Market Structure, Internal Capital Markets, and the Boundaries of the Firm

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ABSTRACT

We study how the creation of an internal capital market (ICM) can invite strategic responses in product markets that, in turn, shape firm boundaries. ICMs provide ex post resource flexibility, but come with ex ante commitment costs. Alternatively, stand-alones possess commitment ability but lack flexibility. By creating flexibility, integration can sometimes deter a rival's entry, but commitment problems can also invite predatory capital raising. These forces drive different organizational equilibria depending on the integrator's relation to the product market. Hybrid organizational forms like strategic alliances can sometimes dominate integration by offering some of its benefits with fewer strategic costs.

THIS PAPER DEVELOPS A THEORY of the firm in which internal capital markets affect the ability to compete in product markets. In our model, a firm's decision to operate an internal capital market affects the fund-raising behavior of its product market rivals. An internal capital market can either scare away rival firms or else induce them to compete more aggressively, raising more capital than they otherwise would. In equilibrium, these strategic interactions determine the boundaries of the firm.

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There is substantial empirical evidence that internal capital markets impact firms' product market decisions. Khanna and Tice (2001) show that incumbents' responses to the entry of Walmart vary depending on the scope of their internal capital markets. Studying clinical trials in biotechnology and pharmaceuticals, Guedj and Scharfstein (2004) find that firms with multiple products in development are quicker to abandon an unpromising drug candidate. Likewise, existing theoretical work confirms that the operation of an internal capital market can create both strategic advantages and disadvantages vis-a-vis product market rivals (Matsusaka and Nanda (2002), Faure-Grimaud and Inderst (2005), and Cestone and Fumagalli (2005)).

Our analysis embeds these strategic advantages and disadvantages in a larger problem in which organizational design choices involve both product market decisions (how aggressively to compete) and capital market decisions (how much financing to raise). As a result, we go beyond prior work to show first how the strategic double-edged sword of internal capital markets affects equilibrium market structure, and second, how these tradeoffs change based on how a potential integrator is related to the industry in question. We also show how strategic alliances provide a partial solution to the problems created by integration, even if alliances do not provide all the benefits of an internal capital market.

In our economy, two projects exist in a winner-take-all Bertrand market of uncertain size. The central decision is whether one of the projects ("Project 1") should be operated as a stand-alone firm or be integrated into another firm ("HQ") that operates assets in a nearby industry. In the language of Stein (1997), this is essentially a decision of whether HQ should undertake "focused" diversification. The other project ("Project 2") operates as a stand-alone.

A stand-alone firm must finance its investments externally via traditional public or private capital markets. We assume that its initial fund-raising decision cannot be amended at a later date. For simplicity, we assume that before financial capital can be employed, it must be transformed into physical capital that is specialized to the firm. This time-to-build problem prevents stand-alone firms from raising additional capital at a later date.[1] Also, because a stand-alone firm has no other divisions with which this physical capital can be interchanged, the firm cannot reallocate its resources to a better use after market uncertainty has been resolved. (Our results, however, are qualitatively unchanged as long as the stand-alone firm cannot reallocate capital as easily as the integrated firm.) This implies that a stand-alone firm has the ability to commit to a final capital allocation ex ante.

An integrated firm, in contrast, operates an internal capital market with the flexibility to re-direct capital towards or away from the innovative project after it has learned about the market's profit potential, as in Stein (1997). Along the lines of Maksimovic and Phillips (2002), we model the firm's internal capital market decisions as though they arise from rational, profit-maximizing behavior on the part of headquarters. The flexibility of the internal capital market comes at the cost of commitment. In our model, it is common knowledge that an integrated firm will always divert resources away from an unprofitable line of business, even if it would like to commit to do otherwise. Similarly, an integrated firm may wish to commit to limit its investment in a project, but cannot. Given these fundamental differences between stand-alones and integrated firms, we study how different product market characteristics endogenously drive integration decisions.

The critical assumption for our analysis is that investment capital is specialized to the firm, not necessarily to a particular project. This reduced-form assumption can be motivated in a number of ways. Perhaps the simplest is that frictions in external asset markets—for example, information asymmetries, bargaining inefficiencies, and the like—make it cheaper to redeploy capital elsewhere in the firm than to sell to another firm. An alternative motivation is the presence of significant firm-specific human capital or organization capital (Prescott and Visscher (1980)). Regardless of the particular rationale, this assumption gives the stand-alone firm the power to commit, since it has no other use inside the firm for the capital it has raised, while it gives the integrated firm flexibility, since it can redeploy its firm-specific assets in other uses in the firm.

In our model, the integration of Project 1 into HQ can cause two strategic effects that link product markets, capital markets, and organizational design. First, the integrated firm's resource flexibility can deter the competing stand-alone firm, Project 2, from raising capital and entering the product market. This *entry deterrence* effect is similar to the classic deep pockets results discussed in, for example, Tirole (1988) and Bolton and Scharfstein (1990). The financial slack created by the internal capital market thus acts as an endogenous barrier to entry that keeps out the stand-alone. This is more likely to occur when product market uncertainty is high.

Second, integration can invite *predatory capital raising* by Project 2. That is, the stand-alone firm can prey on the integrated firm's inability to commit by raising more capital than would otherwise be profitable. The stand-alone firm increases its probability of success by raising more capital, which decreases the attractiveness of the investment to the integrated firm. In this case, the stand-alone firm effectively uses strategic focus and capital raising as a way of committing through sunk costs to compete aggressively. This is more likely when product market uncertainty is low.

As noted above, similar strategic effects have previously been shown in different contexts, but our analysis goes further to develop the equilibrium organizational design implications of these effects. We find that the net effect of entry deterrence and predatory capital raising on the initial integration decision depends on the interaction between product market uncertainty, which determines the salient strategic effect, and the potential integrator's relation to the market in question. We find that lateral integrators are happy to drive out competitors but are sensitive to predatory capital raising. Thus, in equilibrium they will tend to avoid integration when markets are less uncertain and predatory capital raising is more likely.

Vertical integrators are not as easily preyed upon but are more sensitive to the fact that their integration decisions may drive out a potential upstream supplier. In the limit, a downstream integrator with a large stake in the contested market will avoid integration when two conditions are met: market uncertainty is high enough so that integration deters entry, and the desire to have multiple potential sources of supply overpowers the flexibility value of the internal capital market.

The analysis described thus far considers only the flexibility benefit of integration. It is reasonable to think that potential synergies also provide a rationale for integration. In this broader setting, contractual mechanisms such as strategic alliances naturally arise as a mechanism for achieving these synergies without moving firm boundaries.

We model a strategic alliance between two firms as a contract that allows them to partially coordinate their activities, thereby enjoying some physical synergies of integration. At the same time, the firms remain distinct entities; in particular, some of the information problems remain that make it costlier to move assets between firms than within firms. Therefore, alliance partners are not exposed to the funding uncertainty of the internal capital market. In short, an alliance coordinates production to capture synergies but does not allow for ex post capital reallocation between the alliance partners. We show that a lateral integrator will always enter the market in some way when synergies are present, either through full integration or a strategic alliance, and we show that vertical integrators may strictly prefer alliances to standard integration, since alliances deter entry less often.

Whether integration occurs by moving firm boundaries or by contracting with alliance partners, our model shows how product market characteristics affect optimal integration decisions through fund-raising behavior in capital markets. Our model thus provides a theory of the firm that ties together financial markets, product markets, and internal capital markets.

Our model not only generates a number of novel predictions, but also sheds new light on some existing empirical puzzles concerning the differences between integrated and standalone firms. By embedding the strategic effects of internal capital markets into an equilibrium framework in which market structure is codetermined, we develop a series of predictions about when a potential integrator will choose to enter an industry, and if so, how aggressively it will compete with other firms. This naturally gives rise to predictions linking industry characteristics to firms' investment behaviors—whether they smooth investment across divisions, or instead invest more in line with industry q-ratios. Our model also offers novel predictions about industry patterns in strategic alliance activity. We explore these in detail in Section VI.

Our analysis is related to a number of distinct literatures in corporate finance, economic theory, and industrial organization. We build on the classic analysis of Grossman and Hart (1986) and Hart and Moore (1990) as well as more recent treatments such as Rajan and Zingales (1998) that hold the external operating environment of the firm fixed and consider the internal costs and benefits of various organizational design choices (see Bolton and Scharfstein (1998) or Gibbons (2006) for reviews of this literature). But our analysis is different: we instead study how external market conditions can affect the determinants of the boundaries of the firm by affecting the relative costs and benefits of one important organizational design choice, namely, the decision to operate an internal capital market.

As noted earlier, several existing theory papers explore some of the strategic implications of internal capital markets, but without developing a full equilibrium framework to study how these forces can determine optimal organizational design. Matsusaka and Nanda (2002) note that the creation of an internal capital market can make a division more vulnerable to the threat of entry, leading to possible divestiture. Both Faure-Grimaud and Inderst (2005) and Cestone and Fumagalli (2005) show more generally that internal capital markets can create both strategic benefits and strategic costs, albeit in different settings. Faure-Grimaud and Inderst (2005) study how internal capital markets affect the refinancing probability of projects vis-a-vis their operation as stand-alone firms, with a focus on agency problems between firms and outside investors. Instead, Cestone and Fumagalli (2005) focus on business groups and show that affiliation with a group can make a project more or less likely to enter (or stay in) a contested product market, can encourage or discourage predatory behavior by rivals, and can serve as a credible commitment to exert significant R&D effort.

Inderst and Muller (2003) and Berkovitch, Israel, and Tolkowsky (2000) are recent papers that derive the optimal boundaries of the firm with a focus on either internal capital markets or product markets. However, these papers do not consider how these markets interact, nor do they consider how market structure can impact integration decisions. On the other hand, Fulghieri and Sevilir (2003) derive the optimal integration decision for a research unit and downstream customer when they face the possibility of innovation by a competing pair of firms, but they do not investigate the role of internal capital markets in their setting.

In our setting, the operation of an internal capital market sometimes makes the firm a weaker competitor, inviting entry or more aggressive behavior by rivals. There is significant existing evidence that other types of financial “weakness” invite predatory behavior. For instance, Chevalier (1995) shows that supermarket firms that underwent LBOs were more likely to see subsequent entry in their markets. Lerner (1995) finds that disk drive prices were lower in segments with thinly capitalized firms, indicating possible predatory behavior by rivals. Finally, Khanna and Tice (2005) show that when Wal-Mart enters a city for the first time, it locates its stores closer to stores owned by financially weak competitors.

We also contribute more generally to the theoretical literature on the interaction between product markets and capital markets (Brander and Lewis (1986), Maksimovic and Zechner (1999), and Williams (1995)). Finally, our analysis is particularly applicable to innovative industries, and thus provides an answer for why innovation sometimes takes place within a larger established firm, and other times within a small entrepreneurial firm. This issue has been studied in different settings by Gromb and Scharfstein (2002), de Bettignies and Chemla (2007), and Amador and Landier (2003).

The remainder of the paper is organized as follows. In Section I, we lay out the basics of the model and study the benchmark case of no integration. In Section II we present the full model and analyze the various strategic effects of integration. Next, we analyze the special case of lateral integration in Section III, followed by an analysis of downstream integration in Section IV. In Section V, we study how alliances change the analysis. We discuss empirical implications in Section VI and conclude in Section VII. All proofs appear in the Appendix.

I. The Benchmark Model

Our primary unit of analysis is an economic project that operates in a given market. There are two projects in the model, 1 and 2. In the benchmark model we focus on the two projects operating as stand-alone firms.

The two firms must raise capital in order to undertake R&D on a new product. This R&D is either successful, resulting in a marketable product, or not, in which case the project has no further prospects. The payoff to having a successful project depends on whether the other project is also successful as well as the size of the downstream market, which is uncertain. The random variable $\widetilde{\pi}$ represents both the size and profit potential of the downstream market. If a project is successful alone, it is able to generate a net payoff of $\widetilde{\pi}$ by selling its product into the downstream market. If both projects are successful, they both generate a net payoff of zero. This is consistent, for example, with homogeneous Bertrand competition.

