instead measuring only those inputs directly used by wholesalers and retailers in the production of wholesale and retail services. To better measure the flow of goods through these sectors, we the following algorithms.

If industry *J* is in the wholesale sector, we impute the industry's purchases of each commodity *C* using CFS data on establishments' shipments of commodity *C* along with data from the Annual Wholesale Trade Survey (AWTS). The AWTS contains information on wholesale industries' aggregate commodity purchases and aggregate commodity sales. Using data from the AWTS, we compute the ratio R_J of commodity purchases to sales. Aggregating across plants in the CFS gives a measure of aggregate sales of each commodity by each wholesale industry, S_{CJ}. Given these two pieces of information, we impute industry *J*'s purchases of commodity *C* as $P_{CJ} = S_{CJ} \cdot R_J$.

To give an example, establishments in the motor-vehicle-related wholesale industries (SICs 5010-5019) had sales of $159 billion and purchases of $131 billion in 1993. We therefore set $R_J = 0.82$ (131/159) for all vehicle-related wholesale industries. For each commodity and industry within SICs 5010-5019, we impute aggregate purchases as 82% of the shipments of the respective commodity that we observe CFS establishments making.

When *J* is a retail industry, we utilize the CFS data along with the Annual Retail Trade Survey (ARTS). The U.S. Census Bureau uses the ARTS to collect information on purchases of groups of retail industries. For example, in 1993, establishments in the household appliance industries (SICs 5720-5734) purchased $35.8 billion in intermediate materials. Unfortunately, we do not know how much total merchandise was purchased by each SIC industry within these groupings, nor do we know the amount of any specific commodity purchased by these groups. To impute these values, we rely on data from the Commodity Flow Survey and then hand match commodity-specific shipments to the most appropriate retail industry within the ARTS groupings.

To demonstrate, we continue with our household appliance retailers example. Our hand match specifies commodities 510102 (calculating and accounting machines), 510103 (electronic computers), 510104 (computer peripheral equipment), and 510400 (other office machines) as those that are sold to SIC 5734 (computer and software stores). Repeating this process for all commodities and industries yields a table of commodity-retail-industry pairs such that the 4-digit retail industry could potentially purchase the given commodity.[30] The amount of the commodity purchased by the industry is assumed proportional to a) the amount of the good shipped, according to the Commodity Flow Survey, b) the 4-digit retail industry's share of employment among its larger grouping of industries, and c) the total amount purchased by industry group.

For example, suppose we want to impute the purchases of computers (STCC 37531) by computer and software stores. We know that total goods purchases by retailers in SICs 5720-5734 is $35.8 billion. Since employment in computer and software stores is 14.6% (30,000/205,000) of employment in this retailer group, we impute goods purchases of $5.2 billion by computer and software stores.[31] To impute the amount of this total that is computers specifically, we multiply the $5.2 billion figure by the value of shipments of computers as a fraction of all commodities that can be purchased by computer and software stores, where both of these commodity values are computed from the CFS.

C. Additional Robustness Checks

C.1. Plant-Level Shares of Internal Shipments

This section contains three additional robustness checks, related to those presented in Section IV.B.1. First, we compute the distribution of internal shares using successively more restrictive definitions of vertically linked industries. Then, we compare our measures of plants' internal shares to the measures constructed directly from the Census of Manufacturers. Finally, we discuss how our definitions of a) vertically linked industries and b) plants' internal shipments differ from the definitions we gave in an earlier draft. We show that the results are robust to the changes in our definitions.

In the benchmark calculations, we defined industry J to be downstream of industry I provided at least 1 percent of industry I's sales were purchased by establishments in industry J. In Rows 1-3 of Table A1, we consider the effect of changing the 1 percent cutoff to 10 percent, 15 percent, or 20 percent. As the cutoff increases two things occur: First, our sample of upstream establishments shrinks. Second, for any particular establishment in our sample, fewer shipments are classified as being sent along an internal, vertical link. Increasing the cutoff from 1 to 20 percent reduces the size of our sample by three-fifths. At the same time, however, the distribution of establishments' internal shares is not substantially altered using the more restrictive definition of vertical integration. Under the 20 percent cutoff, the 75^{th}(90^{th}) percentile internal shares are 4.5 percent and 28.2 percent, only somewhat smaller than the values given in Table 1.

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[30] The concordance of STCC commodities in the CFS and the commodity classifications in the Input-Output tables is produced in a two-step process. To match STCC commodities to the corresponding SIC industries, we use a table provided to us by John Fowler at the U.S. Census Bureau. To match SIC codes to IOIND commodities, we use the concordance provided by the BEA. The latter table can be found at http://www.bea.gov/industry/io_benchmark.htm.

[31] For these employment figures, see the "Establishment and Firm Size" document at http://www.census.gov/epcd/www/92result.html.

The Census of Manufacturers contains a variable, *interplant transfers*, which describes shipments that are sent to other plants within the firm, for further assembly. Since the Census of Manufacturers also contains information on each plant's total value of shipments, it is straightforward to compute internal shares as the ratio of interplant transfers to total value of shipments. The first row of Table A1 gives the quantiles for the 766 thousand plant-year observations of plants' interplant transfers. Only 2.2 percent of the observations have nonzero internal shares. In the second row, we restrict attention to the 37,034 plants that also take part in the Commodity Flow Survey. For this subsample, a larger fraction, 23.4 percent, have nonzero interplant transfers. The 90^{th} percentile interplant transfers share is 13.2 percent.

Rows 3 and 4 of Table A1 give the corresponding statistics, using our benchmark definitions of plants' internal shares (i.e., using data from the Commodity Flow Survey and the algorithm specified in Section 3 of the paper). Row 3 restricts the benchmark sample to plants in the manufacturing sector. For this subsample, the 75^{th} (90^{th}) percentile internal share is 6.2 percent (33.7 percent), slightly lower than the values given in Table 1 (7.0 percent, and 37.6 percent, respectively).

