

Market Structure, Internal Capital Markets, and the Boundaries of the Firm ^{*}

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Abstract

We study how a firm's optimal integration decision depends on the interaction between the product markets and capital markets in which it operates. An integrated firm operates an internal capital market, which provides allocative flexibility but does not allow the firm to commit to specific capital allocations in advance. A stand-alone firm, in contrast, raises capital ex ante in traditional markets and cannot change its capital level ex post, so it lacks ex post flexibility but has greater ex ante commitment ability. We show that the integrator's resource flexibility can deter entry from stand-alone firms when product markets are uncertain. This is most salient for a downstream integrator, who does not wish to foreclose a potential future supply option. On the other hand, the integrator's capital commitment problems can invite predatory capital raising from a stand alone when product market uncertainty is low. This is most salient for horizontal integrators. We also illustrate how hybrid organizational forms like strategic alliances can dominate either vertical or horizontal integration by offering some of the benefits of integration without imposing these strategic costs.

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1 Introduction

Firms entering innovative markets employ an array of organizational design choices that range from collaboration to integration to going it alone. These different organizational arrangements represent quite distinct approaches to activities in both product markets and capital markets. What drives these seemingly contradictory choices?

In this paper, we show how the interaction between product market competition and fund-raising activity in capital markets can drive a firm's optimal organizational design. In our model, we define an integrated firm by its ability to operate an internal capital market. Stand-alone firms, in contrast, must finance their investments externally via traditional public or private capital markets. This gives integrated firms greater ex post resource flexibility, but at an expense: integrated firms cannot commit ex ante to deploy their capital in the market in question, while stand-alone firms can. Given this fundamental distinction, we study how different product market characteristics endogenously drive firms' integration decisions.

We show that integration can cause two strategic effects that link product markets, capital markets, and organizational design. First, an integrated firm's resource flexibility can deter a stand-alone firm from raising capital and entering the market in the first place. This *entry deterrence* effect is strongest when product market uncertainty is high, and most salient when the integrator is downstream to the market in question. Second, integration can invite *predatory capital raising* by the stand-alone firm. That is, the stand-alone firm can prey on the integrator's inability to commit by raising more capital than would otherwise be profitable. Predatory capital raising is most salient for horizontal integrators facing low product market uncertainty.

We use a simple model of integration in an uncertain environment to derive these results. To keep the analysis as simple as possible, we focus on a single integration opportunity in an innovative industry. This industry has

two competing projects that must raise capital to invest in the development of a new product. The size of the final product market is uncertain, and the probability of successful development is determined by the amount of capital employed. A potential integrator may operate one of the projects internally, or leave it, like the other project, to operate as a stand-alone firm. The success or failure of each project's development effort translates into a final product market configuration that affects overall industry profits.

If the potential integrator chooses to integrate into the market, we assume that it operates an internal capital market with the flexibility to re-direct capital towards or away from this market 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: we assume, as in Robinson (2006), Scharfstein and Stein (2000), Rajan et al. (2000), that a multi-division firm cannot commit ex ante not to reallocate capital optimally towards or away from a particular division ex post. Thus, 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 ex ante to do otherwise.

In contrast, we assume that a stand-alone firm raises all of its capital via a public or private offering, such as a venture capital financing round or initial public offering, before knowing the size of the final product market. This funding decision cannot be amended at a later date because stand-alone firms face a time-to-build problem. Before financial capital can be employed, it must be transformed into physical capital that is specialized to the firm. Because a stand-alone firm has no other divisions with which this physical capital can be interchanged, the firm cannot raise additional funds for investment nor reallocate its resources to a better use after market uncertainty has been

resolved. This implies that a stand-alone firm has the ability to commit to a final capital allocation ex ante.

These assumptions are motivated by a number of empirical observations. To begin with, innovative product markets are often contested by the firm with the fewest outside opportunities, rather than the firm with the deepest pockets. Take recent developments in the online movie rental industry as an example. Throughout 2004 and 2005, the market for online DVD movie rentals was dominated by three players: Netflix, Wal-Mart, and Blockbuster. Netflix operates solely in this industry. Blockbuster operates in this industry, but also operates an extensive chain of stores from which customers can rent and return movies in person. In May, 2005, retail giant Wal-Mart announced that it would withdraw from the online rental market. Rather than exit completely, it instead 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."

This example illustrates that integration by its very nature entails operating an internal capital market. Note that in the online DVD rental case, it was Wal-Mart, with the relatively more diverse internal capital market (and considerably deeper pockets) that chose to exit the industry, not Blockbuster or Netflix. Wal-Mart could easily outspend these more focused competitors if it chose to do so. But instead, it pursued a strategy of devoting resources to other more profitable lines of business within the firm. This suggests that an integrated firm's flexibility to reallocate resources can play an important role in its product market strategy.