The model takes place over three periods, 0, 1, and 2. At time 0, the two firms simultaneously raise funds. This involves pledging a fraction s of the firm's expected cash flows to risk-neutral outside investors who operate in a competitive capital market.[2] Financial capital must be specialized to the firm (i.e., it must be converted into firm-specific physical capital) before it can be put to use. This means that capital raised at time 0 cannot be used for R&D until time 1, and no further capital can fruitfully be raised after time 0. Capital specialized to the firm has no alternative use, and thus is worthless outside of the project.

Between time 0 and time 1, uncertainty about the size of the product market is realized. The random variable $\widetilde{\pi}$ can take on one of two values, $\widetilde{\pi} \in \{0, \pi_H\}$, with $\Pr[\widetilde{\pi} = \pi_H] = q$. For example, it could be the case that with probability $(1-q)$ a superior technology will be invented by someone else, rendering any innovation by these two projects worthless.

At time 1, each firm can begin R&D on a new product using its specialized capital. Denote each project's capital level at the start of the R&D phase as $K_i, i = 1, 2$. Capital comes in discrete units, and its cost is normalized to \$1 per unit. For simplicity, we assume each project can have one of three levels of capital: 0, 1, or 2 units, that is, $K_i \in \{0,1,2\}$ for all i. The amount of capital in place affects the project's probability of success. Specifically, the probability of success of Project i is given by the function $\phi(K_i)$, defined as follows: $\phi(K_i) = 0$ if $K_i = 0$, $\phi(K_i) = p$ if $K_i = 1$, and $\phi(K_i) = p + \Delta p$ if $K_i = 2$. For tractability and clarity, we assume $\Delta p \leq p(1-p)$ and $p < 0.5$ throughout.

Finally, at time 2, the R&D efforts are successful or not, and final payoffs are realized. There is no discounting. Figure 1 depicts the time line of the game.

[Please see Figure 1]

We can define the optimization problem for the benchmark case as follows:

$$\max_{K_i} \quad (1-s)\phi(K_i)\left[1-\phi(K_j)\right]q\pi_H \tag{1}$$

$$\text{s/t} \quad s\phi(K_i)\left[1-\phi(K_j)\right]q\pi_H = K_i \quad \forall i,j \in \{1,2\},\ i \neq j. \tag{2}$$

Equation (2) is a break-even condition for outside investors. This expression reflects the fact that investors require an expected gross return of one in a perfectly competitive capital market. An equilibrium in this game occurs when the firms are each happy with their investment decisions given their rivals' actions, and outside investors are happy with the financial contracts they have written with each firm given firms' investment behavior.[3]

Combining equations (2) and (1) yields

$$\max_{K_i} \quad \phi(K_i)\left[1-\phi(K_j)\right]q\pi_H - K_i. \tag{3}$$

This implies that the two projects will raise money and employ capital until the next unit has a negative perceived net present value (NPV). The perceived NPV is based on beliefs about the competing project's capital level and the expected size of the market, $E\pi \equiv q\pi_H$.

Now consider Project 1's capital raising choice. If Project 1's manager believes that Project 2's capital level is $K_2 = 1$, then Project 1's manager is willing to raise \$1 and employ one unit of capital if $pE\pi(1-p) > 1$, that is, if $E\pi > \frac{1}{p(1-p)}$. They are willing to raise enough for two units if $\Delta pE\pi(1-p) > 1$, or $E\pi > \frac{1}{\Delta p(1-p)}$. We focus on pure strategy equilibria, and choose symmetric equilibria where possible. We also assume that Project 1 has the higher capital level in any asymmetric equilibrium.

To solve for the benchmark equilibrium of the capital raising game we define six critical regions for $E\pi$, as defined by the following lemma:

LEMMA 1: *Equilibrium capital levels in the benchmark stand-alone game depend on expected market size in the following manner:*

Region	Range of Expected Market Size ($E\pi = q\pi_H$)	Capital Allocation (Proj. 1, Proj. 2)
$R1$	$[0, \frac{1}{p})$	(0, 0)
$R2$	$[\frac{1}{p}, \frac{1}{p(1-p)})$	(1, 0)
$R3$	$[\frac{1}{p(1-p)}, \frac{1}{p(1-p-\Delta p)})$	(1, 1)
$R4$	$[\frac{1}{p(1-p-\Delta p)}, \frac{1}{\Delta p(1-p)})$	(1, 1)
$R5$	$[\frac{1}{\Delta p(1-p)}, \frac{1}{\Delta p(1-p-\Delta p)})$	(2, 1)
$R6$	$[\frac{1}{\Delta p(1-p-\Delta p)}, \infty)$	(2, 2)

Lemma 1 illustrates the fact that strategic interactions are most likely in medium-sized markets. For very large markets, the optimal decision is to enter no matter what. For very small markets, the expected profits are too low to warrant entry at all. But for moderate-sized markets with varying degrees of uncertainty, represented by regions R2 through R5, the market is large enough to enter but small enough that the actions of one's rivals are salient in the capital allocation decision. This parameter range is likely to capture a variety of situations in which firms face an innovative market whose ultimate profitability is a function of how heavily it is contested.

Given the structure of the benchmark model, the amount of uncertainty over market size, as measured for a given expected size $E\pi$ by the tradeoff between q and π_H, does not matter for determining the benchmark equilibrium. This will become important in the next section, when we consider the possibility of integration.

II. Integration and the Strategic Effect of Internal Capital Markets

A. Model Setup

We now consider a richer version of the model that allows for the integration of one of the two competing projects within a larger firm. For simplicity, we assume that a potential integrator, HQ, has the opportunity to make an integration decision concerning Project 1 prior to the capital raising game. HQ has operations in one or more related markets that use similar capital. Throughout the analysis we assume that integration of both projects 1 and 2 within the same firm is impossible due to antitrust or other concerns.

Since HQ operates in at least one related market, we make the key assumption that it is able to reallocate corporate resources within an internal capital market. That is, it has the ability to adjust capital allocations after observing conditions in its separate markets. Following the preceding discussion, this allocative flexibility, which the stand-alone lacks, reflects the fact that assets are specialized to a firm, not necessarily to a particular project within a firm.

To capture the impact of this flexibility on the integration decision, we assume that if HQ integrates with Project 1 it has a reallocation opportunity after the capital raising game but before the implementation of R&D. At this point it can costlessly reallocate units of capital to or from Project 1. For clarity and simplicity, we assume that HQ has a sufficient existing stock of specialized capital to fully fund Project 1 at any feasible level, and that any units of capital reallocated to or from Project 1 are zero NPV if used elsewhere in the firm.

Following the final implementation of R&D, any capital in Project 1 is worthless. In essence, the integrated firm can adjust the capital allocation for Project 1 at an intermediate stage, but is bound just as the stand-alone firm to use up the capital once its is fully committed to the R&D effort. The overall setup can be seen as a simplified version of Stein (1997), where HQ's other project is a "boring" project with unlimited zero NPV investment opportunities.

We also assume that one of HQ's divisions may operate downstream from projects 1 and 2, giving it a separate stake in the success of the R&D efforts.[4] Specifically, we assume that if there is success in the upstream market, HQ enjoys an additive benefit. The magnitude of this benefit depends on whether both projects are successful or one is successful alone. If only one project is successful, we assume that HQ receives a net incremental benefit (i.e., separate from the project's payoff $\widetilde{\pi}$) of $\alpha\widetilde{\pi}$, where $\alpha \in [0,1]$. If both projects are successful, we assume that HQ gets a benefit of $2\alpha\widetilde{\widetilde{\pi}}$. In other words, we have the payoff matrix described in Table I. Note that competition between the two projects is unchanged from the benchmark case in the absence of integration since the payoff to a stand-alone firm upon sole success is still $\widetilde{\pi}$.

[Please see Table I]

We use this reduced-form structure for its simplicity and intuitive clarity. For further motivation of the assumptions, consider the following underlying market structure. Assume that HQ and each of the other downstream firms acts as a local monopolist in a segmented market. Now assume that use of the upstream innovation would increase HQ's local monopoly profits by Δ_{HQ}, while it increases the *sum* of the monopoly profits of the other downstream firms by Δ_{Others}. The way in which the innovation increases monopoly profits does not matter – it could be a marginal or fixed cost improvement, a product quality improvement, etc. Now, if a single upstream firm is successful, assume that it Nash bargains with each downstream firm to supply the innovation. Thus, in each negotiation the surplus from the use of the innovation is split in half. If HQ and Project 1 are integrated, and Project 1 is successful alone, HQ will enjoy the entire surplus from its own market, and will happily sell the innovation (again, via

Nash bargaining) to the other downstream firms since its own profits are not affected. Finally, if both are successful, the downstream firms each capture the full surplus in their market because of competition between the projects. This market structure corresponds directly to the reduced-form specification in Table I with $\pi = \frac{1}{2}(\Delta_{HQ} + \Delta_{Others})$ and $\alpha = \frac{\Delta_{HQ}}{\Delta_{HQ}+\Delta_{Others}}$. Thus, as we vary α holding π constant, we hold the sum $\Delta_{HQ} + \Delta_{Others}$ constant while increasing Δ_{HQ}. In other words, HQ is becoming a more important part of the downstream market, the overall size of which is being held constant at a total of $\Delta_{HQ} + \Delta_{Others} = 2\pi$. For the remainder of the paper, we refer solely to the reduced-form representation.

A number of our results make use of two extreme special cases, where HQ either does not trade with the market in question, or accounts for the entire downstream market. In particular, if $\alpha = 0$ and HQ has no separate stake in the success of the two projects, we refer to HQ as a "lateral" integrator. If, on the other hand, $\alpha = 1$ and HQ's downstream division effectively accounts for *all* of the available surplus, we refer to HQ as a "single downstream" integrator.

The timing of the game exactly matches that of the benchmark model, except that HQ has an initial move in which it can make an integration decision. In addition, because it is an integrated firm, it has investment options at time 1 that a stand-alone lacks—it can divert capital towards or away from the industry in question if it is profitable to do so.

HQ first decides whether or not Project 1 should be integrated. The decision is based on the maximization of the joint bilateral payoff of HQ and Project 1. This is consistent with either of two situations. Project 1 could currently be a stand-alone firm, and if integration maximizes their joint payoff they could bargain efficiently (again, assuming no agency problems) over a merger. Alternatively, Project 1 could be an internal project that HQ considers spinning off.

[Please see Figure 2]

At time 0, after the integration decision is made, any stand-alone firms raise funds simultaneously in a competitive capital market, and HQ makes an initial (tentative) allocation of capital to Project 1.[5] Next, the value of $\widetilde{\pi}$ is revealed. At time 1, if HQ is integrated it chooses whether to reallocate any capital among its divisions, and all projects with capital initiate R&D if $\widetilde{\pi} = \pi_H$. Finally, at time 2, success or failure occurs according to the probability structure introduced in Section I, and payoffs are realized. Figure 2 illustrates the modified timeline.

B. The Strategic Effect of Internal Capital Markets

In this subsection, we analyze the modified version of the game described above. To begin, note that the game is identical to the benchmark model if HQ chooses non-integration.

If HQ chooses integration, the final decision on Project 1's capital level occurs after Project 2 has raised its funds and specialized its capital. In a sense, HQ has become a Stackelberg follower, but with superior information on market size at the time of its final decision. Project 2, as the leader in this sequential game, makes its decision knowing how its own choice will affect HQ's final decision, conditional on the final market size. Formally, following equation (3), Project 2's problem following the integration of Project 1 into HQ is as follows:

$$\max_{K_2} \quad \phi(K_2)\left[1-\phi(K_1(K_2))\right] q\pi_H - K_2. \tag{4}$$

Here, $K_1(K_2)$ denotes the fact that the integrated firm will make its capital reallocation choice in response to the observed capital raising choice of Project 2. By the same token, however, Project 2 is making its capital raising choice in response to the observed organizational design choice of HQ, which here is to integrate with Project 1.