The difference between Rows 5 and 6 originates from differences in what is defined as an internal shipment. Interplant transfers, which are shipments to other plants for further assembly, only includes shipments sent to plants in the manufacturing sector. Our definition, using data from the Commodity Flow Survey, includes shipments sent to same-firm plants in any sector.

In Row 4, we only count a shipment as internal if there is a downstream plant, from the same firm, that is also in the manufacturing sector. [32] The 75^{th}(90^{th}) percentile internal shares are 0.3 percent and 11.7 percent, reasonably close to the values given in Row 5.

To summarize, the interplant transfers variable yields smaller values for internal shipments, compared to the variable constructed from the Commodity Flow Survey, because it omits shipments sent to non-manufacturing establishments. If it were not for this difference, the two variables would be similar to one another.

Our definitions over which industries are vertically linked and when shipments are counted as internal were slightly different in an earlier draft of the paper (Hortacsu and Syverson, 2007b). It turns out that results are qualitatively similar whether one uses the old or new definitions of vertically linked industries or internal shipments. For completeness, we review these old definitions, as well as the internal shares that resulted from these definitions.

In the previous draft, we had a less stringent definition for internal shipments. We did not require that the shipment be destined to an establishment that is in an industry directly downstream to the shipping establishment, only that the destination be a plant that is on the downstream end of *any* vertical link in a firm.[33] In Row 8 of Table A1, we recomputed internal shares for the benchmark sample, with this less strict definition of internal shipments.

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[32] Consider the following example of a plant, sending a shipment of auto parts to zip code, z. Suppose there is a same-firm auto parts wholesaler (SIC=5013), but no manufacturing plants in an industry that consumes auto parts, in zip code z. This shipment would be classified as internal according to the calculations of Row 3, but in not the calculations corresponding to Row 4.

[33] For instance, suppose a firm has two upstream establishments U_1 and U_2, and two downstream establishments D_1 and D_2, and U_1-$D_1$and U_2-D_2 are separate vertical links. According to the old definitions, a shipment from U_1 would be classified as internal if it is destined to *either* D_1 or D_2's ZIP codes, not just D_1's.

The median plant has an internal share of 3.0 percent, and only 29.1 percent of plants have no internal shipments. Compared to the benchmark calculations, the mean internal share is almost 6 percent larger (16.1 percent, compared to 10.2 percent). Thus, under our old definitions, we were being very liberal when computing internal shipments.[34]

A second difference, compared to the previous draft, originates from the way in which vertically linked industries are defined. In the previous draft, we defined two industries to be vertically linked only using information from the BEA input-output tables. Specifically, a substantial link exists between Industry A (using the BEA definition of input-output industries) and any industry from which A buys at least five percent of its intermediate materials, or any industry to which A sells at least five percent of its own output. As we discuss in Section 3, the old definition is potentially problematic if the downstream industry is retail or wholesale. For wholesalers and retailers, the BEA doesn't keep track of the gross shipments by sent to wholesalers/retailers. Instead, the BEA measures the industries which are used by wholesalers/retailers in the "production" of wholesale/retail services. Because of this issue, there are several pairs of industries that are, in reality, linked with one another, but are not classified as such under the old definition.

In Row 9 of Table A1, we compute internal shares using the old definition of vertically linked industries (but retain the new definition of when shipments are internal to the firm). With the old definition of vertically linked industries, the sample of vertically integrated establishments is less than half as large, 29893 compared to 67552 plant-years. The 75th percentile (90th percentile) internal share is 1.0 percent (17.4 percent). These are considerably less than corresponding values of the benchmark calculations for the 75th and 90th percentiles, 7.0 percent and 37.6 percent.

In the final row, Row 10, of Table A1, we compute internal shares using both the old definition of when shipments are classified as internal, and the old definition of when industries are classified as vertically linked. Under these definitions, the median establishment has an internal share of 2.5 percent, the 90th percentile plant has an internal share of 57.7 percent, and 2.1percent of plants have a 100 percent internal share.

C.2. Is Geographic Closeness Important?

It's quite likely that some of the low internal shares we see above arise because a firm's plants are too spatially separated to make internal shipments practical. Of course, if this is the case, this may be a *result* as much a *cause* of the lack of within-firm goods transfers along a production chain. If moving physical products down a production chain was the only reason for vertical ownership, after all, no firm would own vertically related plants that were located too far from one another to make intra-firm shipments impractical. The fact that firms do own vertically linked producers that are far apart suggests other motives for ownership.[35]

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[34] Since a main objective of the paper is to point out that internal shipments are surprisingly small, being liberal in defining internal shipments is innocuous.

[35] Hortaçsu and Syverson (2007) document examples of vertically integrated cement and concrete firms that own clusters of ready-mixed concrete plants that are remotely located from their upstream cement plants. These firms, in fact, do not internally supply these clusters with cement. The downstream concrete plants report instead buying cement in the local market from the firm's upstream competitors. We find evidence that the firms' motives for owning these concrete plant clusters is to harness logistical efficiencies in a business that shares a common final demand sector (construction) with cement.

Nevertheless, it is interesting to quantify how much distance matters. We take two approaches. The first is to compute the distribution of internal shipment shares for firms whose plants are all located close to one another. The second is to compare plants' shipment distances to the distances they are from other plants in their firms.

To see shipment patterns of closely-spaced firms, we use the subset of upstream plants from our CFS sample where *all* of the plants that their firm owns are in the same county. (This is determined from the Economic Census, which includes state and county codes for virtually all establishments. This location information is not subject to the limitations of the EC zip code data, where codes for 10 percent of plants are missing.) This subset is small—2254 plant-years and 199,712 shipments—and contains a large number of two-plant firms with one upstream and downstream plant each. Nevertheless, it offers a rough gauge the role of distance.

