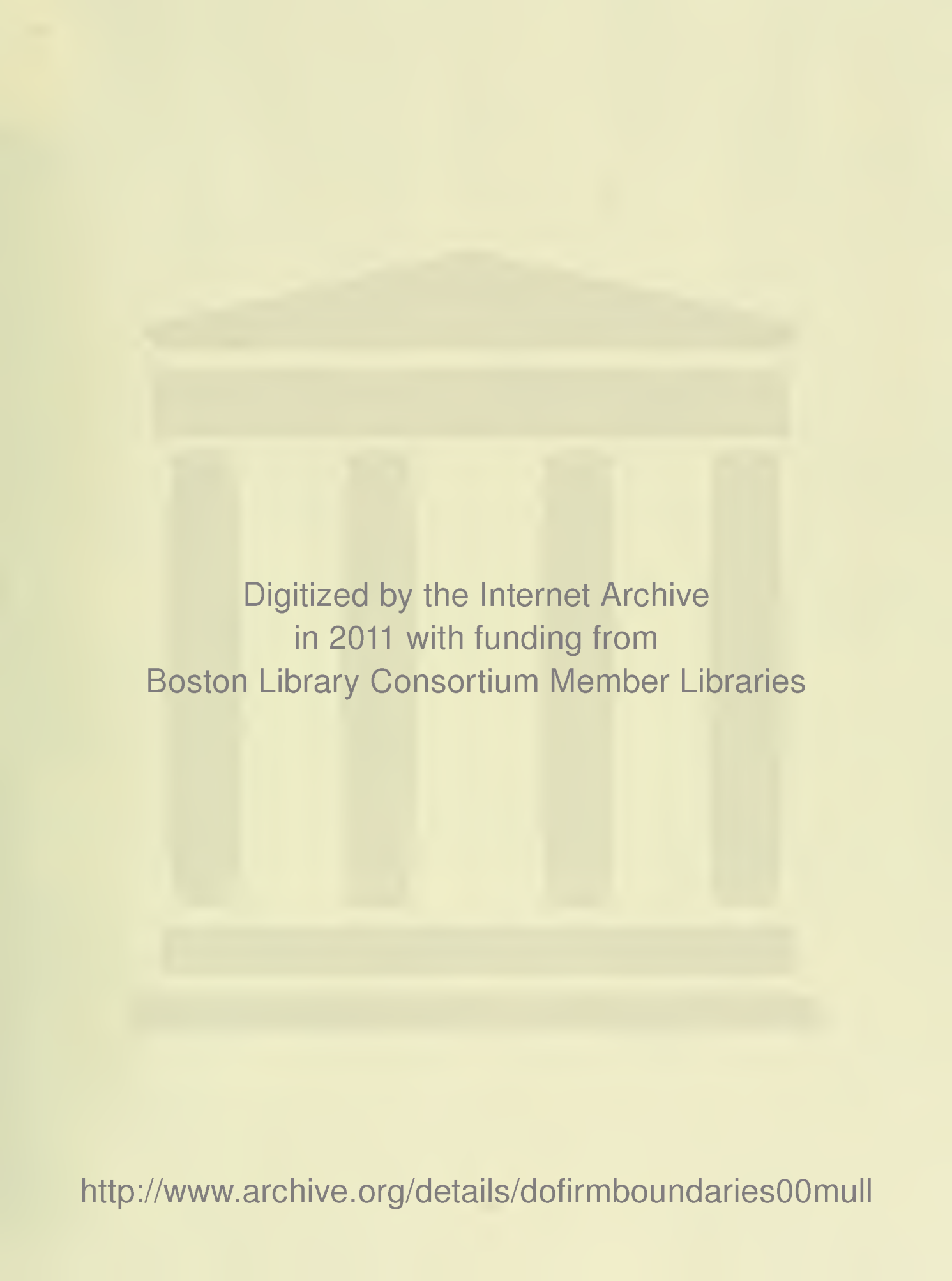

Massachusetts Institute of Technology
Department of Economics
Working Paper Series

DO FIRM BOUNDARIES MATTER?