As equation (4) illustrates, the relevant strategic impact of integration boils down to its effect on Project 2's equilibrium capital level, which in turn affects the integrated firm's final allocation. There are two important possibilities. First, integration could deter Project 2 from raising any capital when it otherwise would, which we call "entry deterrence." In this case, the integrated firm's ability to move later makes it more aggressive in expectation, scaring away Project 2. Second, integration could cause Project 2 to raise more capital than it otherwise would in order to reduce the integrated firm's final allocation, which we call "predatory capital raising." In this case, Project 2 is able to exploit its first-mover advantage to gain a competitive edge.

Whether integration invites predatory capital raising or deters entry depends critically on the degree of uncertainty relative to expected market size, as these determine both the scope and incentives for strategic behavior. For a given expected market size, $E\pi = q\pi_H$, greater uncertainty is synonymous with lower q and therefore a higher payoff conditional on the good state, π_H. Since HQ allocates capital after observing the market size, greater uncertainty means a more aggressive final capital allocation, all else equal, by HQ. This in turn reduces the profitability of capital for Project 2 (in the only state with a positive payoff, it faces a more aggressive competitor), and is therefore more likely to deter entry. With less uncertainty, HQ's aggressiveness is tempered, and there is greater opportunity for predatory capital raising.

We solve the model via backward induction, starting with HQ's final capital allocation assuming integration. If $\widetilde{\pi} = 0$, HQ clearly redeems any capital previously provided to Project 1. If $\widetilde{\pi} = \pi_H$, HQ's decision depends on π_H and Project 2's capital level, K_2.

For notational compactness, from here on we let $\phi_i \equiv \phi(K_i)$ represent the probability of success for Project i implied by K_i. Now consider the integrated firm's marginal decision for the first unit of capital. If it chooses zero units, the only chance of a positive payoff is if Project 2 is successful and the integrated firm engages in bilateral bargaining with Project 2 to source the product, implying an expected payoff for the integrated firm of $\phi_2 \alpha \pi_H$.

If the integrated firm chooses one unit, there are three possibilities where it has a positive payoff. If Project 1 is successful alone, the integrated firm enjoys the surplus generated by its internal trade as well as trade with any other downstream firms, so its payoff is $\pi_H(1+\alpha)$. If Project 2 is successful alone, the integrated firm engages in bilateral bargaining with Project 2 to source the product, resulting in a payoff of $\alpha\pi_H$. Finally, if both are successful they compete away any surplus related to trade with downstream firms other than HQ, so the integrated firm enjoys only the surplus from the trade between its internal divisions, or $2\alpha\pi_H$. Weighting these three possibilities by their probabilities given one unit of capital for the integrated firm yields an expected payoff of $p(1-\phi_2)\pi_H(1+\alpha)+(1-p)\phi_2\alpha\pi_H+2p\phi_2\alpha\pi_H$, or, simplifying, $\pi_H(p(1-\phi_2)+\alpha(p+\phi_2))$. Thus, the marginal payoff of the first unit of capital is this expected payoff minus the expected payoff with zero units derived above, or $\pi_H(p(1-\phi_2)+\alpha p)$.

Using analogous logic, it is easy to show that the marginal payoff of the second unit is $\pi_H(\Delta p(1-\phi_2)+\alpha\Delta p)$. HQ thus allocates zero units to Project 1 if $\pi_H < \frac{1}{p(1-\phi_2)+\alpha p}$, one unit if $\pi_H \in [\frac{1}{p(1-\phi_2)+\alpha p}, \frac{1}{\Delta p(1-\phi_2)+\alpha\Delta p})$, and two units if $\pi_H \geq \frac{1}{\Delta p(1-\phi_2)+\alpha\Delta p}$.

Given this analysis we can define critical regions for π_H, similar to the regions for $E\pi$ in Lemma 1, by replacing ϕ_2 in the equations above with its possible realizations. In Table II, we lay out these regions, and for comparison purposes we provide the regions previously defined for $E\pi$. It is important to note that the regions are identical if $\alpha = 0$, that is, in the lateral case.

[Please see Table II]

Backing up a step, Project 2's capital raising decision takes HQ's optimal reallocation strategy into account (note that HQ's tentative initial allocation to Project 1 has no strategic importance and can be ignored). Project 2 gets no payoff if it has zero capital, so its decision hinges on HQ's response to one or two units of capital. Replacing ϕ_2 in the above cutoff levels of π_H, we see that the scope for strategic behavior by Project 2 depends on which region in Table II that π_H falls into. Since our assumption that $\Delta p \leq p(1-p)$ implies $\Delta p(1-p) \leq p(1-p-\Delta p)$, HQ's allocation depends on Project 2's capital as described in Table III.

[Please see Table III]

If π_H is in regions $R1^{'}$, $R2^{'}$, $R4^{'}$, or $R6^{'}$, Project 2 always faces the same final capital level for Project 1 in the good state if it enters. However, in regions $R3^{'}$ and $R5^{'}$, Project 2 can affect HQ's allocation with its own choice. Also, if Project 2 enters in region $R2^{'}$, it will drive the integrated firm to zero (Project 2 can never profitably enter in region $R1^{'}$). As noted previously, whenever these possibilities induce Project 2 to take on a higher capital level under integration than in the benchmark model, we call this "predatory capital raising." Whenever integration causes it to stay out when it would otherwise enter the market, we call this "entry deterrence."

We now have all of the ingredients to determine Project 2's equilibrium capital level choice. If we let $1^{\pi_H}_{(Rj')}$ be an indicator function equalling one if π_H is in region Rj', then the net expected payoff (NPV) of Project 2 as a one-unit firm can be written as

$$E\pi\left[p1^{\pi_H}_{(R1',R2')} + p(1-p)1^{\pi_H}_{(R3',R4')} + p(1-p-\Delta p)1^{\pi_H}_{(R5',R6')}\right] - 1. \tag{5}$$

Its expected payoff as a two-unit firm can be written as

$$E\pi\left[(p+\Delta p)1^{\pi_H}_{(R1',R2',R3')} + (p+\Delta p)(1-p)1^{\pi_H}_{(R4',R5')} + (p+\Delta p)(1-p-\Delta p)1^{\pi_H}_{(R6')}\right] - 2. \tag{6}$$

The strategic effect of Project 2's capital raising decision can be seen in this equation by noting that when it increases K_2 from one to two, it faces a zero- or one-unit competitor instead of a one- or two-unit competitor at higher levels of π_H.

Project 2's capital level is determined by choosing the higher of equations (5) and (6), or choosing zero units if both are negative. The strategic effect of its allocation decision can be seen more clearly by studying the incremental net payoff of the second unit of capital, that is, equation (6) minus equation (5):

$$E\pi\left[\Delta p1^{\pi_H}_{(R1',R2')} + (\Delta p + p^2)1^{\pi_H}_{(R3')} + \Delta p(1-p)1^{\pi_H}_{(R4')} + \Delta p1^{\pi_H}_{(R5')} + \Delta p(1-p-\Delta p)1^{\pi_H}_{(R6')}\right] - 1. \tag{7}$$

Here we see that if π_H is in either $R3'$ or $R5'$, the second unit of capital has a larger marginal impact on the NPV of the project because it causes HQ to reduce its allocation to Project 1. So the scope and incentives for predatory capital raising and entry deterrence obviously depend on both the region in which $E\pi$ falls and the region in which π_H falls, that is, it depends on both expected market size and degree of uncertainty. For a given $E\pi$, a higher region for π_H implies greater uncertainty (lower q).

By definition, π_H must always fall in the same or higher region than $E\pi$. Lemma 2 gives the conditions under which integration will provoke predatory capital raising and deter entry. It shows that predatory capital raising is more likely when uncertainty is small relative to expected market size, while entry deterrence is more likely when uncertainty is large relative to expected market size.

LEMMA 2: *Integration provokes predatory capital raising if and only if one of the following three sets of conditions holds:*

1. $\pi_H \in R2'$ *and* $E\pi > \frac{1}{p}$;
2. $\pi_H \in R3'$ *and* $E\pi > max(\frac{1}{\Delta p + p^2}, \frac{2}{p+\Delta p})$;
3. $\pi_H \in R5'$ *and* $E\pi > max(\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)})$.

Integration causes entry deterrence if and only if $E\pi \in R3$, *either* $\pi_H \in R6'$ *or* $\pi_H \in R5'$, *and there is no predatory capital raising according to part (3).*

This result can be understood intuitively using the following figure, in which ex post market size conditional on high profitability, π_H, increases along the vertical axis and the ex ante probability of a profitable market, q, increases along the horizontal axis. The figure represents an actual numerical example with $p = 0.45$, $\Delta p = 0.17$, and $\alpha = 0$.

[Please see Figure 3]

In this figure, the curved lines represent iso-expected market size lines: they fix $E\pi$ but vary π_H and q. Moving along an iso-expected market size line from the top left to the bottom right represents moving from a situation of extreme uncertainty (and hence a large ex post market size for a fixed expected size) to a situation of low uncertainty (high success probability but low stakes conditional on success). The five iso-expected market size lines correspond to the borders between the regions for $E\pi$, progressing from $R1$ to $R6$ as one moves from the lower left corner to the upper right corner of the figure. Similarly, the horizontal lines represent the borders between the π_H regions, progressing from $R1'$ to $R6'$ as one moves from the bottom to the top of the figure.

Intuitively, entry deterrence, represented by the black region, is only possible when expected market size is large enough to accommodate two firms, but not so large as to make entry profitable no matter what. This is why the entry deterrence region is limited to the $E\pi \in R3$ band in regions $R5'$ and $R6'$. Here the expected market size is moderate, but the high uncertainty (low q) makes it unattractive for a competitor to enter unconditionally.

Predatory capital raising, represented by the shaded regions, is possible for a wider range of expected market sizes because it can occur both at the zero- vs. one-unit margin for HQ and the one- vs. two-unit margin. Furthermore, predatory capital raising tends to be possible only at lower uncertainty, while entry deterrence requires higher uncertainty. If the good state is very unlikely, facing a tougher competitor in that state reduces Project 2's ex ante expected payoff relatively more. Similarly, when uncertainty is low Project 2 is safer and therefore more likely to engage in predatory behavior.

For the remainder of the analysis, we assume that $\pi_H > \frac{1}{p}$ to eliminate trivial cases in which a laterally integrated firm would not enter in the absence of competition.

III. Lateral Integration

We now analyze the initial integration decision. To make the intuition as clear as possible, we look first at the special case of pure lateral integration, or $\alpha = 0$. In the next section we show the effect of increases in α and the extreme case of a single downstream firm.

Given the analysis above, it is straightforward to determine HQ's initial integration decision. It simply compares the expected payoff for Project 1 under integration versus its expected payoff in the benchmark model. The analysis provides Proposition 1, which describes when a lateral integrator optimally chooses to integrate with Project 1. It shows that the lateral firm is always happy to integrate and enjoy the benefits of flexibility when it either has no effect on Project 2 or deters its entry (a strategic benefit). However, it generally avoids integration when the inability to commit to a final capital allocation invites the competitor to predate.

PROPOSITION 1: *If lateral integration does not invite predatory capital raising, integration always occurs. If lateral integration does invite predatory capital raising, integration never occurs unless the following three conditions hold:*

- $E\pi p\Delta p < 1 - q$,
- $E\pi \in R3$ *or* $R4$,
- *and* $\pi_H \in R5'$.

The second and third bullets identify the region in which integration may occur despite predatory capital raising. The inequality in the first bullet provides the condition for integration to occur in this region. Since the right-hand side is decreasing in q, the equation shows that integration will be chosen only when uncertainty is high enough (q is low enough) for a given expected market size, $E\pi$. In other words, the only exception to HQ's unwillingness to integrate in the face of predatory capital raising occurs when expected market size is small enough relative to the degree of uncertainty that the flexibility value of the internal capital market (i.e., the value of being able to postpone the final allocation decision until uncertainty is resolved) exceeds the strategic cost of facing a more aggressive competitor. In this case, Project 1 has a single unit of capital either way, but Project 2 takes on two rather than one unit following integration to keep HQ from allocating two units in the good state.