The results are consistent with the patterns above. Just under half (46.7 percent) of the upstream plants report no shipments to downstream units in their firm. The 90^{th} percentile plant ships 49.0 percent of the value of its shipments internally. The fraction of plants with all shipments staying in the firm is above that in the benchmark sample, however, at 2.4 percent. Thus it appears that vertically structured firms with closely located plants are less likely to make internal shipments on average, but somewhat more likely to contain internally dedicated upstream plants.

We next compare the shipment distances of our entire sample of upstream plants in the CFS to their distances from other plants in their firms (both measured in great circle terms). It's clear from pooling shipments across plants that internal shipments go shorter distances. In fact, the average external shipment is sent roughly three times as far as the average internal shipment. This may reflect upstream plants "bypassing" their downstream units with some of their shipments, but it may also reflect composition effects if internally dedicated, high-volume upstream establishments are located close to downstream units in their firm.

We can decompose these contributions to the pooled numbers by looking within plants. We find that for 21.9 percent of upstream shipment plants, their farthest-traveling shipment does not go as far as the distance to the nearest downstream plant in their firm. These plants account for just under one-third of the one-half of our upstream plants that report no internal shipments, showing the importance of distance. But this also means the other two-thirds of plants reporting no internal shipments do send output at least as far as their nearest plant. This pattern isn't unusual across the broader sample. Looking across plants, the average of the within-plant medians of reported shipment distances is 274 miles, while the average distance to the closest downstream plant within the firm is 192 miles.

C.3. Is There Vertical Integration Within Plants?

Our definition of vertically integrated ownership links requires multiple plants by definition. A firm must own at least one plant each in vertically related upstream and downstream industries. This definition could be problematic if firms commonly vertically integrate production within a single plant. In such cases, the firm would be operating a vertically integrated production process and obviously supplying its own input needs. We would miss this type of integration, however, because we would not classify the plant as integrated. There would be no shipments from the upstream to downstream parts of the production process in the CFS, since those goods transfers never leave the plant.

To give a concrete example, consider the two following hypothetical firms. One has two plants. The upstream plant refines copper ore into billets which are then shipped to the downstream plant to be extruded into pipe. The second firm operates a similar production process in a single plant: one side refines ore into billets, and the other side turns billets into pipe. We would define the former plants as vertically integrated, but not the latter, even though each firm operates the same production processes.

How can we tell if this sort of misclassification is a big problem? We compare the materials purchase patterns of plants that we classify as being in vertical structures to those in the same industry not classified as such. In the context of the above example, we compare the two copper pipe plants. (Since plants are classified into industries in the Economic Census based upon their outputs, both the downstream plant in the first firm and the second firm's plant would be classified in the same industry, SIC 3351: Rolling, Drawing, and Extruding of Copper.) The pipe plant in the first firm—the one that we would have classified as in a vertical ownership structure—will list copper billets as an intermediate materials purchase in the Census of Manufactures materials supplement. The second plant, where billet production is inside the plant, will list copper ore as a materials purchase. Hence if we see substantial differences in materials use patterns across plants (in the same industry) that we classify respectively as vertically linked or not, we should be concerned that we are missing a lot of vertical production that occurs "under one roof." On the other hand, a lack of significant differences suggests this sort of misclassification is less of a concern.

We make three such comparisons between the materials use patterns of what we classify as vertically linked plants and others in their industry. (Again our analysis is restricted to plants in the manufacturing sector because of the detailed intermediate materials data requirements.) We first compute the share of each plant's intermediate materials purchases that is for "raw materials," which we define as the products of the agricultural, fisheries, forestry, or mining sectors—i.e., SIC product codes beginning with "14" or below. We then regress this share on a set of industry-year fixed effects and an indicator equal to one if we classify the plant as in a vertical ownership link. In essence, we test whether there are significant differences in the intensity of raw materials use across plants that we classify as vertical and non-vertical in the same industry. We would expect that if the "under one roof" misclassification problem were substantial, we would find that plants we designate as *non*-vertical would have a larger raw materials share, since a greater portion of the production chain would be operated within the plant. Again, to return to our example, the pipe plant in the second firm reports copper ore (a raw material) as a materials purchase, while the plant in the first firm purchases copper billets.

We run this regression on a sample of over 453 thousand plant-years from the Census of Manufactures. (We don't need the CFS for this.) The coefficient on the vertical ownership link indicator is 0.47 percent, with a standard error of 0.05 percent. Thus plants we classify as vertical use raw materials more, not less, intensively compared to other plants in their industry. (Recall that we would expect plants we classify as vertically linked to use raw materials less intensively). Further, the point estimate of the share difference is small, less than one-fifteenth the average raw materials share of 8.2 percent. Even if we restrict our comparisons only to those roughly 85,000 plants that report using positive raw materials shares, the vertically linked coefficient is -1.87 percent with a 0.19

percent standard error. The estimated difference is small, relative to the 44 percent average materials share, for plants that report positive materials purchases.

Our second check aggregates this raw materials use data to the industry level. We add up raw and total materials use of plants classified as vertical within an industry year, and compare the ratio of the two to the same share computed for non-vertical (again, under our classification) plants in the same industry. We then conduct a t-test for equality of means across our sample of 1867 industry-years. The mean difference is 0.08 percent, with a standard error of 0.22 percent. Here, there are no significant within-industry differences in raw materials usage intensity across the two types of plants.

Our final check is also done at the industry-year level. We separately aggregate materials purchases of our designated vertical and non-vertical plants for each industry year. We then order materials by decreasing intensity of use for each type of plant (as measured by their aggregate share of purchases). This yields 86,659 industry-year-materials ranks for both vertical and non-vertical plants. We then compare these ranks within industry-year to see if there are systematic differences. The two ranks move together; the correlation coefficient is 0.74. Table A2 shows the frequency of relative rank orderings for the five most intensively used materials by industries' non-vertical plants. (Material 1 is the most intensively used.) Only ranks 1-7 of vertical plants are shown for parsimony. If materials usage patterns were exactly the same, we would only see entries on the diagonal of the table. The most intensively used material of an industry's vertical plants would be the most intensively used among its non-vertical plants; the second-most used would be so for both types of plants, and so on. Clearly, this is not the case. However, the general pattern holds. The diagonal is the largest element of a row or column, and the frequency of other pairings falls as they move further away from the diagonal. Hence these results suggest, as do the raw materials use tests above, that there are not systematic differences in the mix of materials used by plants we classify as in vertical ownership links and those we do not classify as such.