Similar behavior has been documented in other empirical settings. Khanna and Tice (2001) study the response of discount retailers to the entry of Wal-mart into their market. They find that discount retailers that operate as divisions of diversified firms are quicker, relative to focused firms that raise capital

directly from external markets, to make the decision to ‘cut and run’ versus ‘stay and fight.’ Their capital expenditure decisions (at the conglomerate level) are more sensitive to the productivity of the division facing Wal-mart. Studying clinical trials in biotechnology and pharmaceuticals, Guedj and Scharfstein (2004) find that firms with multiple products in development are quicker to abandon an un-promising drug candidate. Stand-alone firms advance drugs from Stage I clinical trials to Stage II clinical trials more often, but this results in fewer ultimate drugs on the market. This evidence further supports the idea that integrated firms will have greater flexibility to reallocate resources in response to developments in the product market, and that this flexibility can have important strategic implications.

To keep the model as simple as possible, we maintain the extreme assumption that integrated firms have complete flexibility to redeploy capital after uncertainty has been realized, while stand alone firms have none. However, the results are qualitatively unchanged as long as the integrated firm has significantly greater flexibility in reallocating capital ex post.¹

Our analysis shows that the optimal integration decision depends on whether integration causes entry deterrence or invites predatory capital raising, as discussed above. In essence, entry deterrence occurs because the stand-alone firm is driven away by the integrator’s ability to move capital into the industry after uncertainty has been realized. The financial slack created by the internal capital market thus acts as an endogenous barrier to entry. Predatory capital raising occurs because it may be optimal to act aggressively in the presence of

¹ For simplicity of exposition we focus on the time-to-build problem described above as the source of this flexibility differential. However, there are a number of other economic factors that could contribute to this phenomenon. For example, there could be a hold-up problem that is more severe across firms than within firms, or an agency problem, whereby stand-alone managers are unwilling to release their capital because they would lose private benefits of control. Also, if stand-alone firms are more financially constrained than integrated firms, then even if they face a later stage funding opportunity, they may be less able to take advantage of it. This could be exacerbated by an asymmetric information problem between the firm and outside investors.

an integrated competitor, since the integrated firm will divert resources away from projects that are ex post unprofitable. 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 short, because a stand alone has no financial slack, it can use fund-raising in the capital market to commit to aggressive actions in the product market. It thereby preys on the integrator's inability to commit.

In general, entry deterrence is more likely to occur when there is considerable product market uncertainty. This is when the integrated firm's flexibility value is highest. On the other hand, predatory capital raising is more likely when product market uncertainty is lower. This is when the integrated firm's commitment cost is highest.

The effect of entry deterrence and predatory capital raising on the initial integration decision depends on how the potential integrator is related to the market in question. If the integrator is neither a direct competitor nor vertically related to the contested market (which we call a "horizontal" integrator), the scope for predatory capital raising is maximized while the chance of entry deterrence is minimized. Such an integrator generally avoids integration when it invites predatory capital raising from the stand-alone firm, but is otherwise happy to integrate, especially when it will deter entry.

On the other hand, a downstream integrator has its own stake in the success of the contested market. This naturally makes it a more aggressive investor, which reduces the scope for predatory capital raising and increases the chance of entry deterrence. But, unlike the horizontal case, the downstream integrator may wish to avoid entry deterrence: since it uses the upstream product as an input, it could be concerned that *someone* in the upstream industry be successful, even if success does not occur in its own internal division, so that it can produce its downstream product. In the limit, a downstream integrator with a large stake in the contested market will avoid integration when two conditions are met: integration deters entry; and, the desire to have multiple

potential sources of supply overpowers the flexibility value of the internal capital market.

Next we consider which type of integration is likely to dominate. When a horizontal and vertical integrator are allowed to compete for control of the project, the vertical integrator is generally the one that can offer the greatest surplus in the transaction. The only time that a vertical integrator will acquiesce to a horizontal integrator is when its own integration will deter entry, but the horizontal integrator's will not; or, when the benefits to integration are sufficiently large that they outweigh the product market considerations.

In light of these findings, a natural question that arises is whether some intermediate organizational form can do better than either a stand alone or an integrated firm can do. To put the question differently, our analysis thus far has only examined integration that occurs by moving the boundaries of the firm. Firms can also integrate through contractual mechanisms, such as strategic alliances. Strategic alliances allow physical integration to occur but leave the boundaries of the firm intact.

To study alliances, we modify the model slightly. We allow for integration to involve not only the use of an internal capital market, but also the realization of a physical synergy. Departing from Grossman and Hart (1986), we assume that the physical synergy can be contracted upon, whereas the non-contractible aspects of the relationship are captured by the headquarters' inability to commit to capital allocations in an internal capital market.