Sendhil Mullainathan
David Scharfstein

Working Paper 01-05
January 2001

Room E52-251
50 Memorial Drive
Cambridge, MA 02142

Massachusetts Institute of Technology
Department of Economics
Working Paper Series

DO FIRM BOUNDARIES MATTER?

Sendhil Mullainathan
David Scharfstein

Working Paper 01-05
January 2001

Room E52-251
50 Memorial Drive
Cambridge, MA 02142

Do Firm Boundaries Matter?

Sendhil Mullainathan and David Scharfstein*

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 producers of 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, PVC is not a by-product of VCM production. 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. We ask instead whether integrated and non-integrated VCM producers invest differently in production capacity.

I. Data

Our analysis is based on a global dataset of VCM and PVC manufacturers provided to us by SRI Consulting, Inc., a 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. We construct firm-level production capacities of VCM and PVC by aggregating this data 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. The average firm accounts for 13.2% of country VCM capacity (280.15/2115.72). Integrated firms account for two thirds of the observations.[1] These firms differ themselves in the nature of their integration. The firms that have more VCM production capacity than they can consume internally, we label as *merchant* firms because they likely sell part of their output to the outside market. 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.

II. Analysis

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) $$log(Capacity_{it}) = a_i + b_t + c*log(Consumption_{it})$$

The dependent variable in this equation is the log of VCM capacity of firm i in year t. The key explanatory variable, $\log(Consumption_{it})$ is log consumption of VCM by PVC producers in the country where firm i is located at time t.[3] Because the regression also includes 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 the capacity of integrated firms is more or less sensitive than the capacity of non-integrated firms to downstream consumption.

The first column in Table 2 indicates that non-integrated firms are extremely sensitive to consumption. The coefficient of 0.977 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 (0.038). 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. The third column of Table 2 shows the regression coefficients for merchant firms. The coefficient of 0.205 is substantially smaller than that of the non-integrated firms, but it is borderline statistically significant. This suggests that merchant firms move less in tandem with markets than do non-integrated firms; however, they are less out of step with the market than captive firms are. The fourth column shows that the sensitivity of capacity to consumption is –0.160. which is both the opposite sign than one would expect and statistically insignificant. As a whole, these results suggest that merchant firms lie somewhere between stand-alone and captive firms in their sensitivity to market conditions.

Do Integrated Firms Hold Capacity at the Right Times?

While these results tell us that integrated firms are less sensitive than non-integrated firms 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:

(2) $$log(Capacity_{it}) = a_i + b_t + c*log(Consumption_{it}) + d*log(VCMCapacity_{it})$$

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 $d < 0$; when industry capacity is higher, for the same level of consumption, the firm has less incentive to hold capacity.

The first column of Table 3 reports the results of estimating this equation for non-integrated firms. We see, as before, that the capacity of non-integrated firms comoves closely with consumption (0.913). But, we also see that their capacity is also sensitive to industry capacity; they are less likely to increase capacity when industry capacity is high (-0.184). For the same level of consumption, a 1 percent increase in industry capacity reduces non-integrated firm's capacity by roughly 0.18%. The second column of Table 3 indicates that integrated firms behave quite differently. As before, their capacity is insensitive to consumption (0.074), but it is also quite insensitive to industry capacity. While the coefficient of industry capacity is statistically significant, it is less than one third the magnitude of the coefficient for non-integrated firms. In other words, it is not as if integrated firms are better at "timing" the market and simply holding the capacity at the right time.

The last two columns of Table 3 again separately analyze merchant and captive firms. The tird column shows, as before, that the capacity of merchant firms is in fact sensitive to consumption (0.301), though less so than the capacity of non-integrated firms. It also shows that their capacity is negatively related to industry capacity, though the coefficient is not statistically significant. In the fourth column, we see that captive firms not only show no sensitivity to consumption, 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.

Is the Capacity of Integrated Firms Sensitive to Internal Demand?