C.4. Cross-Industry Differences in Internal Shares

Table A3 presents, for different 2 and 3-digit industries, establishments' average internal shares. The first three columns use data from the Commodity Flow Survey, while the final three columns use data from the Census of Manufacturers.

The first column gives, for all establishments surveyed in the Commodity Flow Survey, the fraction of plants that have a positive internal share. There is substantial variation, across different goods-producing industries. Plants in petroleum and transportation equipment manufacturing have the largest fraction of plants within positive internal shares; furniture manufacturers and furniture and lumber wholesalers have the smallest fraction of plants with positive internal shares. The second and third columns give the revenue-weighted average share of plants' internal shares. Again, there is substantial variation, among industries with the highest average internal shares (fabric and petroleum manufacturing, and chemicals and beer/wine wholesaling) and the industries with the lowest average internal shares (furniture manufacturing and lumber, metals, drugs, and petroleum wholesaling.

Columns 4-6 display the corresponding calculations, using data from the Census of Manufacturers. While both the sample and the definition of internal shares differ between columns 1-3 and columns 4-6, the cross-industry patterns of internal shares are similar across the two sets of calculations. Paper, transportation equipment, and primary metals manufacturing are some of the more vertically integrated industries; furniture manufacturing and printing are two of the least vertically integrated.

The petroleum industry is a bit of an outlier, and deserves extra attention. Petroleum is an industry that has one of the highest internal shares in columns 1-3, but one of the lowest internal shares in columns 4-6. This difference results from the different definitions of internal shipments across the two datasets. The Interplant Transfers variable, collected in the Census of Manufacturers, asks plants to give the value of shipments sent to other manufacturing plants for further assembly. Since shipments by petroleum manufacturers are mainly sent to wholesalers, and not to other manufacturers, the internal shares computed from the Census of Manufacturers tend to be significantly smaller than the internal shares computed using data from the Commodity Flow Survey.

C.5. Firm Size Differences by Firm Structure

Figure A1 plots the densities of firm size (logged total employment, since revenue is unavailable outside of manufacturing) for three mutually exclusive and exhaustive sets of multi-establishment firms. One set includes firms with vertical ownership structures.[36] The other two multi-unit organizational structures are single-industry and multi-industry-unintegrated firms.[37]

The figure reveals that each of the (logged) employment size distributions is unimodal, though they clearly have different central tendencies.[38] Single-industry multi-unit firms are the smallest and have the most symmetric size distribution. Vertically integrated firms are clearly the largest on average, and their distribution is more skewed than the other firm types. (While not plotted, single-establishment firms are smaller than the multi-unit single-industry firms, as one might expect.) Thus not only are vertically integrated plants larger, their firms are as well.

C.6. Flows of Intangible Inputs

In our product mix and shipment destination tests, we use the following algorithm to identify plants that experienced ownership changes. From the Longitudinal Business Database, we begin with all establishments for which the firm identifier changes between *t* and *t*+1. Since firm identifiers may change across years for a number of reasons, we need to discard the observations which are unrelated to mergers or acquisitions.[39] To identify actual

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[36] Recall that we define vertical ownership at the plant, not firm level. For our purposes here, however, we define a firm as vertically structured if it owns any vertically linked establishments. As a practical matter, most plants in what we call vertically structured firms here are also in vertical chains according to our plant-specific definition.

[37] The distribution of plants across these firm sets is as follows. Over the entire manufacturing sample, multi-unit plants of all types accounted for 19.7 percent of establishments, 71.8 percent of employment, and 86.5 percent of the capital stock. Vertically integrated plants' shares were, respectively, 14.3, 60.1, and 79.1 percent. Multi-unit single-industry plants accounted for 2.8 percent of establishments and 5.1 and 3.2 percent of employment and capital, while multi-industry unintegrated plants comprised 3.9, 8.3, and 5.5 percent of establishments, employment, and capital.

[38] We only plot the 1997 distributions rather than those pooled across years in order to remove any secular shifts in firm sizes. Checks of other years show similarly shaped distributions.

[39] For example, legal reorganizations may cause a change in firm identifiers without an actual change in ownership. For an additional example, multi-unit and single-unit firms are coded differently by the Census: a single-unit

changes in ownership, we consider the set of establishments that have the same firm identifier as that establishment in years *t* and *t*+1. For these establishments, we say that a change of ownership has occurred if they share the same firm identifier with some other set of establishments in period *t*+1, but not in period *t*. We define the other set of establishments to be an acquiring firm, if their firm identifier is the same in both years *t* and *t*+1.[40]

Here, we complement our analysis in the main text of summary data on changes in product mix and shipment destinations among acquired plants with more formal analyses. In Table A4, we estimate the probability that plant *i* will produce a given 7-digit product in year *t* as a function of the year *t*-5 production patterns of the acquiring and acquired firms. We find a plant is more likely to produce a product in year *t* if either the acquiring or the acquired firm was producing the product. The probability that an acquired plant produces a given 7-digit product in year *t* is 6 percent higher for products that were produced by the acquiring firm in year *t*-5. Compared to other products in their industry, acquired establishments are also more likely to produce the products that its original firm was producing. The probability that establishment *i* produces a given 7-digit product is 7 percent higher for products that were produced in year *t*-5 by some other establishments of the acquired firm.