For further intuition, consider the following figure, which is based on the same numerical example as above. The figure maps the equilibrium integration decision for different combinations of q and π_H. The shaded regions represent instances in which entry would be profitable for an integrated firm in the absence of competition, but non-integration is optimal.

[Please see Figure 4]

The regions with non-integration occur only when integration would invite predatory capital raising (compare this figure to Figure 3). Notably, the lateral firm always avoids integration when predatory capital raising would drive it out of the market completely ($\pi_H \in R2'$ or $R3'$). However, when predatory capital raising simply keeps the integrated firm down to one unit of capital ($\pi_H \in R5'$), integration sometimes occurs because the flexibility benefit outweighs the cost of a more aggressive competitor (i.e., the non-integration region with $\pi_H \in R5'$ is smaller than the corresponding predatory capital raising region in Figure 3).

IV. Vertical Integration

From Table III, an increase in HQ's downstream stake in project success, that is, an increase in α, clearly makes it more aggressive in its allocations. This effect is similar to the internalization of a double marginalization problem. The stand-alone project tends to underinvest relative to the optimum because it receives only part of the surplus. Thus, predatory capital raising tends to become more difficult for Project 2 and entry deterrence becomes more likely.

LEMMA 3: *Increasing the vertical relatedness of Project 1 and HQ decreases the scope for predatory capital raising and increases the scope for entry deterrence: an increase in α decreases the area of the parameter space in which integration causes predatory capital raising, and increases the area of the parameter space in which integration causes entry deterrence.*

Graphically, this translates into a downward compression of the horizontal lines in Figure 3, decreasing the vertical height of regions $R1'$ through $R5'$, and increasing the area covered by region $R6'$. Thus, the predatory capital raising regions would all contract, while the deterrence region would be stretched further down through the curved $E\pi \in R3$ band.

It is now possible to characterize the vertically related firm's integration decision. Vertical concerns not only change the scope for predatory capital raising and deterrence, they also change their impact on HQ's integration decision. Predatory capital raising becomes both less likely and less costly, since HQ gains some surplus even if Project 2 is successful alone. Entry deterrence, on the other hand, can become costly since HQ would like to have someone else produce the product if its internal division fails. These effects lead to Proposition 2, which characterizes the equilibrium entry decision for the downstream integrator. The result shows that both predatory capital raising and entry deterrence can forestall vertical integration. However, vertical integration can occur in the face of predation or entry deterrence if the market is sufficiently risky for its size, leading to a high flexibility benefit (the ability to move later is more valuable the higher is uncertainty). The result also shows that an increase in vertical relatedness (α) makes integration in the face of predatory capital raising more likely, while it makes integration in the face of entry deterrence less likely.

PROPOSITION 2: *If vertical integration provokes predatory capital raising, integration never occurs unless one of the following two sets of conditions holds:*

- $E\pi \in R2$, $\pi_H \in R3^{'}$, *and* $E\pi(p - \alpha\Delta p) < 1$*; or*
- $E\pi \in R3$ *or* $R4$, $\pi_H \in R5^{'}$, *and* $E\pi\Delta p(p - \alpha) < 1 - q$.

If vertical integration deters entry, integration never occurs unless

$$E\pi(\Delta p(1+\alpha) - p(\alpha - p)) < 1 - 2q.$$

Otherwise, a vertical integrator always integrates with Project 1 if integration neither invites predatory capital raising nor deters entry.

Predatory capital raising is less costly now that HQ gets a positive payoff when Project 2 is successful alone. This is reflected in the fact that the $E\pi$ condition in the first bullet point is weakly more likely to hold than the analogous cutoff for the lateral firm from Proposition 1. So integration will occur at lower levels of uncertainty. Furthermore, there is the additional possibility that the downstream firm will choose to integrate even if it will be entirely driven out of the market by predatory capital raising (the $E\pi \in R2$, $\pi_H \in R3^{'}$ case in the second bullet point). This can occur because the alternative stand-alone equilibrium has a single competitor with one unit of capital. Integrating leads Project 2 to predate with two units, which raises the overall probability of success. This can be optimal despite having to shut down Project 1 if the second unit has a large enough impact on the overall success probability (Δp is large enough) and if HQ's downstream concerns are large enough (α is large enough). Note that since q does not appear in the right-hand side of the inequality, the level of uncertainty does not matter for this decision given $E\pi$, only the relative marginal impact of the first and second unit of capital and the strength of HQ's vertical relationship matter.

On the other hand, entry deterrence makes integration less likely for the vertical firm overall due to its desire to source from Project 2 if Project 1 fails. In particular, note that the left-hand side of the last inequality in the proposition is decreasing in α. This reflects the fact that entry deterrence becomes costlier, and thus integration less likely, when entry is deterred since HQ's vertical relationship becomes stronger. However, because of the value of flexibility, represented by the right-hand side of the last inequality, integration occurs for sure when uncertainty is high enough (q is low enough) for a given expected market size.

For further clarity, consider the single downstream firm case, i.e., $\alpha = 1$. This is the most extreme case we allow, with the least scope for predatory capital raising and both the greatest scope for and greatest cost of deterrence.

In this case we have the following result.

PROPOSITION 3: *Anticipated entry deterrence thwarts integration by a single downstream firm unless* $E\pi(2\Delta p - p(1-p)) < 1 - 2q$. *If entry deterrence is not anticipated, integration always occurs.*

Here, we see that predatory capital raising is not a concern for the single downstream firm. This is because of its very high incentives to provide capital to an internal project as well as the reduced cost of predatory capital raising. However, entry deterrence is particularly costly. To understand this, consider the following figure, which is generated by the same numerical example used above, but with $\alpha = 1$. Again, the shaded region represents cases in which an integrated firm could enter in the absence of competition, but non-integration is optimal.

[Please see Figure 5]

The single downstream firm generally prefers integration, both because it is less subject to predatory capital raising and because integration provides flexibility plus a solution to double marginalization. However, when entry is deterred, non-integration is preferred for lower levels of uncertainty (the right-hand side of the inequality in Proposition 3 is decreasing in q for a given expected market size). Note that the horizontal lines demarcating the critical regions for π_H have collapsed downward so far that the predatory capital raising regions have been eliminated, while integration would cause entry deterrence over the entire $E\pi \in R3$ band.

Comparing Propositions 3 and 1, it is clear that there are cases in which a vertical firm will integrate and a lateral firm will not, and vice versa. In particular, the vertical firm always integrates when $E\pi$ is small or large, that is, in regions $R1, R2, R4, R5$, and $R6$, whereas the lateral firm sometimes does not do so for low or moderate levels of uncertainty due to predatory capital raising. On the other hand, the vertical firm's region of non-integration can clearly overlap with areas where the lateral firm would be happy to integrate. In these areas, lateral integration does not invite predatory capital raising and may or may not deter entry.

These results naturally lead to the question of what would happen if both a lateral and vertical firm were available to integrate with Project 1. To address this, we define "active competition" as a case in which both a lateral integrator (with $\alpha = 0$) and a single downstream firm (with $\alpha = 1$) are available and at least one of them would like to purchase Project 1 in isolation. We assume that they compete in a standard second-price auction to purchase Project 1 and that the downstream firm wins if both have the same willingness to pay. Intuitively, one would expect that the vertical firm should generally win such a contest since it enjoys both flexibility and a solution to double marginalization. This intuition is largely confirmed by Proposition 4.

PROPOSITION 4: *If there is active competition for control of Project 1, the single downstream firm purchases Project 1 whenever its purchase does not deter entry.*

While this result covers much of the parameter space, there are a significant number of cases in which this basic intuition is overturned. As implied by Proposition 4, this possibility hinges on cases in which the downstream firm faces the strategic cost of entry deterrence. In these cases we have Proposition 5.

PROPOSITION 5: *If integration by the single downstream firm would deter entry and the lateral firm is willing to integrate, then the lateral firm purchases Project 1 unless:*
(a) its purchase will deter entry;
(b) its purchase has no effect on Project 2's capital decision and $\pi_H(2\Delta p - p(1-p)) > 1$*; or*
(c) its purchase would invite predatory capital raising and $\pi_H(\Delta p - p(1-p-\Delta p)) > 1$.

When the downstream firm's integration would deter Project 2's entry, it will sometimes prefer to let the lateral firm integrate with Project 1 instead. In particular, it is happy to let the lateral firm buy Project 1 unless lateral integration would deter entry (part (a)) or the added benefit of eliminating double marginalization is too great (represented by the inequalities in parts (b) and (c)). Note that the inequality in part (b) is always less likely to hold than the inequality in Proposition 3, implying that the downstream firm will acquiesce to the lateral firm in some cases in which it would otherwise acquire the project and deter entry. In other words, the lateral firm can be a better integrator from the point of view of the downstream firm when lateral integration does not deter entry. Furthermore, the downstream firm is particularly happy to let the lateral firm buy Project 1 in cases in which the lateral firm is willing to purchase despite inviting predatory capital raising (part (c)). The extra effort this induces on the part of Project 2 is very attractive to the downstream firm. On the other hand, if lateral integration will deter entry, the vertical firm prefers to integrate instead and solve double marginalization (part (a)). Thus, it is possible that in some cases it will integrate in the face of competition from a lateral firm when it would otherwise prefer non-integration.

V. Strategic Alliances and Physical Synergies

Thus far our analysis only considers the flexibility benefits associated with integration. However, there are often other physical benefits associated with integration. These include knowledge spillovers along the lines of Mowery, Oxley, and Silverman (1996), the specialization of assets to one another's production process as in a more typical Grossman-Hart-Moore framework, or some form of cost reduction. In this section we consider how such physical synergies can lead to a natural role for hybrid organizational forms such as strategic alliances.

To allow a role for alliances, we assume that HQ can choose to enter into an alliance with Project 1 at the time of the organizational design choice instead of integrating. We define an alliance as a legal contract between otherwise distinct organizations that allows them to share the surplus from any physical synergy gains, but does not allow for the operation of an internal capital market. (Strategic alliances play a similar role here to that in Robinson (2006), where they provide firms with the possibility of contracting around the winner-picking that otherwise occurs in internal capital markets.) Thus, an alliance brings with it the ability to exploit the physical synergy but no flexibility benefits—both projects still raise capital simultaneously in a competitive capital market and cannot adjust their capital level later. (We assume that the same market frictions that prevent asset interchangeability between firms still exist, even if to a lesser extent, between alliance partners.) Note that this does not preclude co-financing arrangements between the stand-alone and the integrating firm á la Allen and Phillips (2000) or Mathews (2006); it simply precludes the use of internal capital markets that would arise through full integration.

The optimality of an alliance then depends on how the physical synergy is modeled. First, if the physical synergy is simply an exogenous benefit enjoyed following an alliance or full integration, then an alliance will always dominate leaving Project 1 as a stand-alone. The firms can enjoy the synergy benefit without imposing any strategic costs from operating an internal capital market. In this case, the preceding results in the paper could be recast in terms of the tradeoff between conducting an alliance versus full integration, where firms choose to form an alliance when full integration proves too strategically costly. This type of synergy could result, for example, from a knowledge spillover from Project 1 to HQ's other divisions. In particular, this implies that lateral alliances may be most likely when full integration would invite predatory capital raising. As seen in Lemma 2, these cases are most likely when expected market size is small or moderate, and uncertainty over market size is relatively low. In these situations, a potential integrator prefers forming an alliance to either full integration or remaining completely out of the industry.

On the other hand, with vertically related firms physical synergies often come in the form of specialization. This will likely increase surplus only if the affiliated project, Project 1 in our setting, is successful. Such specialization is also likely to affect the amount of surplus available if the affiliated project fails and the unaffiliated project succeeds. We formally explore the implications of this in the remainder of this section.

For simplicity and intuitive clarity, we focus on the single downstream case. In particular, we assume that if HQ forms an alliance or is fully integrated with Project 1, it can specialize the firms' assets such that the total surplus available to be shared between them following success by Project 1 is increased to $2\pi_H(1+\delta_1)$ from $2\pi_H$. Specialization has the additional effect of reducing the payoff for Project 2 in the good state following sole success to $\pi_H(1-\delta_2)$.