We model a strategic alliance between two firms as a contract that allows them to enjoy the physical synergies of integration without exposing the alliance project to the funding uncertainty of the internal capital market. In other words, an alliance coordinates production to capture synergies but does not allow for ex post capital reallocation between the alliance partners. There are two key results in this section. The first is that a horizontal integrator always enters the market in some way when synergies are present, either through full integration or a strategic alliance. An alliance is used when full integration

would invite predatory capital raising. The second result is that vertical integrators may strictly prefer alliances to standard integration, since alliances deter entry less often. This is likely to occur when industry risk is not too high and expected market size is large enough to allow competition against an alliance, but not large enough to invite entry against a fully integrated firm.

The papers that are most closely related to our analysis are Matsusaka and Nanda (2002), Cestone and Fumagalli (2005), and Robinson (2006). In a world with no uncertainty, Matsusaka and Nanda (2002) show that an internal capital market can invite predation. Our analysis includes this possibility as a special case but also explores how in the presence of uncertainty an internal capital market can deter entry. Furthermore, Matsusaka and Nanda (2002) illustrate some of the interplay between product market considerations and internal capital markets, but stop short of developing an equilibrium relation between internal and external organization.

The role of resource flexibility in the Cestone and Fumagalli (2005) analysis of business groups is similar to ours, but their overall focus and their analytical setup is quite different. Their primary focus is on the efficiency of cross-subsidization and winner-picking in a model where business group affiliates can raise external capital to supplement their internal funding provisions. In their model of an internal capital market, all capital allocation decisions are made *ex ante*, so there is no scope for conditioning the capital allocation on new information.

Strategic alliances play a similar role in our model to that played in Robinson (2006), where they provide firms with the possibility of contracting around the winner-picking that otherwise occurs in internal capital markets. While Robinson (2006) contrasts alliances with internal capital markets, Robinson (2006) does not consider the endogeneity of market structure to the organizational design decision.

Our findings are also related to other literatures in corporate finance and economics. For example, our model could provide insights into staged financing

arrangements, which may provide some of the flexibility benefits of integration and suffer from a similar lack of commitment ability. Along these lines, Bolton and Scharfstein (1990) show that financing arrangements designed to control agency problems, such as staged financing in venture capital, can invite predation. We also contribute more generally to the theoretical literature on the interaction between product markets and capital markets, including papers such as Bolton and Scharfstein (1990), Brander and Lewis (1986), Maksimovic and Zechner (1999), and Williams (1995). Like Matsusaka and Nanda (2002) and Cestone and Fumagalli (2005), our work builds on the real options literature, notably Dixit and Pindyck (1994). 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 in a small entrepreneurial firm. This issue has been studied in different settings by, for example, Gromb and Scharfstein (2002) and Fulghieri and Sevilir (2003).

The remainder of the paper is organized as follows. We lay out the basics of the model and study the benchmark case of no integration in Section 2. In Section 3 we present the full model and analyze the various strategic effects of integration. Next, we analyze the special case of horizontal integration in Section 4, followed by an analysis of downstream integration in Section 5. In Section 6, we study how alliances change the analysis. We discuss some broader implications of our theory and conclude in Section 7. All proofs are collected in the Appendix.

2 The Benchmark Model

Our primary unit of analysis is an economic project which 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 $\tilde{\pi}$ 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 $\tilde{\pi}$ 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 Bertrand price competition with homogeneous products.

The model takes place over three periods, 0, 1, and 2. At time 0, the two firms simultaneously raise funds. 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 creates a time-to-build problem, which 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 $\tilde{\pi}$ can take on one of two values, $\tilde{\pi} \in \{0, \pi_H\}$, with $\Pr[\tilde{\pi} = \pi_H] = q$. 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, i.e. $K_i \in \{0, 1, 2\}$ 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 zero if $K_i = 0$, p if $K_i = 1$, and $p + \Delta p$ 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.

[Please see Figure 1]

Given this set-up, the two projects raise money and employ capital up to the point where the next unit has a negative perceived net present value (NPV). The perceived NPV is based on their expectation of the competing project's capital level and the size of the market. We use $E\pi \equiv q\pi_H$, the expected profit to a project successful alone, as our measure of expected market size. 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 $pE\pi(1-p) > 1$, i.e. 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 the expected market size, each of which has a unique equilibrium given our selection criteria. The following lemma defines these ranges and gives the corresponding equilibrium capital allocations.

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: (Firm 1, Firm 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 underscores the fact that our model is designed to capture innovative markets, since it illustrates that strategic interactions are most likely in medium sized markets. For very large markets, each player’s optimal decision is to enter regardless of its opponent. 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, captured in our model by regions R2 through R5, the market is large enough to enter but small enough to make one’s rivals actions 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.

3 Integration and the Strategic Effect of Internal Capital Markets

3.1 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 organizational design choice for 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 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.

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. Note that by setting the NPV to zero, we remove any scope for value destruction to occur as a result of capital misallocation.