If capacity of captive firms does not comove with external market factors, with what does it move? One possibility is that they respond to internal demand for their product from their downstream PVC plants To assess whether this is the case we now estimate the following regression for integrated firms:

(2) $log(Capacity_{it}) = a_i + b_t + c*log(Consumption_{it}) + d*log(VCM\ Capacity_{it}) + e*log(InternalDemand_{it})$

In this equation $InternalDemand_{it}$ measures the implied demand for VCM from firm i's PVC capacity at time t (assuming that the downstream PVC plants operate at full capacity).

The first column of Table 4 estimates this equation for merchant firms. We see that the capacity of these firms is very sensitive to internal demand.[4] One finds a similar pattern in the second column for captive firms, though captive firms show greater sensitivity to internal demand. Thus, both merchant and captive firms in fact adjust their capacity, but only to internal demand not external demand.

III. Conclusion

Our findings suggest that there are differences in the way integrated and non-integrated firms allocate resources. The capacity of integrated VCM producers appears to be insensitive to downstream consumption, while the capacity of non-integrated producers is very sensitive to consumption. The capacity of integrated producers depends only on the internal demand for VCM from its own downstream PVC units.

These empirical findings suggest that integrated firms are inwardly focused, holding capacity for internal demand only and largely ignoring changes in external demand for their product. Our findings also suggest a potential inefficient allocation of resources in that integrated firms seem to hold capacity when it is least needed, i.e., when there is a lot of capacity relative to consumption.

What might explain this insulation from the external market? Our investigation is much 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. And, because the firm has not focused in the past, it 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 that differs from the market price --- say at average cost --- then they may not respond as strongly as non-integrated producers to changes in market demand. The fact that merchant producers --- those that appear to sell internally and externally --- behave somewhat like non-integrated producers 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.

References

Coase, Ronald, "The Nature of the Firm," *Economica,* 1937, 4, 386-405.

Grossman, Sanford, and Oliver Hart, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy,* 1986, 94, 691-719.

Klein, Benjamin, Robert Crawford, and Armen Alchian, "Vertical Integration, Approbriable Rents, and the Comeptitive Contracting Process," *Journal of Law and Economics*, 1978, 21, 297-326.

Williamson, Oliver, Markets and Hierarchies: Analysis and Antitrust Implications. New York: Free Press, 1975.

Williamson, Oliver, The Economic Institutions of Capitalism. New York: Free Press, 1985.

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	0.977 (6.24)	0.038 (0.35)	0.205 (1.95)	-0.160 (1.14)
R^2	0.922	0.942	0.949	0.966
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)	0.913	0.074	0.301	-0.137
	(5.59)	(0.65)	(2.64)	(0.88
Log(Country Capacity)	-0.184	-0.050	-0.074	-0.037
	(3.01)	(2.49)	(1.73)	(0.70)
R^2	0.924	0.943	0.952	0.967
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)	0.051	-0.545
	(0.52)	(3.89)
Log(Country Capacity)	-0.017	0.028
	(0.89)	(0.94)
Log(Internal VCM Demand)	0.476	0.681
	(4.49)	(5.86)
R^2	0.971	0.976
Number of Observations	491	351

Footnotes

*MIT and NBER; MIT and NBER. We are grateful to the National Science Foundation for research support, to Oghuzan Ozbas for exceptional research assistance, Paul Bjacek of SRI Consulting for supplying data and insights and to Jeffrey Zwiebel for helpful comments.

[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 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.

[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.

Filename:	Mullain0105
Directory:	C:\Program Files\Eudora\Attach
Template:	C:\Program Files\Microsoft Office\Templates\Normal.dot
Title:	3
Subject:	
Author:	Sendhil Mullainathan
Keywords:	
Comments:	
Creation Date:	02/13/01 2:53 PM
Change Number:	2
Last Saved On:	02/13/01 2:53 PM
Last Saved By:	linda woodbury
Total Editing Time:	0 Minutes
Last Printed On:	02/13/01 3:23 PM
As of Last Complete Printing	
Number of Pages:	13
Number of Words:	2,481 (approx.)
Number of Characters:	14,145 (approx.)