This setup can significantly affect the equilibrium since specialization reduces the payoff to the "outside option" of sourcing from Project 2 if Project 1 fails. It also makes entry deterrence more likely, and can deter entry even in the absence of integration. To simplify matters, we assume that specialization is always optimal *ex post*. That is, if the firms have an alliance or are integrated, they always choose to specialize at the time of the final capital allocation if they have not done so before. This basically requires that δ_2 not be too large relative to δ_1. Specifically, the condition is $2p\delta_1 > (p+\Delta p)(1-p)\delta_2$. To make the analysis tractable we also assume that $\Delta p \leq p(1-p-\Delta p)$ and $p(1-p-\Delta p)(1-\delta_2) > \Delta p(1-p)(1+\delta_1)$. We discuss the effect of relaxing the former condition following the result. The latter condition ensures that $K_1 = 1$ in the relevant range of $E\pi$ for both the stand-alone equilibrium and the alliance equilibrium. Finally, we focus on the range of $E\pi$ in which an alliance can be relevant, i.e., when full integration may deter Project 2's entry. We have the following result.

PROPOSITION 6: *A single downstream integrator's choice is as follows:*
(a) If $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{p(1-p)(1-\delta_2)})$, for every $E\pi$ there exists a critical level of uncertainty (i.e., 1-q) such that for levels of uncertainty below the critical level there is no integration and no alliance, and otherwise there is integration.
(b) If $E\pi \in [\frac{1}{p(1-p)(1-\delta_2)}, \frac{1}{p(1-p-\Delta p)(1-\delta_2)})$, there is an alliance if $E\pi(\Delta p(2(1+\delta_1) - p(1-\delta_2))) > q$ and $E\pi(2\Delta p(1+\delta_1) - p(1-p)(1-\delta_2)) > 1-2q$, and otherwise there is integration.

The intuition behind this result is as follows. For small expected market sizes an alliance by itself deters entry, so HQ trades off full integration, which also deters entry but has additional flexibility benefits, versus leaving Project 1 as a stand-alone firm (part (a) of the result). However, there is a range of intermediate market sizes such that an alliance with $K_1 = 1$ does not deter entry, but integration will if uncertainty is high enough. If Project 1 raises only one unit of capital in that range, which is true given the assumptions above, then an alliance is preferred to complete non-integration because it provides the synergy benefit without deterring entry. Thus, over this intermediate range of expected market sizes HQ chooses either an alliance or integration, where an alliance is preferred unless uncertainty is low enough that integration does not deter entry (given by the first inequality in part (b), in which the right-hand side is increasing in q), or uncertainty is high enough that the flexibility benefit outweighs entry deterrence (given by the second inequality in part (b), in which the right-hand side is decreasing in q). Note that if we relax the assumption that $\Delta p \leq p(1-p-\Delta p)$, the only change in the result would be an additional region where integration is chosen instead of an alliance in part (b) because the flexibility provided by full integration invites Project 2 to predate, and thus raises its capital level relative to the alliance case.

VI. Empirical Implications

Our model is certainly stark, but by embedding the strategic effects of internal capital markets into an equilibrium framework in which market structure is co-determined, it nevertheless provides some novel empirical predictions that are not found in prior work.

In recent work, Khanna and Tice (2001) show that diversified firms sometimes compete more aggressively, and sometimes less aggressively, than their stand-alone peers. Our analysis offers unique guidance on this issue, since it describes how market characteristics and the relatedness of the firms to the market in question affect how aggressively they compete. Propositions 1, 2, and 3 of our model predict that a focused firm will be a relatively more aggressive competitor when it operates in a smaller market, when there is less overall uncertainty in market size, and when it faces lateral diversified competitors. On the other hand, these propositions predict that the diversified firm will naturally be a more aggressive competitor when markets are more uncertain and when they are situated downstream from the market in question.

If we take a broader view of our analysis, we can also offer some novel implications about expected patterns of integration across industries. Propositions 4 and 5 indicate that lateral integrators are commonly either dominated by vertical integrators or else preyed upon by stand-alone firms through their behavior in capital markets. Thus, we should expect that industries will typically be populated either by vertical integrators operating alongside stand-alone firms, or else dominated by lateral integrators. Lateral integrators operating alongside stand-alone firms, on the other hand, should be relatively uncommon. (Instead, our model predicts they collaborate through arms-length contracts like alliances). Proposition 4 also offers a prediction about how takeover premia should vary with the identity of the acquiring firm: it predicts that downstream firms should be willing to offer larger premia for a target firm, since their combination should generate larger overall value than an otherwise identical situation with a horizontal acquirer.

We can also generalize our analysis to offer predictions about observed differences in investment levels between stand-alones and diversified firms. The empirical literature here has drawn mixed conclusions, with some noting that internal capital markets seem to operate in a socialistic fashion (e.g., Scharfstein (1998), Scharfstein and Stein (2000), or Shin and Stulz (1998)) and others providing evidence of efficient internal reallocation in response to industry shocks (Khanna and Tice (2001), Maksimovic and Phillips (2002)). Our model predicts that these observations are impacted by both the product market characteristics of the markets in question, as well as how the potential integrator (i.e., the diversified firm) is related to the industry in question. Under certain market conditions, conglomerates may display socialistic looking responses to positive demand shocks because the anticipated strategic behavior of their rivals constrains their optimal investment. Critically, this depends on how the conglomerate is related to the industry in question. If it is laterally related, the conglomerate's investment is driven down by strong stand-alone firms, especially in smaller, less uncertain markets. On the other hand, in a vertically related context aggressive investment might drive out weaker stand-alone firms, shutting down potentially important supply channels. Thus, we might also expect their observed investment patterns to appear less sensitive to industry investment opportunities in these situations, corresponding to larger, more uncertain markets.

On a closely related point, it has long been observed in the empirical literature that investment prospects may differ for stand-alone versus diversified firms, rendering segment-level average Tobin's q ratios a poor metric for comparing firm performance (Chevalier (1995), Whited (2001), Maksimovic and Phillips (2002)). Our model offers a neoclassical rationale for this observation, predicting that these differences in investment prospects should be tied to characteristics of the product markets in which the firms operate, as well as their relatedness to these markets. For example, a downstream potential integrator is a less aggressive competitor in our model when it fears that its investment decisions may drive out other firms; as such, it may appear to behave in a socialistic fashion empirically, failing to invest where measured investment opportunities appear to be promising. Yet, in our model the firm is not simply smoothing investment across divisions out of a sense of fairness for division managers; instead, it is rationally internalizing the strategic affects of its increased investment in a fragile, but fruitful, industry.

Our model also offers perspectives on the patterns of alliance activity that we see across industries, one that differs from standard arguments based on organizational real options or knowledge transfer. Indeed, our model suggests two rationales for strategic alliance formation based on the manner in which a firm is related to a particular industry.

First, alliance formation can be a strategic response to aggressive competition from stand-alone firms. When a conglomerate would otherwise be a weak competitor, our model predicts that it would instead form an alliance if the alliance allowed it to reap operating synergies while not exposing it to strategic commitment problems. (Note that this is exactly the opposite of the standard real options-based logic implicit in many discussions of alliance formation, since this predicts increased alliance activity when uncertainty is low, not high.) Thus, while other models predict that alliances are optimal when uncertainty is high and alliance formation can delay potentially large investment costs, our model predicts that they will also occur when a firm *cannot* commit investment to a certain industry but would like to. This motive is especially strong for firms operating in laterally related industries.[6]

Second, alliance formation can be a strategic alternative to integration when an entrant would like to avoid crowding out the upstream market for inputs to its production. This may explain why vertical alliance activity seems to cluster in industries like pharmaceuticals and computers, where the underlying uncertainty makes the entry deterrence effects of the integrator's investment especially salient. One prediction of our model is that vertical alliance activity will be less common in industry settings that are equally risky but differ in the degree to which the upstream market matters for the downstream integrator's success.

Finally, to see how our model sometimes overturns the standard deep pockets logic of Bolton and Scharfstein (1990) and others, consider recent developments in the market for online DVD rentals. Throughout 2004 and 2005, this market was dominated by three players: Netflix, Wal-Mart, and Blockbuster. Netflix is essentially a stand-alone firm focused entirely on this market. Blockbuster operates in this industry, but also operates an extensive chain of "bricks and mortar" rental locations. Walmart is, of course, a large retail conglomerate.

In May 2005, retail giant Wal-Mart announced that it would withdraw from the online rental market. Rather than exit completely, it entered into a co-marketing agreement with Netflix whereby it directed its consumers to Netflix in exchange for Netflix' promotion of Wal-Mart DVD sales. In response to the news announcement, Wal-Mart Chief Executive John Fleming was quoted as saying that the decision was "really a question of focus."

The fact that Walmart chose to form an alliance rather than exit completely conforms exactly to the predictions of Section VI, where we note that a lateral integrator always prefers an alliance to exit. But this example illustrates a deeper point about the role of commitment problems in internal capital markets in our model. In this situation, Netflix corresponds to one of the stand-alone projects in the industry, and Blockbuster and Walmart represent two outside integrators that differ in terms of how diverse their internal capital markets are. In our analysis, the integrated firm can costlessly redeploy assets, no matter what. But what if some factor, like the correlation structure across internal projects, made reallocation costly? This example offers insight into exactly this question. Presumably the bricks and mortar DVD rental operation of Blockbuster was more highly correlated with the online rental business than the various consumer retail divisions of Walmart. Our model predicts that because its internal diversification opportunities were greater, Walmart would be a weaker competitor in this market, and that the more aggressive Blockbuster would choose to stay while Walmart would choose to exit. Indeed, this appears to be exactly what happened.

VII. Conclusion

The tradeoffs between the flexibility of operating internal capital markets and the discipline imposed by external funding play an important role in determining how organizations decide what types of activities occur inside the firm, as opposed to between distinct firms. Yet firms do not operate internal capital markets in an economic vacuum. Instead, they must balance the benefits of an internal capital market against the potential strategic costs that they face vis-a-vis other firms operating in the same industry.

We capture this message using a simple model in which organizational design choices are embedded in a larger problem involving product market decisions (how aggressively to compete) and capital market decisions (how much financing to raise). Our analysis shows how the strategic double-edged sword of internal capital markets affects equilibrium entry decisions based on how a potential integrator is related to the industry in question. We also show how strategic alliances provide a partial solution to the problems created by integration, even if alliances do not provide all the benefits of an internal capital market.

Our initial analysis suggests a number of fruitful extensions. Our model is silent on how different modes of financing may give rise to differences in commitment ability, and thus market structure. One interesting extension of the model is to investigate how different financing choices may affect the flexibility of capital and thus the strategic implications of integration. The different control rights and cash flow rights that accrue to debt and equity holders could create important differences in a stand-alone's commitment ability when it attempts to raise external funding for investment in a sector. The equilibrium relation between capital structure choice and product market characteristics is thus one fruitful avenue for future work.

Important differences also exist between private and public sources of capital. Private capital, such as venture capital or concentrated ownership claims by other firms, naturally facilitates monitoring possibilities that are not present when ownership claims are widely disbursed in a public capital market. Thus, the choice between public and private capital could also affect the optimal level of commitment the stand-alone undertakes in the presence of competition from firms in neighboring industries.

Appendix

Proof of Lemma 1: Follows directly from the application of the discussion in the text to the optimal strategy of each project in each range of $E\pi$ given the possible strategies of the other project, and choosing symmetric Nash equilibria where possible.

Proof of Lemma 2: First consider predatory capital raising. Assume $\pi_H \in R1^{'}$. This implies $E\pi < \frac{1}{p+\alpha p}$, and from (5) and (6), Project 2 can never be positive NPV. Next assume $\pi_H \in R2^{'}$, which implies $E\pi \in R1$ or $E\pi \in R2$. From (5), the NPV of Project 2's first unit is $pE\pi - 1$, and from (7) the incremental NPV of the second unit is $\Delta pE\pi - 1$. Thus, the first unit is positive NPV iff $E\pi \in R2$, while the second is never positive NPV. From Lemma 1, this implies that predatory capital raising occurs iff $E\pi \in R2$.