Following the final implementation of R&D, any capital used by Project 1 becomes worthless. In essence, the integrated firm has the ability to change 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 they fully commit 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.² To formally capture these considerations, 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. In particular, we assume that if only one project is successful, HQ receives a net incremental benefit (i.e., separate from the project's payoff $\tilde{\pi}$) of $\alpha\tilde{\pi}$, where $\alpha \in [0, 1]$. If both projects are successful, we assume that HQ gets a benefit of $2\alpha\tilde{\pi}$. To operationalize this further, one could assume that if one project is successful, HQ engages in bilateral Nash bargaining with it, thus

² It makes no difference whether HQ is situated upstream or downstream from the competing projects. We assume the latter purely for simplicity of exposition.

leading to an even split ($\alpha\tilde{\pi}$ to each firm) of $2\alpha\tilde{\pi}$, the total surplus generated by their bilateral trade (note that this implies that $(1 - \alpha)\tilde{\pi}$ of the successful firm's total payoff of $\tilde{\pi}$ arises from trade with other downstream firms). If both are successful, they compete away their profits from dealing with HQ and any other downstream firms, so HQ is able to enjoy the entire $2\alpha\tilde{\pi}$ surplus from its downstream market. In other words, we have the payoff matrix described in Table 1.

[Please see Table 1]

Note that this payoff structure does not admit the possibility of competition *between* HQ and any other downstream firms that may exist. Also note that the integrated firm's payoff is no higher than the stand-alone project's when *both* are successful. This reflects the facts that HQ realizes all of the surplus for its own market due to competition between the two stand alones in the non-integrated case, and that an integrated firm competes directly with Project 2 for the business of any other vertically related firms. We use this structure for its simplicity and intuitive clarity.

In the absence of integration, competition between the two projects is unchanged from the benchmark case since the payoff to a stand-alone firm upon sole success is still $\tilde{\pi}$. However, the parameter α is a natural gauge of the importance of HQ's downstream division to the contested upstream market. In particular, if $\alpha = 0$, HQ accounts for none of the upstream market's surplus, and HQ thus has no separate stake in the success of the two projects. In other words, its interest in their success is limited to any ownership stake it may have in Project 1. We label this the "horizontal" case. If $\alpha = 1$, on the other hand, we can say that trade with HQ's downstream division effectively accounts for *all* of the surplus available in the upstream market. Thus, we label this the "single downstream" case.

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 1.³ Next, the value of $\tilde{\pi}$ is revealed. At time 1, HQ chooses whether to reallocate any capital among its divisions if it is integrated, and all projects with capital initiate R&D if $\tilde{\pi} = \pi_H$. Finally, at time 2, success or failure is determined according to the probability structure introduced in Section 2, and payoffs are realized. Figure 2 illustrates this modified timeline.

3.2 The Strategic Effect of Internal Capital Markets

The game is identical to the benchmark model if HQ chooses non-integration. If HQ and Project 1 are integrated, the final decision on Project 1's capital allocation occurs after the stand-alone firm has raised funds and committed to its capital level. In this sense, HQ has made itself into a Stackelberg follower, but with superior information on market size at the time of its strategic decision. Project 2, on the other hand, makes its capital decision knowing the effect its own capital level will have on HQ's decision for each possible re-

³ 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.

alization of market size. The integration decision thus balances the value of flexibility and superior knowledge against any possible strategic costs.

The relevant strategic impact of integration boils down to the 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." 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."

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 the 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 learning the actual 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 result in entry deterrence. With less uncertainty, HQ's aggressiveness is tempered, and there is greater opportunity for predatory capital raising by Project 2.

We solve the model via backward induction, starting with HQ's final capital allocation assuming integration. Clearly, if HQ learns that $\tilde{\pi} = 0$ it redeems any capital previously provided to Project 1 and shuts it down. If it learns that $\tilde{\pi} = \pi_H$, its decision depends on π_H and Project 2's known capital level, K_2 .

Let p_2 represent the probability of success for Project 2 implied by K_2 , and 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 $p_2\alpha\pi_H$.

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 $p(1-p_2)\pi_H(1+\alpha)+(1-p)p_2\alpha\pi_H+2pp_2\alpha\pi_H$, or, simplifying, $\pi_H(p(1-p_2) + \alpha(p + p_2))$. Thus, the marginal payoff of the first unit of capital is this minus the expected payoff with zero units derived above, or $\pi_H(p(1-p_2) + \alpha p)$.

Using analogous logic, it is easy to show that the marginal payoff of the second unit is $\pi_H(\Delta p(1-p_2) + \alpha\Delta p)$. HQ thus allocates zero units to Project 1 if $\pi_H < \frac{1}{p(1-p_2)+\alpha p}$, one unit if $\pi_H \in [\frac{1}{p(1-p_2)+\alpha p}, \frac{1}{\Delta p(1-p_2)+\alpha\Delta p})$, and two units if $\pi_H \geq \frac{1}{\Delta p(1-p_2)+\alpha\Delta p}$.

Given this analysis we can define critical regions for π_H , similar to the regions for $E\pi$ that were derived in Lemma 1, by replacing p_2 in the above equations with its possible realizations. In Table 2, 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 $\alpha = 0$, i.e., in the horizontal case.

