

Do Firm Boundaries Matter?*

Sendhil Mullainathan
MIT and NBER

David Scharfstein
MIT and NBER

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1. Introduction

In his famous article, "The Nature of the Firm," Ronald Coase (1937) raised two fundamental questions that have spawned a large body of research: Do firm boundaries affect the allocation of resources? And, what determines where firm boundaries are drawn? While the first of these questions has received some theoretical attention --- notably Oliver Williamson (1975, 1985), Benjamin Klein, Robert Crawford, and Armen Alchian (1978) and Sanford Grossman and Oliver Hart, (1986) --- it has largely been ignored empirically. Instead, the empirical work in this area, discussed in the other articles in this session, has addressed the second question by analyzing the determinants of vertical integration. Thus, while we know something about the forces that determine firm boundaries, we know relatively little about how these boundaries affect actual firm behavior. This is a major limitation in our understanding of the nature of the firm.

To begin to assess how firm boundaries affect behavior, we analyze whether there are differences between integrated and non-integrated chemical manufacturers in their investments in production capacity. We focus on the producers of the vinyl chloride monomer (VCM), the sole use of which is in the production of the widely used waterproof plastic, polyvinyl chloride (PVC). VCM is a homogenous commodity and is traded in relatively liquid markets. Moreover, there is no obvious production link between VCM and PVC other than that one is an input into the other. For example, unlike some chemicals, PVC is not a by-product of VCM, but rather requires a separate production process. Nevertheless, two thirds of VCM producers in our sample are integrated downstream into PVC. The existing literature would ask why we observe this degree of integration --- and might well come up short given the focus of that literature

on incomplete contracts, lock-in, opportunistic behavior, and relationship-specific investments, none of which appear to be important in this setting. We ask instead whether integrated VCM producers invest production capacity in a different fashion than non-integrated producers, taking as given their organizational forms.

In particular, we ask the following questions: Are integrated VCM producers more or less prone than non-integrated producers to add capacity as PVC producers increase their consumption of VCM? Are integrated producers more or less prone to hold capacity during periods when industry capacity is relatively abundant? Do the answers to these questions depend on the degree to which VCM producers are integrated downstream?

We find that the capacity of integrated producers does not move in line with VCM consumption whereas the capacity of non-integrated producers is very closely related to VCM consumption. Moreover, integrated producers tend to hold more capacity when other firms in the industry also have a lot of capacity. The capacity of integrated producers is related mainly to the internal demand for VCM from its own downstream PVC units. Finally, integrated firms that supply downstream units as well as sell units outside the firm act like hybrids of the two types of firms; their capacity moves in line with VCM consumption, but not as closely as fully non-integrated VCM producers.

These empirical findings suggest that integrated firms hold capacity to meet the input needs of their downstream PVC production units and that they largely ignore changes in the demand for their product from other PVC producers. It also suggests a potential inefficient allocation of resources in that integrated firms seem to hold capacity when it is least needed. We leave a discussion as to why we observe these findings to

Section 4. In the next section, we describe our data and in Section 3 we present the empirical findings.

2. Data

Our analysis is based on a global dataset of VCM and PVC manufacturers provided to us by SRI, Inc., a consulting firm based in Menlo Park, CA. The dataset contains detailed plant-level information on VCM and PVC production capacities from 1974 to 1998 in 61 countries. It also includes country-level information on production and consumption of VCM and PVC, but no information on prices and plant-level production.

Our analysis is conducted at the firm level. Thus, we construct firm-level production capacities of VCM and PVC by aggregating across plant-level observations. We restrict our analysis to firms operating in consistently market-based economies with a minimum level of GDP. This leaves us with 1257 observations in 17 countries.

Table 1 provides summary information on the firms in our sample. Mean firm VCM capacity is 280.15 units. The average firm accounts for 13.2% of country VCM capacity which has a mean of 2115.72 units. Two thirds of the observations are accounted for by integrated firms.¹ These firms differ themselves in the nature of their integration. Some firms have more VCM production capacity than they can consume internally with their PVC capacity; we label these firms merchant VCM producers because they likely sell their output in the VCM market in addition to supplying their downstream plants. Other firms have less VCM capacity than they need for downstream

PVC production. Because these firms likely only supply to downstream PVC plants that they own, we label them captive producers.