To further explore the evolution of acquired establishments' shipping patterns, we run a series of logit regressions to estimate the probability that an acquired plant *i* will ship to any particular zip code *z* in 1997. In these regressions, the variables of interest measure the shipping patterns of the acquiring and acquired firms in 1993. In addition, we include the following variables as controls: establishment-by-destination-county fixed effects; controls for total sales to zip code *z* as well as the great-circle distance between *i* and *z*, an indicator variable equal to one if there exists an establishment from the same firm in 1997, and an indicator variable equal to one if establishment *i* shipped to *z* in 1993.

Table A5 contains the results from these regressions. An establishment is significantly more likely to ship to a zip code if either the acquiring or acquired firm sold to that zip code in previous years. The probability that plant *i* sells to zip code *z* in 1997 is 1.2 percent higher when an establishment from the acquiring firm sold to that zip code in 1993. The estimated marginal effect is significantly larger, 9.6 percent, if the establishment from the acquiring firm shares the same 4-digit industry as the acquired establishment. Finally, these marginal effects are economically meaningful. The average probability that an acquired establishment in our sample sells to a particular zip code is 4.0 percent. Furthermore, the acquired plant *i* is more likely to ship to the zip codes that it used to sell to, and to the zip codes that other plants in the acquired firm were selling to.

We also estimate these logit regressions with different subsets of the sample of acquired establishments. In

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establishment that opens a new establishment elsewhere will have its firm identifier change, again without any change in ownership.

[40] An example will help explain how the algorithm works. Consider a two-establishment firm with establishment identifiers I_1 and I_2, and firm identifier F in year *t*, and firm identifier G in year *t*+1. If there are no other establishments in year *t*+1 that have firm identifier G, then the algorithm would not identify a change of ownership. On the other hand, if there exists some establishment, I_3 that had firm identifier G in year *t*, our algorithm would identify I_3 as the sole establishment in the acquiring firm; I_1 and I_2 would then be classified as members of the acquired firm. Using a different method, Nguyen (1998) constructs a sample of acquired establishments, called the Ownership Change Database. As a robustness check, we re-create Tables A5 and A6 using the Ownership Change Database. The results are presented in the final columns of Tables A6 and A7.

Table A6, we re-estimate the probability than a plant manufacturers a given 7-digit product. Again, we cut the data according to the year of the acquisition (column 1 versus column 2). We also run the logit regression separately for plants that were in multi-unit firms and single-unit firms (column 3 versus column 4). Finally, we use a dataset—the Ownership Change Database constructed by Sang V. Nguyen of the Census Bureau, as the source of acquired establishments. Coefficient estimates are similar across the different subsamples. In particular, in each specification, the probability that plant i manufactures a particular 7-digit product is at least 5.5 percent larger when the acquiring firm had a plant that, in year *t*-5, produced that same product.

Table A7 presents robustness checks related to the estimation of the probability that an acquired establishment ships to a particular zip code. In the first two columns, we show that the estimated effects are similar for plants that merge earlier or later on. In the third and fourth columns, we show that the estimated effects are similar for establishments that were, in 1992, part of a multi-unit or a single-unit firm.[41] In the fifth column, we estimate the probability of shipping to a particular zip code for plants in the wholesale, instead of the manufacturing, sector. For wholesalers, the coefficient on the indicator that another establishment in the same 2- (or 4-) digit SIC sells to *z* in 1993 is statistically indistinguishable from 0. Finally, in the sixth column, there is no substantial difference in the estimated effects from using the Ownership Change Database to define the set of acquired establishments.

[41] Since, in the fourth column, the sample includes only establishments that are in single-unit firms in 1992, the I(in 1993, another establishment, from the acquired firm, shipped to z) indicator is 0 for all plants. Thus, this variable is excluded from the list of independent variables.

Table A1. Plant-Level Shares of Internal Shipments: Additional Robustness Checks

	Percentile							
Specification/Sample	25th	50th	75th	90th	95th	Frac. = 0	Frac. = 1	Approx. Plant-years
1. 10% cutoff definition for VI	0.0%	0.0%	4.4%	28.7%	58.8%	55.1%	0.8%	43,000
2. 15% cutoff definition for VI	0.0%	0.0%	4.3%	27.3%	55.3%	55.0%	0.7%	34,000
3. 20% cutoff definition for VI	0.0%	0.0%	4.5%	28.2%	55.1%	55.1%	0.7%	27,000
4. Interplant transfers	0.0%	0.0%	0.0%	0.0%	0.0%	97.8%	0.1%	766,000
5. Interplant transfers, plants surveyed in CFS	0.0%	0.0%	0.0%	13.2%	51.1%	76.6%	1.1%	37,000
6. Plants that are in the CMF	0.0%	0.0%	6.2%	33.7%	64.5%	50.9%	1.1%	37,000
7. Plants that are in the CFM, shipments to manufacturers	0.0%	0.0%	0.3%	11.7%	33.5%	71.1%	1.1%	37,000
8. Don’t require the sending and receiving establishments to be part of a vertical link	0.0%	3.0%	19.4%	59.2%	84.8%	29.1%	2.1%	68,000
9. Original method for defining vertical links	0.0%	0.0%	1.0%	17.4%	44.5%	67.5%	0.8%	30,000
10. Original method for defining vertical links & Don’t require the sending and receiving establishments to be part of a vertical link.	0.0%	2.5%	18.9%	57.7%	84.0%	33.7%	2.1%	30,000

Notes: Each row shows for a different subsample the distributions of the shares (by dollar value) of upstream integrated establishments’ shipments that are internal to the firm. The criteria for inclusion in and size of each subsample is discussed in the text. For data confidentiality reasons, the reported percentiles are averages of immediately surrounding percentiles; e.g., the median = 0.5*(49th percentile + 51st percentile).