[Please see Table 2]

Backing up a step, Project 2's capital raising decision takes HQ's optimal reallocation decision into account (note that HQ's tentative initial allocation to Project 1 has no strategic importance and can therefore be ignored). Project 2 gets no payoff if it takes on zero capital, so its decision hinges on HQ's response

to one or two units of capital. Replacing p_2 in the above cutoff levels of π_H , we see that the scope for strategic behavior by Project 2 depends on which region from Table 2 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 3.

[Please see Table 3]

If π_H is in regions $R1'$, $R2'$, $R4'$, or $R6'$, Project 2 always faces the same final level of capital for Project 1 in the good state if it enters. However, in regions $R3'$ and $R5'$ Project 2 can affect HQ's final allocation to Project 1 with its own allocation. Also, if Project 2 enters in region $R2'$, it will drive the integrated firm to zero (it 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 of the market when it would otherwise enter, we call this "entry deterrence."

We now have all of the ingredients to determine Project 2's equilibrium capital level choice. If we let $1_{(Rj')}^{\pi_H}$ be an indicator function equalling 1 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

$$E\pi \left[p1_{(R1',R2')}^{\pi_H} + p(1-p)1_{(R3',R4')}^{\pi_H} + p(1-p-\Delta p)1_{(R5',R6')}^{\pi_H} \right] - 1. \quad (1)$$

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

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

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 (1) and (2), 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, i.e. equation (2) minus equation (1):

$$E\pi \left[\Delta p 1_{(R1', R2')}^{\pi_H} + (\Delta p + p^2) 1_{(R3')}^{\pi_H} + \Delta p(1 - p) 1_{(R4')}^{\pi_H} + \Delta p 1_{(R5')}^{\pi_H} + \Delta p(1 - p - \Delta p) 1_{(R6')}^{\pi_H} \right] - 1. \quad (3)$$

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, i.e. 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 product market uncertainty is small relative to market size, while entry deterrence is more likely when uncertainty is large relative to 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 $E\pi \in R3$ and 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 the total size of the market and the probability of success accordingly. 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 presented in the figure correspond to the borders between the various 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 regardless of your competitor's aggressiveness. 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 uncertainty (captured by relatively 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 where an integrated horizontal firm would not enter in the absence of competition.

4 Horizontal 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 horizontal 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 from the benchmark model. The analysis provides Proposition 1, which describes whether a horizontal integrator optimally chooses to integrate with Project 1. It shows that the horizontal firm is always happy to integrate and enjoy the benefits of flexibility when integration 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 allocation of capital invites the competitor to predate.

Proposition 1 *If horizontal integration does not invite predatory capital raising, integration always occurs. If horizontal 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 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 where 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 horizontal 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 ($\pi_H \in R5'$), integration sometimes occurs because the flexibility benefit outweighs the cost of a more aggressive competitor (ie, the non-integration region with $\pi_H \in R5'$ is smaller than the corresponding predatory capital raising region in Figure 3).

5 Vertical Integration

From Table 3, an increase in HQ's downstream stake in project success, represented by 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 would translate into a downward collapse 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 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:*

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

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 horizontal 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 and greatest cost for 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 no longer 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 fact that predatory capital raising is less costly. However, entry deterrence becomes particularly costly. To understand this result, consider the following figure, which is generated by the same numerical example used above, except with $\alpha = 1$. Again, the shaded region represents cases where 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 entry deterrence holds for the entire $E\pi \in R3$ band.

Comparing propositions 3 and 1, it is clear that there are cases where a vertical firm will integrate and a horizontal firm will not, and vice versa. In particular, the vertical firm always integrates when $E\pi$ is small or large, i.e. in regions $R1, R2, R4, R5$, and $R6$, whereas the horizontal 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 horizontal firm would be happy to integrate. In these areas, horizontal integration does not invite predatory capital raising and may or may not deter entry.

These results naturally lead to a question of what would happen if both a horizontal and vertical firm were available to integrate with Project 1. To address this, we define “active competition” as a case in which both a purely horizontal 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 the double marginalization problem. 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 where this basic intuition is overturned. As implied by Proposition 4, this possibility hinges on cases where 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 horizontal firm is willing to integrate, then the horizontal 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 horizontal firm integrate with Project 1 instead. In particular, it is happy to let the horizontal firm buy Project 1 unless horizontal 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 horizontal firm in some cases where it would otherwise acquire the project and deter entry. In other words, the horizontal firm can be a better integrator from the point of view of the downstream firm when horizontal integration does not deter entry. Furthermore, the downstream firm is particularly happy to let the horizontal firm buy Project 1 in cases where the horizontal 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 horizontal 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 horizontal firm when it would otherwise prefer nonintegration.

Using our numerical example, we have the following figure that corresponds to this result.