To measure whether VCM producers are merchant or captive, we calculate the internal demand ratio --- the ratio of a firm's demand for VCM from its own PVC plants to the upstream supply of VCM (assuming both types of plants operate at full capacity). This calculation uses information on the units of VCM required to produce one unit of PVC.² The internal demand ratio is zero for non-integrated VCM producers; positive but less than one for "merchant" VCM producers; and greater than one for captive producers. Table 1 indicates that the average internal demand ratio is 1.10. 58.3% of integrated firms are merchant producers and 41.7% are captive producers by our definitions.

2. Analysis

A. Integration and the Sensitivity of Capacity to Consumption

We begin by examining the sensitivity of VCM capacity to downstream industry consumption of VCM. To do this, we estimate the following simple equation:

$$(1) \quad \log(\text{Capacity}_{it}) = a_i + b_t + c * \text{Consumption}_{it}$$

The dependent variable in this equation is the log of VCM capacity of firm i in year t .

The key explanatory variable, Consumption_{it} is log consumption of VCM by PVC producers in the country where the firm is located.³ Because the regression also includes

¹ Note that firms that we consider non-integrated for the purposes of this analysis may, in fact, be integrated further upstream from ethyl dichloride into VCM. Our focus, however, is on the VCM-PVC integration link.

² Private communication with SRI, Inc.

³ The consumption measure is defined at the country-year level, whereas the dependent variable (capacity) is defined at the firm-year level. One, therefore, naturally worries that the standard errors may be understated. To deal with this problem, we have allowed for firm-year random effects (clustering) in all the regressions. It is also worth noting that in this equation we will be focusing on capacity changes and

firm fixed effects (a_i), the coefficient c measures the extent to which firm changes in capacity correspond to changes in consumption. We expect c to be positive, that firms will increase capacity in line with consumption.

We are interested, of course, in how these sensitivities differ for integrated and non-integrated firms. Consequently, we will estimate this equation separately for these two groups. Comparing the resulting sensitivities will then tell us whether integrated firms are more or less sensitive to downstream consumption in their investment decisions.

The first column in Table (2) shows us that non-integrated firms are extremely sensitive to consumption. The coefficient of 0.9766 implies roughly an elasticity of 1: a one percent increase in consumption corresponds roughly to a 1 percent increase in capacity for non-integrated firms. The second column shows, in contrast, that integrated firms are completely insensitive to consumption. Not only is the estimated sensitivity statistically insignificant, the magnitude is extremely small (0.03). These results suggest that integrated firm capacity does not move in step with the market.

These regressions compare integrated to non-integrated firms. But, as noted earlier, among integrated firms, it is interesting to compare merchant and captive producers. Column (3) shows the regression for merchant firms. The coefficient of 0.2052 is significantly smaller than that of stand-alones, but it is marginally significant. This suggests that merchant firms move less in tandem with markets than stand-alones. But they are less out of step than captive firms are. In column (4) we see that these firms show a coefficient of $-.1601$, which is both the wrong sign and statistically insignificant.

abstracting from changes in capacity utilization. Ideally, we would like to look at both but lacking firm level data on utilization we can only examine one of the two dimensions for adjustment.

As a whole, these results suggest that merchant firms lie somewhere between stand-alone and captive firms in their sensitivity to market conditions.

B. Do Integrated Firms Hold Capacity at the Right Times?

While these results tell us that captive firms are less sensitive to outside conditions, they do not tell us whether this reduced sensitivity is good or bad. For example, suppose that industries are stuck in hog cycles, in which firms are overly sensitive to demand shocks, investing too much during good times. In that case, the lower sensitivities by integrated firms would actually be a good thing. To assess this, we now ask how sensitive integrated firms are to industry capacity as well as to consumption. We estimate:

$$\log(\text{Capacity})_{it} = a_i + b_t + c * \text{Consumption}_{it} + d * \text{VCMCapacity}_{it}$$

In this equation, VCMCapacity_{it} denotes the total VCM capacity in the country of firm i at time t (excluding the firm's own capacity). The coefficient d tells us how sensitive the firm is to the capacity of competitors, *holding constant consumption*. We would expect $d < 0$; that is when capacity is higher, for the same level of consumption, the firm should be less interested in investing.