Table A2. Relative Material Use Intensity Ranks between Plants in Vertical Ownership Structures and Other Plants

		Material's intensity rank in non-vertically linked plants				
		1	2	3	4	5
Material's intensity rank in vertically linked 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%

Notes: This table shows, for a sample of 9545 industry-material-year cells, the ranks of materials intensity use (by share of materials purchases) for the five most intensively used materials in plants we define as not in vertical ownership structures. The entries in the table correspond to the fraction of cells where vertical and non-vertical plants in the same industry share a particular pair of materials intensity rankings. For example, across all industry-years in the sample, the most intensively used (rank 1) material by non-vertical plants in an industry-year is the most intensively used material by the industry-year's vertical plants 50.5 percent of the time. Non-vertical plants' rank 1 material is vertical plants' second most intensively used material 14.7 percent of the time, and so on.

Table A3. Plant-Level Shares of Internal Shipments, by Industry

	Using Commodity Flow Survey Data			Using Census of Manufacturers Data		
Industry	Fraction of plants w/ share > 0	Mean share	Mean share, cond. on share > 0	Fraction of plants w/ share > 0	Mean share	Mean share, cond. on share > 0
12, Coal Mining	26.0%	10.6%	40.8%			
14, Stone	27.7%	6.6%	23.7%			
20, Food	52.4%	11.0%	20.9%	3.7%	3.5%	13.9%
22, Fabric	50.5%	17.4%	34.4%	8.3%	20.5%	53.1%
23, Apparel	32.9%	6.6%	19.9%	0.8%	4.3%	46.4%
24, Wood	31.1%	6.1%	19.5%	1.4%	4.7%	27.3%
25, Furniture	16.1%	1.6%	10.2%	0.9%	0.9%	10.1%
26, Paper	40.4%	5.6%	13.9%	11.1%	10.0%	25.1%
27, Printing	21.6%	2.4%	11.2%	0.3%	0.6%	16.7%
28, Chemicals	49.2%	8.3%	16.9%	6.4%	7.5%	19.4%
29, Petroleum	76.8%	28.8%	37.5%	8.8%	3.0%	6.8%
30, Plastics	28.0%	4.4%	15.8%	4.0%	3.4%	18.0%
31, Leather	38.0%	11.2%	29.6%	1.3%	3.7%	31.3%
32, Glass, Stone	38.5%	6.1%	15.9%	1.5%	4.0%	25.0%
33, Primary Metals	48.9%	8.4%	17.2%	7.6%	11.0%	26.1%
34, Fabr.Metals	26.7%	5.4%	20.3%	2.1%	6.1%	34.2%
35, Ind. Machinery	40.8%	4.8%	11.9%	1.3%	4.4%	18.8%
36, Elc. Equipment	46.4%	7.1%	15.3%	3.5%	6.5%	26.3%
37, Trans. Equip.	65.6%	11.2%	17.2%	4.5%	9.4%	28.6%
38, Instruments	43.8%	6.7%	15.4%	2.2%	3.3%	11.4%
39, Miscellaneous	11.9%	2.2%	18.4%	0.5%	1.1%	13.3%
501, Vehicles	52.7%	6.7%	12.7%			
502, Furniture	17.5%	2.2%	12.5%			
503, Lumber	17.9%	1.5%	8.4%			
504, Prof. Equip.	31.4%	5.1%	16.1%			
505, Metals	24.3%	2.0%	8.4%			
506, Electrical	34.4%	3.5%	10.0%			

507, Hardware	25.3%	2.8%	10.9%
508, Machinery	29.1%	2.9%	10.0%
509, Miscellaneous	8.7%	1.1%	13.1%
511, Paper	34.8%	2.5%	7.2%
512, Drugs	26.5%	1.3%	5.0%
513, Apparel	27.6%	3.5%	12.8%
514, Groceries	32.3%	6.8%	21.0%
516, Chemicals	33.1%	12.6%	38.0%
517, Petroleum	20.4%	1.8%	8.8%
518, Beer & Wine	52.9%	17.2%	32.5%
519, Miscellaneous	11.1%	1.2%	11.0%

Note: Each row shows, for a different SIC industry, the fraction of plants that have positive internal shipments, as well as the average share of internal shipments. Industries in the mining and manufacturing sectors are averaged over 2-digit industries. Industries in the wholesale sector are averaged over 3-digit industries.

Table A4. Logit Regression: Probability Plant *i* Produces a Given 7-digit Product in Year *t*

I(estab. produced 6-digit product in t-5)	1.215* (0.037) 0.086	0.921* (0.038) 0.052	1.058* (0.039) 0.063
I(estab. produced 7-digit product in t-5)	2.366* (0.036) 0.422	2.189* (0.037) 0.400	2.189* (0.037) 0.399
I(in t-5, another estab. from the acquired firm produced the 6-digit product)		0.321* (0.059) 0.018	0.321* (0.059) 0.018
I(in t-5, an estab. from the acquiring firm produced the 6-digit product)		0.113* (0.054) 0.006	0.113* (0.054) 0.006
I(in t-5, another estab. from the acquired firm produced the 7-digit product)			0.608* (0.054) 0.052
I(in t-5, an estab. from the acquiring firm produced the 7-digit product)			0.702* (0.051) 0.053
Approx. N	140,000	140,000	140,000
Approx. number of establishment-by-4-digit industry groups	7,600	7,600	7,600
Pseudo R^2	0.353	0.363	0.368
Average probability that i produces the 7-digit good in year t	13.1%	13.1%	13.1%

Notes: Each column gives the results from a separate logit regression. The dependent variable equals 1 provided plant *i* produces 7-digit product, *p*, in year *t*. The sample includes all *i*-*p* pairs for which a) *i* was purchased between *t*-5 and *t*-1, and b) product *p* was produced at least such acquired plant in year *t*. Controls for total sales in year *t* of the 7-digit product (minus sales of the product by plant *i*) are included, but not reported. $t \in \{1987, 1992\}$. All regressions include establishment-by-4-digit-product fixed effects. An asterisk denotes significance at a five percent level.