[Please see Figure 6]

The black region represents horizontal integration, while the shaded region represents no integration, which occurs when there is no active competition, i.e., when integration would not be profitable for either firm. In the figure

there is vertical integration most of the time, except that there is horizontal integration when vertical integration deters entry and horizontal integration does not, and no integration when vertical integration deters entry while horizontal integration invites predatory capital raising. Note that in this case, competition leads to less vertical integration since the horizontal firm is a better integrator over a significant area of the parameter space.

6 Strategic Alliances and Physical Synergies

Thus far we have assumed that there are no synergies when Project 1 is integrated with HQ other than the ability to operate an internal capital market. However, there are often other physical benefits such as product specialization or cost reduction. In this section we consider how such physical synergies may affect the integration decision. We show that these concerns lead to a natural role for hybrid organizational forms such as strategic alliances.

We assume that if HQ is integrated with Project 1, it can choose to create a physical synergy such that the success payoff for Project 1 in the good state is increased to $\pi_H(1 + \delta_1)$. The physical synergy may arise from an inter-firm knowledge transfer along the lines of Mowery et al. (1996), or it may arise from the specialization of assets to one another's production process as in a more typical Grossman-Hart-Moore framework. The firm can choose to implement this synergy at any time up to its final capital allocation. We also assume that we are either in the horizontal case or the single downstream case. In the single downstream case, creation of the physical synergy has the additional effect of reducing the success payoff for Project 2 in the good state to $\pi_H(1 - \delta_2)$. This is particularly relevant if the synergy results from a specialization of HQ's downstream assets to Project 1.

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. An alliance is a legal contract between otherwise distinct

organizations that allows them to share the surplus from the synergy gains but does not allow for the operation of an internal capital market. Thus, it 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. Note that this does not preclude co-financing arrangements between the stand alone and 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.

If HQ is horizontal, the effect of physical synergies is straightforward. First note that if an alliance is impossible, a physical synergy has effects similar to vertical concerns. Specifically, it makes the integrated firm more aggressive in its capital allocations, which reduces the scope for predatory capital raising and increases the scope for entry deterrence. Furthermore, the integrated firm always takes advantage of the physical synergy given that there is no explicit cost. Next note that an alliance always dominates the benchmark stand-alone equilibrium since it increases Project 1’s expected payoff but cannot invite predatory capital raising. Thus we have the following result.

Proposition 6 *A horizontal integrator always either forms an alliance or integrates with Project 1.*

This result implies that horizontal alliances will be likely in cases where horizontal 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.

Decisions can be different in the single downstream firm case because specialization also 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 if the firm is not integrated. 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 we have $K_1 = 1$ in the relevant range of $E\pi$ for both the stand-alone equilibrium and the alliance equilibrium. Finally, we focus our analysis on the range of $E\pi$ where an alliance can be relevant, i.e. when full integration may deter Project 2's entry. We have the following result.

Proposition 7 *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 full 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 full 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 where 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.

For further intuition consider the following figure, which is derived from the numerical example used above assuming $\delta_1 = 0.05$ and $\delta_2 = 0.1$.

[Please see Figure 7]

The figure focuses on a narrower range of q and π_H to highlight the regions of interest. The narrow curved band corresponds to the $E\pi$ region considered in part (a), while the thicker curved band represents that in part (b). The black region represents cases where an alliance is optimal, and the shaded region represents cases with no alliance and no integration. The figure clearly shows that choosing integration over an alliance in the higher $E\pi$ region requires greater uncertainty than does choosing integration over non-integration in the lower $E\pi$ region.

7 Discussion and Conclusion

The tradeoffs between operating internal capital markets and seeking external funding play an important role in determining how firms decide what types of activities occur inside their boundaries, 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 study these issues in a simple model in which firms make simultaneous tradeoffs between organizational design choices, behavior in product markets, and behavior in capital markets. To keep the analysis as simple as possible, we focus on a single firm who may optimally choose to integrate into an innovative industry, where it may face potential threats from stand-alone firms.

This allows us to study how product market interactions with other potential competitors reinforce or undermine the outsider's natural desire to integrate based on the stand-alone's anticipated capital market behavior.

In the presence of product market interactions, two strategic effects arise from the ability to operate an internal capital market. Flexibility may cause entry deterrence when a competitor anticipates that the integrated firm may make a large capital allocation to the industry in question, driving down the expected profitability for a rival. This effect dominates when product market uncertainty is high, and is particularly salient for downstream integrators, who may wish to avoid foreclosing upstream supply channels. In contrast, a horizontal integrator is always happy to deter entry.

Flexibility may also invite predatory capital raising, however. In particular, because the integrated firm cannot commit to certain capital allocations, a rival may commit large capital infusions to ward off the would-be integrator's entry. This is more likely to occur when product market uncertainty is low, and the effect is most salient for horizontal integrators.

This framework naturally gives rise to a role for strategic alliances, which we model as legally binding collaborations between organizationally distinct firms. The collaboration allows for sharing knowledge transfers or other positive synergies to be realized, while maintaining the organizational distinction between the two firms. This distinction prevents any internal capital market reallocations from occurring. Alliances are therefore valuable when full integration and its requisite internal capital flexibility would be too strategically costly, either inviting predatory capital raising or forestalling valuable entry.