Column (1) of Table 3 estimates this equation for non-integrated firms. We see as before that non-integrated firms are comove with consumption (.9131). But, we also see that they are extremely sensitive to industry capacity; they are less likely to increase capacity when industry capacity is high (-.1837). For the same level of consumption, a 1 percent increase in industry capacity reduces non-integrated firm's capacity by roughly.18%. In column (2), we see that integrated firms behave quite differently. As

before, they are quite insensitive to consumption (.0738), but they are also quite insensitive to industry capacity. The coefficient on industry capacity is statistically significant but less than a third the magnitude. In other words, it is not as if integrated firms are better “timing” the market and simply holding the capacity at the right time.

Columns (3) and (4) again separately analyze merchant and captive firms.

Column (3) shows as before that merchant firms are in fact sensitive to consumption (.3008), though less than stand alones. It also shows that they are negatively sensitive to industry capacity, though the coefficient is not statistically significant. In column (4), we see that captive firms not only show zero sensitivity to external demand, but also very little sensitivity to industry capacity. Their sensitivity to capacity is half that of merchant firms. As before, merchant firms are somewhere in between stand alones and captive firms.

C. Is the Capacity of Integrated Firms Sensitive to Internal Demand?

If captive firms are insensitive to external factors, are they sensitive to anything at all? One suspects that they should respond to internal demand for their product. To assess whether this is the case we now estimate, for integrated firms:

$$\log(\text{capacity})_{it} = a_i + b_t + c * \text{Consumption}_{it} + d * \text{VCMCapacity}_{it} + e * \text{InternalDemand}_{it}$$

In this equation *Internal Demand* measures log of the implied demand for VCM from the firm’s PVC capacity (assuming that the downstream PVC plants operate at full capacity).

Column (1) of Table 4 estimates this equation for merchant firms. We see that these firms appear quite sensitive to internal demand.⁴ One finds a similar pattern in

⁴ One artifact of this regression is worth noting. The addition of internal demand makes the effect of country consumption insignificant. This, however, is because downstream industry *capacity* is a better predictor of upstream capacity than downstream industry *consumption*. If we use downstream capacity instead, it remains significant.

column (2) for captive firms, though captive firms show greater sensitivity to internal demand. Thus, both merchant and captive firms in fact adjust their capacity to internal demand.

4. Conclusion

These results suggest that integrated firms do in fact behave quite differently from non-integrated ones. Their investments in production capacity appears to be more inwardly focused. When a significant fraction of the firm's output is utilized internally, investment appears to be insensitive to external demand and supply conditions. Investment, instead, seems driven by internal considerations alone. In other words, these firms appear insulated from the external market.

What might explain this insulation? These results are too preliminary to single out one answer. But two possibilities seem important to us. The first might be broadly called organizational focus. Managers in a firm that has a VCM plant whose output is essentially used for PVC production may be focusing on different markets. These managers may view themselves as primarily PVC producers and focus their energies on the PVC market. This focus on PVC may in turn result in them failing to notice a profitable opportunity in VCM production. Of course, "focus" here could be broader than simply attention at any given point of time. Because this firm has not focused in the past, they may lack the contacts or specific human capital necessary to sell to the outside VCM market.

A second possible explanation of our findings would stem from differences in the way transfer prices and market prices are set. If VCM producers sell internally at a price

below the market price --- say at average cost --- then they may not respond as strongly as non-integrated producers to changes in demand. The fact that merchant producers --- those that appear to sell internally and externally --- behave somewhat like non-integrated producers also suggests that this may be part of the explanation of our findings.

Separating out these (and possibly other) explanations is an interesting avenue of future research that will help to tell us whether firm boundaries affect the allocation of resources.