Now assume $\pi_H \in R3^{'}$. From (6), two-unit entry is profitable for Project 2 if $E\pi > \frac{2}{p+\Delta p}$, and from (7) the second unit is incrementally positive NPV if $E\pi > \frac{1}{\Delta p+p^2}$. Thus, Project 2 raises two units if $E\pi > \max[\frac{1}{\Delta p+p^2}, \frac{2}{p+\Delta p}]$. From (5), it will otherwise raise either one unit (if $E\pi > \frac{1}{p(1-p)}$) or zero, which is the same as in Lemma 1. The result follows since $E\pi \leq \frac{1}{p(1-p-\Delta p)}$ holds for $\pi_H \in R3^{'}$, and, in Lemma 1, Project 2 has zero or one units in such cases.

Now assume $\pi_H \in R4^{'}$. From (5), Project 2's first unit is positive NPV if $E\pi > \frac{1}{p(1-p)}$, and from (7) the second unit is incrementally positive NPV if $E\pi > \frac{1}{\Delta p(1-p)}$. Also, Project 2 will never be a two-unit firm if $E\pi < \frac{1}{p(1-p)}$ since this would require, from (6), that $E\pi > \frac{2}{(p+\Delta p)(1-p)}$, and $\Delta p < p$ rules this out. Thus, Project 2 has zero units if $E\pi < \frac{1}{p(1-p)}$ and one if $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p)}]$, as in Lemma 1. Finally, $E\pi > \frac{1}{\Delta p(1-p)}$ is not possible here.

Now assume $\pi_H \in R5^{'}$. From (5) and (6), Project 2 will not enter if $E\pi < \frac{1}{p(1-p)}$. However, from (6) it can enter as a two-unit firm if $E\pi > \frac{2}{(p+\Delta p)(1-p)}$ and from (7) the second unit is incrementally positive NPV if $E\pi > \frac{1}{\Delta p}$. Thus, Project 2 raises two units if $E\pi > \max[\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)}]$. The result follows since $E\pi \leq \frac{1}{\Delta p(1-p-\Delta p)}$ must hold for $\pi_H \in R5^{'}$, and, in 1, Project 2 has one unit when $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p-\Delta p)}]$.

Now assume $\pi_H \in R6'$. From (5) and (6), Project 2 will never enter if $E\pi < \frac{1}{p(1-p-\Delta p)}$. For $E\pi > \frac{1}{p(1-p-\Delta p)}$ it will take two units only if $E\pi > \frac{1}{\Delta p(1-p-\Delta p)}$ (see (7)). Thus, its capital allocation is as in Lemma 1.

Now consider entry deterrence. From (5), if $E\pi > \frac{1}{p(1-p-\Delta p)}$, Project 2's first unit is positive NPV, while if $E\pi < \frac{1}{p(1-p)}$ Project 2 has zero units in Lemma 1. Thus, only $E\pi \in R3$ is relevant. Since $E\pi > \frac{1}{p(1-p)}$, $K_1 = 2$ is required. From Table III this requires $\pi_H \in R5'$ or $R6'$, and from above it occurs in $R5'$ only if there is no predatory capital raising.

Proof of Proposition 1: If Project 2's capital level is unchanged by integration, Project 1 never receives less capital in the good state than it would raise alone, since $\pi_H \geq E\pi$. However, each unit has an ex ante price of q, for a minimum integration gain of $1-q$. If HQ allocates more, the extra unit must be positive NPV, which increases the integration gain. Finally, if integration deters Project 2's entry, this increases the expected payoff for HQ.

Now assume integration invites predatory capital raising. From Lemma 2 and Table III, if $\pi_H \in R2'$ or $R3'$, the integrated firm is driven out, while stand-alone operation is profitable, so there is no integration. Next assume $\pi_H \in R5'$, the only other case with predatory capital raising. From the proof of Lemma 2, predatory capital raising requires $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p-\Delta p)}]$ (i.e., $E\pi \in [R3, R4$, or $R5]$). From Lemma 1, if $E\pi < \frac{1}{\Delta p(1-p)}$ (i.e., $E\pi \in [R3$ or $R4]$), HQ compares the integrated payoff with a benchmark of one unit for both. From Table III, if $\pi_H \in R5'$ predatory capital raising implies two units for Project 2 and one for Project 1 if $\widetilde{\pi} = \pi_H$. Thus, the integrated payoff for HQ and Project 1 is

$$p(1-p-\Delta p)E\pi - q, \tag{A1}$$

whereas their joint exected payoff in the benchmark model is $p(1-p)E\pi - 1$. Subtracting this from (A1) yields the condition in the proposition.

Now assume $E\pi > \frac{1}{\Delta p(1-p)}$ (i.e., $E\pi \in R5$). In this case, the benchmark has $K_1 = 2$ (if $\widetilde{\pi} = \pi_H$) and $K_2 = 1$. Thus, the joint payoff of HQ and Project 1 in the benchmark model is $(p+\Delta p)(1-p)E\pi - 2$. Subtracting this from (A1), integration will be chosen iff $E\pi < \frac{2-q}{\Delta p}$.

Finally, it suffices to prove that $E\pi > \frac{1}{\Delta p(1-p)}$ and $E\pi < \frac{2-q}{\Delta p}$ cannot both hold. This would require $2-q > \frac{1}{1-p}$, which is more likely the lower is q. The lowest possible q under these conditions and $\pi_H \in R5'$ arises if $\pi_H = \frac{1}{\Delta p(1-p-\Delta p)}$ and $E\pi = \frac{1}{\Delta p(1-p)}$, which has $q = \frac{1-p-\Delta p}{1-p}$. Thus, $2-q$ equals at most $2 - \frac{1-p-\Delta p}{1-p} = \frac{1-p+\Delta p}{1-p} < \frac{1}{1-p}$.

Proof of Lemma 3: From Lemma 2, in each range in which predatory capital raising is possible there is a minimum level of $E\pi$ beyond which it occurs. We show that for given p and Δp, the area of the (q, π_H) parameter space with predatory capital raising shrinks, while the area with deterrence expands as α rises.

Let $\Psi_1 \equiv \Delta p(1-p-\Delta p) + \alpha\Delta p$, $\Psi_2 \equiv \Delta p(1-p) + \alpha\Delta p$, $\Psi_3 \equiv p(1-p-\Delta p) + \alpha p$, and $\Psi_4 \equiv p(1-p) + \alpha p$. In each case Ψ_i is increasing in α, so $\frac{1}{\Psi_i}$ is decreasing. Now assume $\pi_H \in R5'$. In (q, π_H) space, for any given $\pi_H \in R5'$ (i.e., $\frac{1}{\Psi_2} < \pi_H < \frac{1}{\Psi_1}$), predatory capital raising occurs for all q such that $q > \frac{max(\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)})}{\pi_H}$, which is decreasing in π_H.

Given this, for $\pi_H \in R5'$ it suffices to show that the predatory capital raising region shrinks along both the π_H dimension and the q dimension as α rises. The π_H dimension is proved by algebraically calculating and signing the derivative $\frac{\partial(\frac{1}{\Psi_1} - \frac{1}{\Psi_2})}{\partial\alpha} < 0$. The q dimension follows from this plus the facts that $\frac{1}{\Psi_1}$ and $\frac{1}{\Psi_2}$ are both decreasing in α, while the minimum q for predatory capital raising, $\frac{max(\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)})}{\pi_H}$, rises as π_H falls. An analogous exercise provides the results for predatory capital raising in regions $R2'$ and $R3'$.

Finally, consider the deterrence region. Since $\frac{1}{\Psi_2}$ falls as α rises while the borders in (q, π_H) space for $E\pi \in R3$ remain the same, the area covered by $R5'$ and $R6'$ within the $E\pi \in R3$ region expands, which weakly increases the deterrence area holding $\frac{1}{\Psi_1}$ fixed. Now note that as $\frac{1}{\Psi_1}$ falls, the deterrence area is weakly increased as deterrence replaces any predatory capital raising in the $E\pi \in R3$ region between the old and new $\frac{1}{\Psi_1}$.

Proof of Proposition 2: First consider the last part. If integration does not invite predatory capital raising or deter entry, then Project 2's capital is unchanged (Project 2 has two units in the benchmark model only if $E\pi > \frac{1}{\Delta p(1-p-\Delta p)}$, and it will continue to have two units in such cases following integration). Thus, integration has a minimum benefit of $1-q$.

Now assume predatory capital raising would drive out HQ, that is, $\pi_H \in R2^{'}$ or $R3^{'}$. If $\pi_H \in R2^{'}$, from (5) and (7), Project 2 must have one unit. The joint payoff of HQ and Project 1 is then $pE\pi\alpha$, versus $pE\pi(1+\alpha)-1$ in the benchmark model, which is greater if $E\pi > \frac{1}{p}$ (which must be true for Project 2 to find it profitable to predate). If $\pi_H \in R3^{'}$, predatory capital raising implies that Project 2 must have two units of capital (it would have one unit in the benchmark model if $E\pi > \frac{1}{p(1-p)}$, and if $E\pi < \frac{1}{p(1-p)}$ and Project 1 is integrated Project 2 cannot be profitable with one unit according to (5)). Thus, HQ and Project 1's joint payoff is $(p+\Delta p)E\pi\alpha$ if they are integrated. If they are not, their joint benchmark payoff is either

$$pE\pi(1+\alpha)-1 \tag{A2}$$

if $E\pi \in R2$ or

$$E\pi(p(1-p)+2\alpha p)-1 \tag{A3}$$

if $E\pi \in R3$. Subtracting (A2) from their integrated payoff, integration is optimal if $E\pi < \frac{1}{p-\Delta p\alpha}$ when $E\pi \in R2$, which gives the first bullet. Subtracting (A3) from their integrated payoff yields $1 - E\pi(\alpha p + p(1-p) - \alpha\Delta p) < 0$, where the inequality follows from $E\pi > \frac{1}{p(1-p)}$ when $E\pi \in R3$, so predatory capital raising deters integration in this case.

Now assume $\pi_H \in R5^{'}$. In this case predatory capital raising implies $K_2 = 2$ and $K_1 = 1$ (if $\widetilde{\pi} = \pi_H$). From Lemma 2 this requires $E\pi > \frac{1}{p(1-p)}$ given $\Delta p \le p(1-p)$. If they are integrated, HQ and Project 1 have a joint payoff of

$$E\pi(2p(p+\Delta p)\alpha + p(1-p-\Delta p)(1+\alpha) + (p+\Delta p)(1-p)\alpha) - q. \tag{A4}$$

If they are not integrated and $E\pi \in R5$, according to Lemma 1 their joint payoff is

$$E\pi(2p(p+\Delta p)\alpha + (p+\Delta p)(1-p)(1+\alpha) + p(1-p-\Delta p)\alpha) - 2. \tag{A5}$$

Subtracting (A5) from (A4) yields

$$2 - q - \Delta p E\pi < 0. \tag{A6}$$

To see the inequality, note that $E\pi > \frac{1}{\Delta p(1-p)}$ if $E\pi \in R5$, and the smallest possible q in this case occurs if $E\pi = \frac{1}{\Delta p(1-p)}$ and π_H is as high as possible, which, with $\pi_H \in R5^{'}$, must be less than $\frac{1}{\Delta p(1-p-\Delta p)}$. Thus, we have $q \geq \frac{(1-p-\Delta p)}{(1-p)}$. Substituting into (A6) yields $\frac{\Delta p - p}{1-p} < 0$, implying that non-integration is optimal when $\pi_H \in R5^{'}$ and $E\pi \in R5$. If HQ and Project 1 are not integrated and $E\pi \in R3$ or $R4$, according to Lemma 1 they have a joint payoff of (A3). Subtracting (A3) from (A4) and rearranging gives the second bullet.