While the model is narrowly framed in terms of a single potential integration opportunity operating alongside another stand-alone firm, the intuition it provides can be applied more broadly. We discuss some of the broad empirical implications here.

The first implication concerns expected patterns of integration across industries. Consider an integration decision by an outsider deciding to integrate

into an industry in which there are already integrated firms present. The decision by an outsider to integrate is not likely to drive out another integrated firm, since they possess exactly the same resource flexibility as the new entrant. Likewise, the new entrant is unlikely to face predatory capital raising from one of these integrated incumbents, since that incumbent would face the same commitment problem outlined in this paper given the strong incentive to allocate capital away from an ex post failure when other positive NPV opportunities are present. Thus, if horizontal integration is observed, it is more likely to occur in the presence of other integration.

This in turn suggests that we should either see a lot of integration into a market, or only vertical integration and stand-alone firms. We should expect an industry configuration in which a horizontal integrator operates alongside many stand-alone firms to be relatively uncommon.

By this reasoning, our analysis suggests that the configuration of firms in the online DVD market example that begins the paper is inherently unstable. Indeed, the predictions of our model are in line with what we observe empirically. One potential way to think about the behavior of Walmart vis-a-vis Netflix and Blockbuster is to assume that news of impending changes in movie distribution indicate a downward shift in π_H , from a region like R4 to a region like R3. In region R4, the market is large enough to accommodate several players without their investment decisions deterring entry or inviting predatory capital raising; at smaller market sizes this is no longer the case.

We can then rationalize the behavior of Walmart by noting that if market shrank from region R4 to region R3, then Walmart could, as an outside, horizontal integrator, find itself in a position where its investment invited predatory capital raising from Blockbuster, along the lines of Proposition 1. Walmart's response to pull out and form an alliance with Netflix then conforms to Proposition 5, which states that horizontal integrators will use strategic alliances when they cannot integrate directly into an industry.

This last fact arises in our model because it predicts that horizontal alliances will occur in settings in which the horizontal integrator's entry would otherwise invite predatory capital raising from other firms. This underscores an important distinction between horizontal and vertical alliances. The former are motivated solely by the desire to thwart predatory capital raising. The latter, on the other hand, are motivated by the need to capture synergies without deterring entry. This distinction may be important for a deeper understanding of patterns of collaboration in settings such as biotechnology, discussed above.

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. An interesting extension of the model could 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: The discussion in the text implies that each project will prefer one unit of capital if the other has one unit and $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p)}]$. This proves the result for regions R3 and R4 since we choose symmetric equilibria where possible. Also from the discussion in the text, if $E\pi < \frac{1}{p(1-p)}$, each project will want zero capital if the other has one or more units. Thus, the results for regions R1 and R2 follow from the fact that a single unit of capital is positive NPV if the other project has zero units if and only if $pE\pi > 1 \Rightarrow E\pi > \frac{1}{p}$, and that two units is never optimal in these regions. This follows since the second unit's marginal NPV of $\Delta pE\pi - 1$, assuming zero units for the other project, can never be positive when $E\pi < \frac{1}{p(1-p)}$ given our assumption that $\Delta p \leq p(1-p)$. For regions R5 and R6, note that if the other project has two units, a project will want one unit of capital if $pE\pi(1-p-\Delta p) > 1 \Rightarrow E\pi > \frac{1}{p(1-p-\Delta p)}$, and will want two units if $\Delta pE\pi(1-p-\Delta p) > 1 \Rightarrow E\pi > \frac{1}{\Delta p(1-p-\Delta p)}$. Thus, each is happy to have only one unit if the other has two in region R5. From the text, we have that two units will be desired if the other project has one unit and $E\pi > \frac{1}{\Delta p(1-p)}$, which proves the result for R5. The result for R6 follows from the fact that two units are desired if the other project has two units and $E\pi > \frac{1}{\Delta p(1-p-\Delta p)}$.

Proof of Lemma 2: First consider cases where $\pi_H \in R1'$. This implies that $E\pi < \frac{1}{p+\alpha p}$, and from equations (1) and (2), Project 2 can never be positive NPV in such a case, thus predatory capital raising cannot occur. Next consider cases where $\pi_H \in R2'$, which implies $E\pi \in R1$ or $E\pi \in R2$. Using equation (1), the NPV of Project 2's first unit of capital is $pE\pi - 1$ in this case, while using equation (3) 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 unit can never be positive NPV. From Lemma 1, we see that this implies that predatory capital raising occurs iff $E\pi \in R2$, which corresponds to the result.