Table A5. Logit Regression: Probability that Plant *i* Ships to Zip Code *z* in 1997

I(estab. i sold to zip code z in 1993)	2.357* (0.017) 0.178	2.226* (0.018) 0.156	2.215* (0.018) 0.154	2.212* (0.018) 0.153	2.176* (0.039) 0.155	2.223* (0.020) 0.153
I(in 1997, a estab. from the merged firm has a physical location in z)	1.141* (0.030) 0.047	0.988* (0.031) 0.0377	0.986* (0.031) 0.037	0.982* (0.031) 0.037	1.292* (0.050) 0.059	0.794* (0.039) 0.027
ln(distance)	-0.127* (0.017) -0.003	-0.114* (0.017) -0.003	-0.112* (0.017) -0.003	-0.112* (0.017) -0.003	0.007 (0.037) 0.000	-0.152* (0.019) -0.003
I(there is a plant in the downstream zip code in z)	1.141 (0.030) 0.047	0.987 (0.031) 0.037	0.986 (0.031) 0.037	0.982 (0.031) 0.037	1.292 (0.050) 0.059	0.794 (0.039) 0.027
I(in 1993, another estab. from the acquired firm shipped to z)		1.1299* (0.024) 0.046	0.802* (0.044) 0.027	0.801* (0.044) 0.027	0.587* (0.090) 0.019	0.872* (0.051) 0.03
I(in 1993, an estab. from the acquiring firm shipped to z)		0.638* (0.017) 0.02	0.435* (0.022) 0.012	0.432* (0.022) 0.012	0.480* (0.045) 0.014	0.417* (0.025) 0.011
I(in 1993, another estab. in the same 2-digit SIC, from the acquired firm shipped to z)			0.454* (0.051) 0.027	0.155* (0.068) 0.008	0.298* (0.126) 0.014	0.114 (0.082) 0.006
I(in 1993, an estab. in the same 2-digit SIC, from the acquiring firm shipped to z)			0.420* (0.029) 0.017	0.187* (0.034) 0.007	0.186* (0.064) 0.007	0.182* (0.041) 0.007
I(in 1993, another estab. in the same 4-digit SIC, from the acquired firm shipped to z)				0.406* (0.061) 0.027	0.422* (0.109 0.028	0.401* (0.074) 0.027
I(in 1993, an estab. in the same 4-digit SIC, from the acquiring firm shipped to z)				0.526* (0.040) 0.027	0.659* (0.071) 0.039	0.454* (0.049) 0.022
Include establishments with (or without) internal shipments?	Both	Both	Both	Both	Internal Share>0	Internal Share=0
Approx. N	1.45 million	1.45 million	1.45 million	1.45 million	0.31 million	1.14 million
Number of establishment-by-destination counties	46,500	46,500	46,500	46,500	10,500	36,000
Pseudo R^2	0.178	0.189	0.190	0.191	0.203	0.188
Average probability that i ships to z in 1997	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%

Each column gives the results from a separate logit regression. The dependent variable equals 1 provided plant i ships to zip code z in 1997. The sample includes all i-z pairs for which i was purchased between 1992 and 1996, and z was a destination zip code for at least one such acquired plant in 1997. Controls for total sales in zip code z (minus sales from plant i) are included, but not reported. All regressions include establishment-destination county fixed effects. An asterisk denotes significance at a five percent level.

Table A6. Logit Regression: Probability Plant *i* Produces a Given 7-digit Product in Year *t*; Robustness Checks

I(estab. produced 6-digit product in t-5)	1.086* (0.051) 0.070	1.022* (0.061) 0.060	1.066* (0.042) 0.064	1.009* (0.103) 0.064	1.046* (0.034) 0.057
I(estab. produced 7-digit product in t-5)	2.093* (0.049) 0.391	2.326* (0.058) 0.427	2.181* (0.040) 0.399	2.241* (0.101) 0.418	2.379* (0.032) 0.427
I(in t-5, another estab. from the acquired firm produced the 6-digit product)	0.306* (0.074) 0.018	0.336* (0.097) 0.019	0.317* (0.059) 0.018		0.343* (0.051) 0.018
I(in t-5, an estab. from the acquiring firm produced the 6-digit product)	-0.054 (0.072) -0.003	0.343* (0.083) 0.020	0.090 (0.058) 0.005	0.224 (0.142) 0.013	0.065 (0.058) 0.003
I(in t-5, another estab. from the acquired firm produced the 7-digit product)	0.599* (0.069) 0.053	0.631* (0.087) 0.056	0.612* (0.055) 0.052		0.644* (0.047) 0.052
I(in t-5, an estab. from the acquiring firm produced the 7-digit product)	0.752* (0.068) 0.054	0.651* (0.077) 0.056	0.675* (0.055) 0.050	0.879* (0.139) 0.073	0.787* (0.055) 0.055
Year of merger	t-5 to t-3	t-2 to t-1	t-5 to t-1	t-5 to t-1	t-5 to t-1
Multi-unit/single unit in t-5?	Either	Either	Multi	Single	Either
Use Ownership Change Database to define mergers?	No	No	No	No	Yes
Approx. N	83,000	57,000	119,000	21,000	215,000
Approx. number of establishment-by-4-digit-industry groups	4,700	2,900	6,600	1,000	10,600
Pseudo R^2	0.353	0.391	0.375	0.322	0.385
Average probability that i produces the 7-digit good in t	13.2%	13.0%	13.3%	11.8%	11.8%