For the remainder of the result, note that deterrence implies $K_2 = 0$ and $K_1 = 2$ (if $\widetilde{\pi} = \pi_H$). Thus, the integrated payoff for HQ and Project 1 is $(p+\Delta p)E\pi(1+\alpha) - 2q$. The only benchmark equilibrium that is relevant given deterrence has one unit for each, so their joint payoff is (A3). Subtracting (A3) from their integrated payoff provides the result.

Proof of Proposition 3: The first part follows from the proof of the last part of Proposition 2 with $\alpha = 1$. The rest follows from the remainder of Proposition 2 with $\alpha = 1$. In particular, predatory capital raising is impossible with $\alpha = 1$ if $\pi_H \in R2^{'}$ or $R3^{'}$. To see this, note from Table II that the border between $R3^{'}$ and $R4^{'}$ with $\alpha = 1$ is given by $\frac{1}{2p - p(p+\Delta p)} < \frac{1}{p}$, so $\pi_H \leq \frac{1}{p}$. But from (5) and (6), Project 2 cannot profitably enter if $E\pi < \frac{1}{p}$, so $\pi_H \in R2^{'}$ or $R3^{'}$ never occurs for an $E\pi$ such that predatory capital raising is possible.

Next consider cases with $\pi_H \in R5^{'}$. From Table II, the border between $R5^{'}$ and $R6^{'}$ with $\alpha = 1$ is given by $\frac{1}{2\Delta p - \Delta p(p+\Delta p)} < \frac{1}{\Delta p(1-p)}$, so from Lemma 2 predatory capital raising is only possible for $E\pi \in R3$ or $R4$. Then the result follows from plugging $\alpha = 1$ into the relevant expression in Proposition 2 and noting that the inequality can never hold.

Proof of Proposition 4: Let DS denote the downstream HQ and H the lateral HQ. Let P_1 be the equilibrium probability of success for Project 1 conditional on $\widetilde{\pi} = \pi_H$ if DS does not buy it, and similarly let P_2 equal the analogous probability for Project 2 if DS does not buy Project 1. Then let P_1^* and P_2^* be the equilibrium probabilities conditional on $\widetilde{\pi} = \pi_H$ if DS does buy project 1. The proof proceeds by showing that if integration by DS will not deter entry, then the total probability of success for Projects 1 and 2 conditional on $\widetilde{\pi} = \pi_H$ will always be at least as great under integration by DS as under the alternative (i.e., $P_1^* + P_2^* \geq P_1 + P_2$), and that this implies DS is always willing to pay weakly more for Project 1. The details are omitted for brevity, but are available upon request.

Proof of Proposition 5: For part (a), note that DS is always a weakly better integrator than H conditional on entry deterrence. First, let $P_1^* = P_1$ and $P_2^* = P_2 = 0$ and subtract (A8) from (A7), which yields zero. Now let $P_1^* > P_1$, the only other case, and subtract to get $q(2\Delta p \pi_H - 1) > 0$. The inequality follows from the fact that the expression in parentheses equals the NPV of the second unit given $\widetilde{\pi} = \pi_H$, so $P_1^* > P_1$ only if this expression is positive.

Now consider (b) and (c). DS' payoff if it does not acquire Project 1 can be written as $E\pi(2P_1P_2 + P_1(1-P_2) + P_2(1-P_1))$ or, after rearrangement, $E\pi(P_1 + P_2)$. If it does acquire Project 1, its total payoff can be written as $E\pi(P_1^* + P_2^* + P_1^*(1-P_2^*)) - q1_{P_1^*=p} - 2q1_{P_1^*=p+\Delta p}$. DS' willingness to pay can thus be written as

$$E\pi(P_1^* + P_2^* + P_1^*(1-P_2^*) - P_1 - P_2) - q1_{P_1^*=p} - 2q1_{P_1^*=p+\Delta p}. \tag{A7}$$

If H acquires Project 1 their joint payoff is

$$E\pi(P_1(1-P_2)) - q1_{P_1=p} - 2q1_{P_1=p+\Delta p}. \tag{A8}$$

Now note that DS integration implies $K_1 = 2$ since we have assumed entry deterrence, while H integration must have $K_1 = 1$ if $\widetilde{\pi} = \pi_H$ since $K_1 = 2$ would deter entry and we have assumed the lateral firm will integrate, so $K_1 = 0$ is impossible. Thus, if H integration does not affect Project 2, $P_1^* = p + \Delta p$, $P_1 = p$, $P_2^* = 0$, and $P_2 = p$. Subtracting (A8) from (A7) given these yields part (b). If H integration invites predatory capital raising, we have the same except $P_2 = p + \Delta p$, so subtracting (A8) from (A7) yields part (c).

Proof of Proposition 6: First consider part (a). Project 2 cannot profitably enter under specialization, since its first unit has an NPV of $p(1-p)E\pi(1-\delta_2)-1$ and predatory capital raising cannot keep Project 1's capital level to zero (see the proof of Proposition 3). Thus, entry is deterred in either case, and because of the value of flexibility HQ will choose integration over alliance. The joint payoff of HQ and Project 1 in the benchmark model is $E\pi(3p-p^2)-1$ (see below for the proof that each has one unit in the relevant benchmark model), which does not vary with q for a given $E\pi$. Their integrated payoff depends on the choice between one and two units if $\widetilde{\pi} = \pi_H$. Their expected payoff with one unit is $E\pi(2p(1+\delta_1))-q$, and with two units is $E\pi(2(p+\Delta p)(1+\delta_1))-2q$. Both of these increase with $(1-q)$, but the latter increases faster. Thus, they either choose two units for all $(1-q)$ or choose one unit when $(1-q)$ is small, then switch to two units as it rises. Either way, their integration payoff increases smoothly with $(1-q)$, proving the result.

Now consider part (b). Here Project 2 always enters against a specialized Project 1 if it expects $K_1 = 1$ when $\widetilde{\pi} = \pi_H$, but never if it expects $K_2 = 2$. Also, Project 2 will never take on two units unless it can predate. The assumption $p(1-p-\Delta p)(1-\delta_2) > \Delta p(1-p)(1+\delta_1)$ ensures that Project 1 will never take on two units in an alliance in the given range of $E\pi$. It also ensures that the equilibrium of the benchmark model in the $E\pi$ range we consider always has one unit of capital for each firm. For it to be otherwise, $E\pi > \frac{1}{\Delta p(1-p)}$ would be required, which clearly cannot hold without $E\pi > \frac{1}{\Delta p(1-p)(1+\delta_1)}$. Thus, an alliance always dominates the stand-alone option since capital levels are the same, but the firms can specialize.

Now consider alliance versus integration. First we show that integration cannot invite predatory capital raising under our assumptions. From the proof of Proposition 3, predatory capital raising can occur with a DS integrator only if $\pi_H \in R5'$. An equivalent result holds with specialization given the stronger incentive to provide capital to Project 1. The analogous

π_H range with specialization is $[\frac{1}{\Delta p(2(1+\delta_1)-p(1-\delta_2))}, \frac{1}{\Delta p(2(1+\delta_1)-(p+\Delta p)(1-\delta_2))}]$. Here, if Project 2 does not predate with $K_2 = 2$, the integrated firm will choose $K_1 = 2$ if $\widetilde{\pi} = \pi_H$. Thus, given that Project 2 will not enter against an integrated firm if it expects $K_1 = 2$, the predatory capital raising decision is a decision between no entry and entry with $K_2 = 2$. Thus, predatory capital raising will occur if $E\pi > \frac{2}{(p+\Delta p)(1-p)(1-\delta_2)}$. But the region of interest has $E\pi < \frac{1}{p(1-p-\Delta p)(1-\delta_2)}$. These can both hold iff $2p(1-p-\Delta p) < (p+\Delta p)(1-p) \Rightarrow p(1-p-\Delta p) < \Delta p$, which is ruled out by assumption.

Given no predatory capital raising, integration either deters entry if $\pi_H > \frac{1}{\Delta p(2(1+\delta_1)-p(1-\delta_2))}$ (the condition for $K_1 = 2$ with integration), or has one unit for each if $\pi_H < \frac{1}{\Delta p(2(1+\delta_1)-p(1-\delta_2))}$. In the latter case integration is better than alliance since it has the same capital but adds flexibility. In the former case, integration yields a joint payoff of $E\pi(2(p+\Delta p)(1+\delta_1)) - 2q$, whereas an alliance, with one unit for each project, yields $E\pi(2p(1+\delta_1)+p(1-p)(1-\delta_2)) - 1$. Subtracting the latter from the former yields the condition.

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Notes

[1]Even if stand-alones face a later-stage funding opportunity, they may be less able to take advantage of it if they are more financially constrained than integrated firms.

[2]Since the value of the firm takes on only two possible values, one of which is zero (see below), there is no distinction in our model between debt and equity.

[3]We envision each firm obtaining financing from a distinct source, so that each investor only concerns herself with the returns from that project.

[4]It makes no difference whether HQ is situated upstream or downstream from the competing projects. We assume the latter purely for simplicity of exposition.

[5]It does not matter if HQ makes an initial allocation at this time or simply waits until time 1 to allocate any capital to Project 1.

[6]Because our model is designed to yield integration as the equilibrium outcome in the absence of strategic feedback from product markets, it is silent on the standard organizational real options motives for alliance activity.

Table I
Payoff Matrix with Potential Integration

Provides a matrix of payoffs for HQ and Projects 1 and 2 under different possible success scenarios and different possible integration scenarios. The variable $\widetilde{\pi}$ represents the monopoly payoff of a project that is successful alone, while the parameter α measures the degree of vertical relatedness of HQ and the upstream projects.

Successful?		HQ	Proj 1	Proj 2
Both	Stand-alone	$2\alpha\widetilde{\pi}$	0	0
	Integrated	$2\alpha\widetilde{\pi}$	-	0
1 *alone*	Stand-alone	$\alpha\widetilde{\pi}$	$\widetilde{\pi}$	0
	Integrated	$\alpha\widetilde{\pi}+\widetilde{\pi}$	-	0
2 *alone*	Stand-alone	$\alpha\widetilde{\pi}$	0	$\widetilde{\pi}$
	Integrated	$\alpha\widetilde{\pi}$	-	$\widetilde{\pi}$
Neither		0	0	0

Table II
Critical Market Size Ranges under Integration

Gives the range of sizes of π_H, the monopoly payoff conditional on a profitable market, that define the regions $R1'$ through $R6'$. Also gives the ranges from Lemma 1 for comparison. The parameters p and Δp represent the probability of successful integration conditional on one and two units of capital, respectively, while the parameter α measures the degree of vertical relatedness of HQ and the upstream projects.

Region	Size Range for π_H	Benchmark Size Range for $E\pi$
$R1'$	$[0, \frac{1}{p+\alpha p})$	$[0, \frac{1}{p})$
$R2'$	$[\frac{1}{p+\alpha p}, \frac{1}{p(1-p)+\alpha p})$	$[\frac{1}{p}, \frac{1}{p(1-p)})$
$R3'$	$[\frac{1}{p(1-p)+\alpha p}, \frac{1}{p(1-p-\Delta p)+\alpha p)})$	$[\frac{1}{p(1-p)}, \frac{1}{p(1-p-\Delta p)})$
$R4'$	$[\frac{1}{p(1-p-\Delta p)+\alpha p)}, \frac{1}{\Delta p(1-p)+\alpha\Delta p})$	$[\frac{1}{p(1-p-\Delta p)}, \frac{1}{\Delta p(1-p)})$
$R5'$	$[\frac{1}{\Delta p(1-p)+\alpha\Delta p}, \frac{1}{\Delta p(1-p-\Delta p)+\alpha\Delta p)})$	$[\frac{1}{\Delta p(1-p)}, \frac{1}{\Delta p(1-p-\Delta p)})$
$R6'$	$[\frac{1}{\Delta p(1-p-\Delta p)+\alpha\Delta p)}, \infty)$	$[\frac{1}{\Delta p(1-p-\Delta p)}, \infty)$

Table III
HQ and Project 2 Capital Allocations

Gives the capital allocation of HQ (K_1) at time 1 conditional on Project 2's earlier allocation decision (K_2) and the region from Table II within which π_H, the monopoly payoff conditional on a profitable market, falls.