Table 1: Summary Statistics

Observations are by firm, chemical (VCM) and year. Integrattion Dummy equals 1 if the firm produces both PVC and VCM. Internal Demand Ratio is defined for integrated firms only. It is the ratio of VCM consumed to produce PVC at full capacity to total VCM capacity. Country VCM Capacity Utilization is the ratio of country VCM production to VCM Capacity.

	No. of Obs.	Mean	Std. Dev.	Min.	Max
Firm VCM Capacity (000lb)	1257	280.15	226.31	8.00	1634
Country VCM Capacity (000lb)	1257	2115.72	1719.71	8.00	7902.00
Integration Dummy (0 or 1)	1257	0.67	0.47	0	1
Internal PVC Capacity (000lb)	842	235.10	208.24	16.00	1622.00
Internal Demand Ratio	842	1.10	0.81	0.083	10.20
Country PVC Capacity (000lb)	1257	1861.40	1543.67	28.00	6.97
Country VCM Capacity Util.	1257	0.82	0.17	0.00	1.25

Table 2
Integration and Sensitivity to Downstream Demand

Observations are by firm, chemical (VCM) and year. Dependent variable is log VCM capacity. Integrated firms are those that have both VCM and PVC capacity; non-integrated firms are those that have only VCM capacity and no PVC capacity. Integrated merchant firms are integrated firms with VCM capacity that exceeds their internal demand for VCM from their PVC plants. Integrated captive firms are integrated firms with VCM capacity is less than their internal demand for VCM from their PVC plants. The regressions include firm and year fixed effects. t-statistics, which are based on robust standard errors clustered by country and year, are in parentheses.

	Non-Integrated	Integrated	Integrated/ Merchant	Integrated/ Captive
Log Country VCM Consumption	0.9766 (6.24)	0.0382 (0.35)	0.2052 (1.95)	-0.1601 (1.14)
R ²	0.9216	0.9418	0.9488	0.9663
Number of Observations	415	842	492	351

Table 3
Integration and Sensitivity to Downstream Demand

Observations are by firm, chemical (VCM) and year. Dependent variable is log VCM capacity. Integrated firms are those that have both VCM and PVC capacity; non-integrated firms are those that have only VCM capacity and no PVC capacity. Integrated merchant firms are integrated firms with VCM capacity that exceeds their internal demand for VCM from their PVC plants. Integrated captive firms are integrated firms with VCM capacity is less than their internal demand for VCM from their PVC plants. The regressions include firm and year fixed effects. t-statistics, which are based on robust standard errors clustered by country and year, are in parentheses.

	Non-Integrated	Integrated	Integrated/ Merchant	Integrated/ Captive
Log(Country VCM Consumption)	0.9131 (5.59)	0.0738 (0.65)	0.3008 (2.64)	-0.1369 (0.88)
Log(Country Capacity)	-0.1837 (3.01)	-0.0503 (2.49)	-0.0738 (1.73)	-0.0368 (0.70)
R ²	0.9241	0.9430	0.9519	0.9666
Number of Observations	415	842	492	351

Table 4
Integration and Sensitivity to Downstream Demand

Observations are by firm, chemical (VCM) and year. Dependent variable is log VCM capacity. Integrated firms are those that have both VCM and PVC capacity; non-integrated firms are those that have only VCM capacity and no PVC capacity. Integrated merchant firms are integrated firms with VCM capacity that exceeds their internal demand for VCM from their PVC plants. Integrated captive firms are integrated firms with VCM capacity is less than their internal demand for VCM from their PVC plants. The regressions include firm and year fixed effects. t-statistics, which are based on robust standard errors clustered by country and year, are in parentheses.

	Integrated/ Merchant	Integrated/ Captive
Log(Country VCM Consumption)	0.0510 (0.52)	-0.5499 (3.89)
Log(Country Capacity)	-0.0172 (0.89)	0.0279 (0.94)
Log(Internal VCM Demand)	0.4760 (4.49)	0.6808 (5.86)
R ²	0.9709	0.9763
Number of Observations	491	351