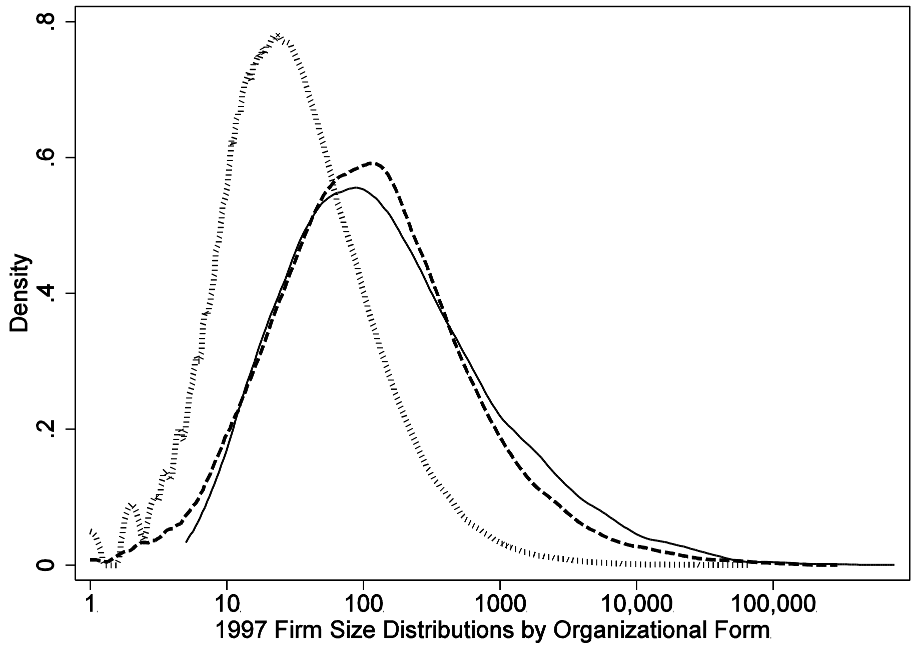
Notes: Each column gives the results from a separate logit regression. The dependent variable equals 1 provided plant i produces 7-digit product, p, in year t. The sample includes all i-p pairs for which a) i was purchased between t-5 and t-1, and b) product p was produced at least such acquired plant in year t. Controls for total sales in year t of the 7-digit product (minus sales of the product by plant i) are included, but not reported. See text for details. t $\in$ {1987, 1992}. All regressions include establishment-4-digit product fixed effects. An asterisk denotes significance at a five percent level.

Table A7. Logit Regressions: Probability Plant *i* Ships to Zip Code *z* in 1997. Robustness Checks

I(Estab. *i* sold to zip code *z* in 1993)	2.184* (0.023) 0.155	2.249* (0.027) 0.152	2.201* (0.019) 0.151	2.304* (0.057) 0.146	1.489* (0.027) 0.132	2.263* (0.015) 0.174
I(in 1997, an estab. from the merged firm has a physical location in z)	0.547* (0.005) 0.013	0.526* (0.006) 0.012	1.003* (0.031) 0.038	0.600* (0.142) 0.016	1.192* (0.055) 0.095	0.991* (0.030) 0.041
ln(distance)	-0.100* (0.022) -0.002	-0.126* (0.026) -0.003	-0.100* (0.018) -0.002	-0.228* (0.052) -0.004	-0.104* (0.021) -0.005	-0.096* (0.015) -0.002
I(in 1993, another estab. from the acquired firm shipped to z)	0.842* (0.058) 0.030	0.746* (0.068) 0.024	0.805* (0.044) 0.027		0.777* (0.124) 0.051	0.558* (0.037) 0.018
I(in 1993, an estab. from the acquiring firm shipped to z)	0.458* (0.030) 0.013	0.406* (0.032) 0.011	0.434* (0.022) 0.012	0.408* (0.085) 0.010	0.595* (0.046) 0.036	0.462* (0.024) 0.014
I(in 1993, another estab. in the same 2-digit SIC, from the acquired firm shipped to z)	0.080 (0.090) 0.004	0.262* (0.105) 0.013	0.161* (0.068) 0.008		0.187 (0.206) 0.018	0.384* (0.052) 0.019
I(in 1993, an estab. in the same 2-digit SIC, from the acquiring firm shipped to z)	0.162* (0.046) 0.006	0.217* (0.051) 0.008	0.187* (0.036) 0.007	0.184 (0.129) 0.005	-0.025 (0.092) -0.002	0.158* (0.038) 0.007
I(in 1993, another estab. in the same 4-digit SIC, from the acquired firm shipped to z)	0.538* (0.080) 0.038	0.216* (0.094) 0.013	0.402* (0.061) 0.027		0.015 (0.173) 0.002	0.450* (0.047) 0.033
I(in 1993, an estab. in the same 4-digit SIC, from the acquiring firm shipped to z)	0.637* (0.053) 0.036	0.381* (0.062) 0.017	0.513* (0.042) 0.026	0.642* (0.133) 0.030	-0.013 (0.121) -0.001	0.552* (0.045) 0.032
Year of merger	92-94	95-96	92-96	92-96	92-96	92-96
Multi-unit/single unit in 1992?	Either	Either	Multi	Single	Either	Either
Manufacturing/wholesale?	Manuf.	Manuf.	Manuf.	Manuf.	Whole.	Manuf.
Use Ownership Change Database to define mergers?	No	No	No	No	No	Yes
Approx. N	869,000	589,000	1.31m	147,000	255,000	1.98m
Approx. number of establishment-by-destination counties	28,000	18,000	42,000	4,700	11,000	65,000
Pseudo R^2	0.192	0.190	0.193	0.179	0.138	0.183
Average probability that i ships to z in 1997	4.0%	4.0%	4.0%	4.0%	7.8%	4.1%

Notes: Each column gives the results from a separate logit regression. The dependent variable equals 1 provided plant *i* ships to zip code *z* in 1997. The sample includes all *i*-*z* pairs for which *i* was purchased between 1992 and 1996, and *z* was a destination zip code for at least one such acquired plant in 1997. Controls for total sales in zip code *z* (minus sales from plant *i*) are included but not reported. All regressions include establishment-destination-county fixed effects. An asterisk denotes significance at a five percent level.

Figure A1. Firm Size Distributions by Organizational Structure



Notes: This figure shows density plots of the firm size distributions (measured by logged total employees) for the three types of multi-establishment firms: single-industry, multi-establishment firms (thick, dashed line); multi-industry, non-VI firms (thin, dashed line); and VI firms (thin, solid line). See text for details.