Profit Region π_H in	HQ Allocation		Project 2 Capital
$R1'$ or $R2'$	$K_1 = 0$	if	$K_2 = 1$ or 2
$R3'$	$K_1 = 1$	if	$K_2 = 1$
	$K_1 = 0$	if	$K_2 = 2$
$R4'$	$K_1 = 1$	if	$K_2 = 1$ or 2
$R5'$	$K_1 = 2$	if	$K_2 = 1$
	$K_1 = 1$	if	$K_2 = 2$
$R6'$	$K_1 = 2$	if	$K_2 = 1$ or 2

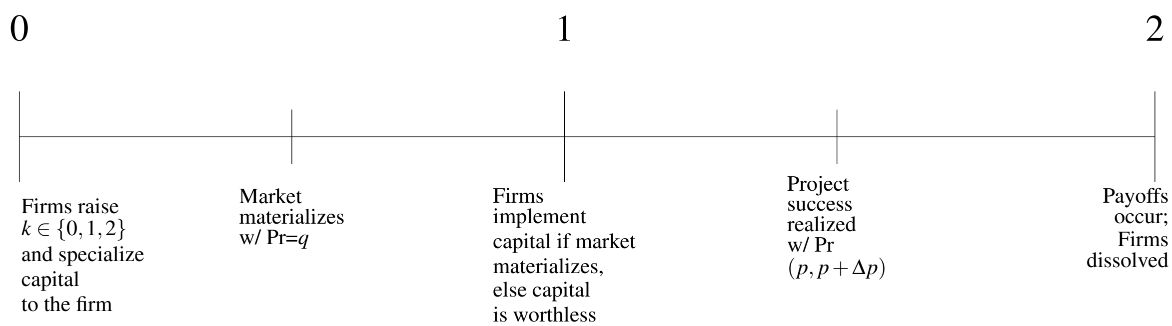

Figure 1. Benchmark time line.

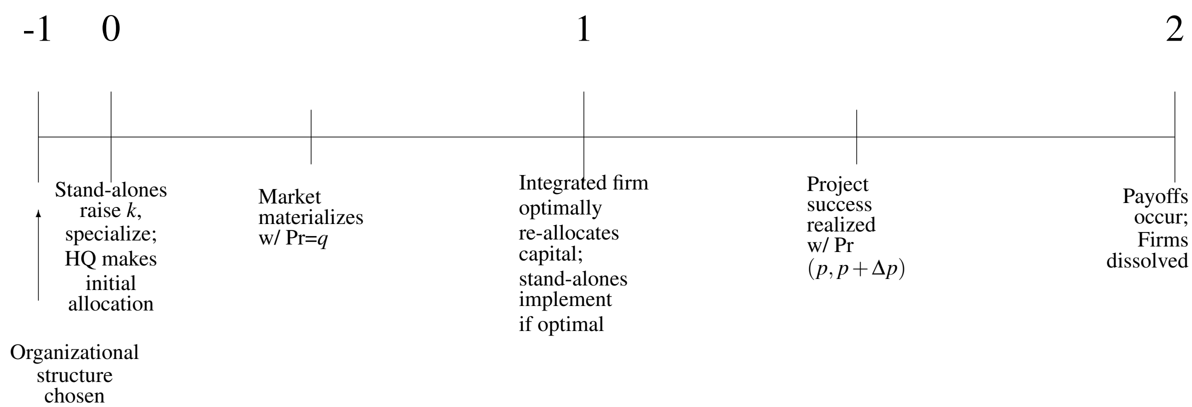

Figure 2. Time line with integration.

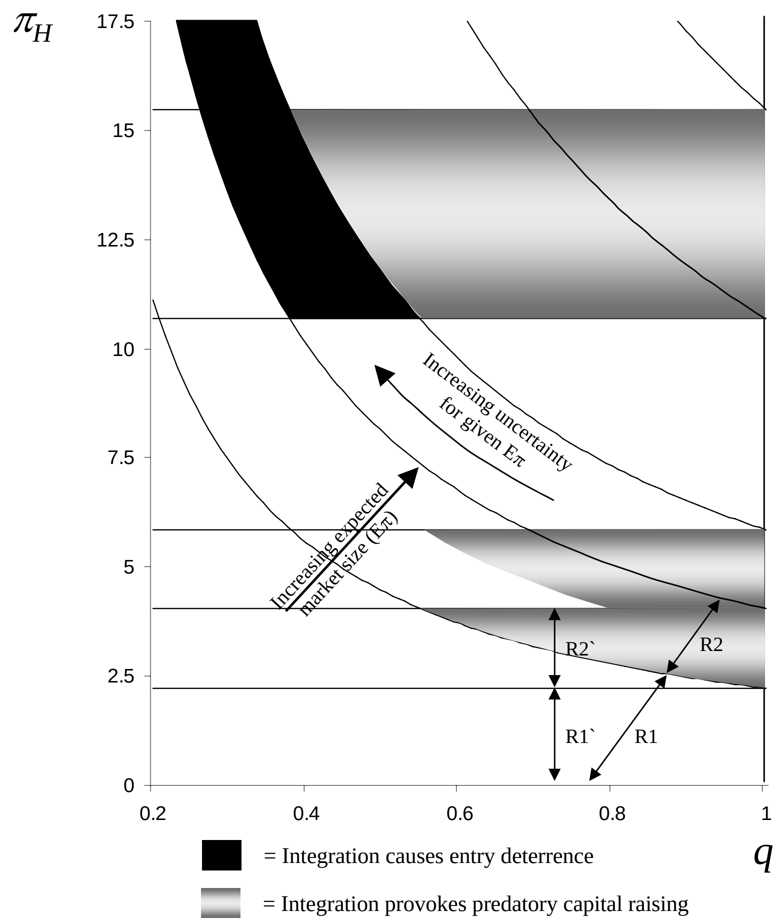

Figure 3. Plots regions in which horizontal integration causes entry deterrence (the black region) or predatory capital raising (the shaded regions). The figure shows that entry deterrence tends to occur when uncertainty is relatively high and market size is moderate. Predatory capital raising tends to occur when uncertainty is low or moderate, and for a wider range of moderate market sizes. The probability that the market is profitable, q, is varied along the horizontal axis, while market size conditional on that event, π_H, is varied along the vertical axis. Expected market size, $E\pi$, is held constant along the curved lines, which represent the border between different critical regions for $E\pi$, that is, $R1$, $R2$, $R3$, etc. The horizontal lines represent the border between different critical regions for π_H, that is, $R1'$, $R2'$, $R3'$, etc. The graph is drawn assuming the following model parameters: $p = 0.45$, $\Delta p = 0.17$, and $\alpha = 0$.

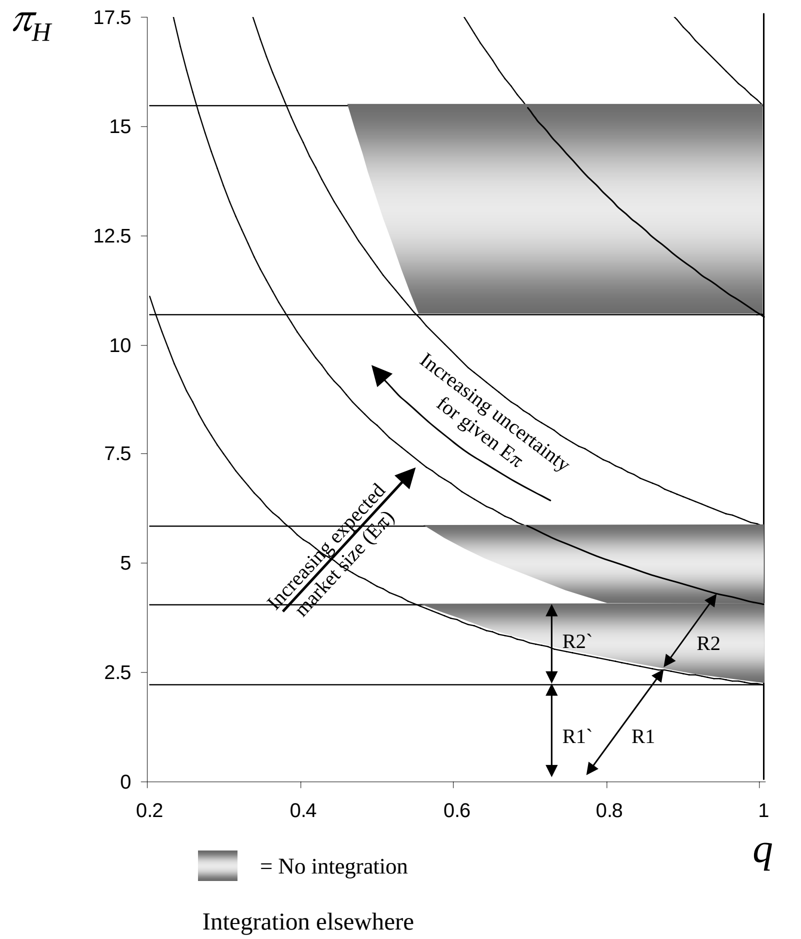

Figure 4. Plots a horizontal integrators integration decision using the same model parameters and setup as Figure 3. The shaded regions represent areas in which integration is avoided due to the threat of predatory capital raising. The figure shows that a horizontal integrator avoids integration whenever predatory capital raising would occur, unless the flexibility benefits of integration are large enough.

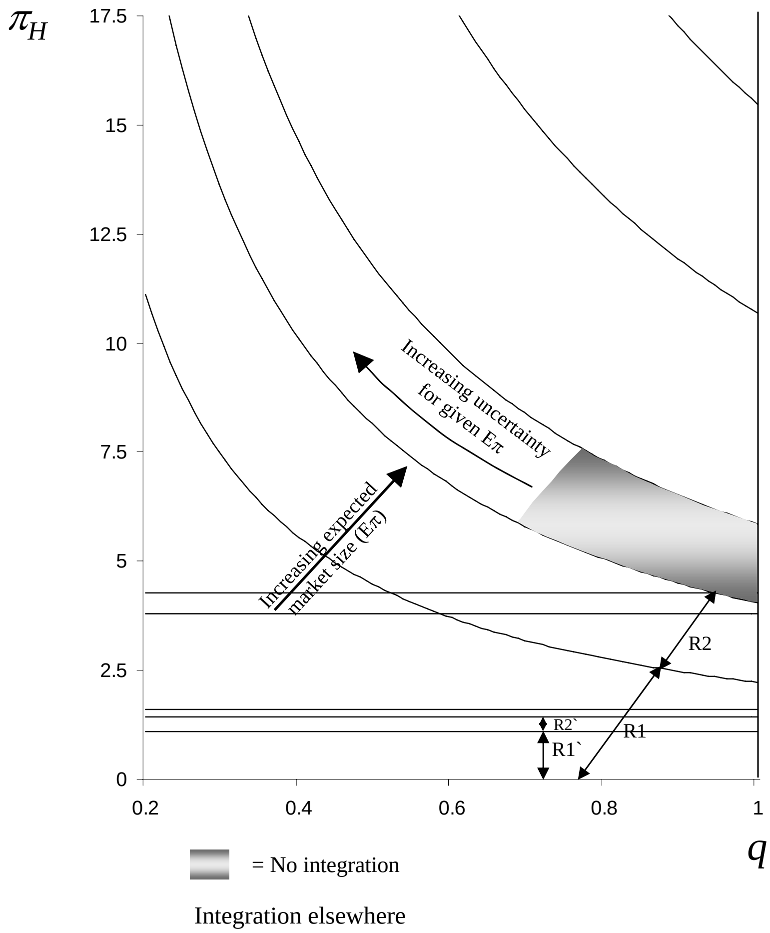

Figure 5. Plots a single downstream integrators integration decision using the same model parameters and setup as the preceding figures, except that $\alpha = 1$. The shaded region represents cases in which integration is avoided so as to preserve Project 2s participation (i.e., avoid entry deterrence). The figure shows that a single downstream integrator avoids integration only when the cost of losing a potential supplier to entry deterrence outweighs the flexibility benefits of integration.