Next consider cases with $\pi_H \in R3'$. From equation (2), Project 2 can profitably enter as a two-unit firm whenever $(p + \Delta p)E\pi - 2 > 0 \Rightarrow E\pi > \frac{2}{p+\Delta p}$ and similarly from equation (3) the second unit's incremental NPV is positive whenever $E\pi > \frac{1}{\Delta p+p^2}$. Thus, Project 2 will raise two units whenever $E\pi > \max[\frac{1}{\Delta p+p^2}, \frac{2}{p+\Delta p}]$. From equation (1), it will otherwise raise one unit if $E\pi > \frac{1}{p(1-p)}$ and zero otherwise, which corresponds exactly to its behavior in Lemma 1. The result follows since $E\pi \leq \frac{1}{p(1-p-\Delta p)}$ must hold for $\pi_H \in R3'$, and, from Lemma 1, Project 2 has zero or one units in such cases in the benchmark model.

Now consider cases with $\pi_H \in R4'$. From equation (1), Project 2's first unit is positive NPV only if $E\pi > \frac{1}{p(1-p)}$, and from equation (3) the second unit is incrementally positive NPV only if $E\pi > \frac{1}{\Delta p(1-p)}$. Furthermore, Project 2 will never be a two unit firm if $E\pi < \frac{1}{p(1-p)}$ since this would require, from equation (2), that $E\pi > \frac{2}{(p+\Delta p)(1-p)}$. These expressions cannot hold simultaneously since $\Delta p < p$. Thus, Project 2 will have zero units for all $E\pi < \frac{1}{p(1-p)}$ and one unit for all $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p)}]$, exactly as in the benchmark model. Finally, note that $E\pi > \frac{1}{\Delta p(1-p)}$ is not possible if $\pi_H \in R4'$.

Now consider cases with $\pi_H \in R5'$. First note from equations (1) and (2) that Project 2 will never enter if $E\pi < \frac{1}{p(1-p)}$, so no predatory capital raising is possible in such cases. However, from equation (2) it can profitably enter as a two-unit firm if $E\pi > \frac{2}{(p+\Delta p)(1-p)}$ and similarly from equation (3) the second unit's incremental NPV is positive whenever $E\pi > \frac{1}{\Delta p}$. Thus, Project 2 will raise two units whenever $E\pi > \max[\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)}]$. The result follows since $E\pi \leq \frac{1}{\Delta p(1-p-\Delta p)}$ must hold for $\pi_H \in R5'$, and, from Lemma 1, Project 2 has one unit when $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p-\Delta p)}]$ in the benchmark model.

Finally, for $\pi_H \in R6'$, from equations (1) and (2), 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 $E\pi > \frac{1}{\Delta p(1-p-\Delta p)}$ (from equation (3)). Thus, its capital allocation conforms to its allocation in Lemma 1.

Now consider the possibility of entry deterrence. Note from equation (1) that if $E\pi > \frac{1}{p(1-p-\Delta p)}$, project 2's first unit will always be positive NPV, while if $E\pi < \frac{1}{p(1-p)}$ entry deterrence is also impossible because Project 2 has zero units of capital in the benchmark model. Thus, we must only consider cases with $E\pi \in R3$. Since $E\pi > \frac{1}{p(1-p)}$ in this range, entry deterrence must imply $K_1 = 2$. From Table 3 this is possible only if $\pi_H \in R5'$ or $R6'$, and from the analysis above it occurs in $R5'$ only if there is no predatory capital raising. The result follows.

Proof of Proposition 1: First note that if integration does not invite predatory capital raising, the horizontal firm with $\alpha = 0$ will always integrate. To see this, note that if Project 2's capital level is not affected by integration, the horizontal firm will always allocate at least as much capital in the good state as Project 1 would raise in the benchmark model, since $\pi_H \geq E\pi$. However, it is able to redeem that capital in the bad state, so that each unit has an ex ante price of q instead of 1, for a minimum flexibility gain from integration of $1 - q$. If the horizontal firm raises its allocation in the good state relative to the benchmark model, that unit must have a positive NPV, which implies that the integration gain must be larger than $1 - q$. Finally, if integration causes Project 2 to decide not to enter when it otherwise would,

this increases the expected payoff for HQ by giving it positive surplus in states of the world where both projects are successful. Thus, there is never any cost of integration if it does not invite predatory capital raising, and always a gain in expectation.

Now assume that integration invites predatory capital raising. First note from Lemma 2 and Table 3 that if $\pi_H \in R2'$ or $R3'$, predatory capital raising implies that the integrated firm is driven out of the market completely, whereas Project 1 was able to profitably enter in such cases in the benchmark model. Thus, integration will not occur. Next assume $\pi_H \in R5'$, the only other case where predatory capital raising is possible. From the proof of Lemma 2, we know that predatory capital raising in this case requires $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p-\Delta p)}]$ (i.e., $E\pi \in [R3, R4, \text{ or } R5]$). From Lemma 1, if $E\pi < \frac{1}{\Delta p(1-p)}$ (i.e., $E\pi \in [R3 \text{ or } R4]$), HQ will compare the integration payoff with a benchmark equilibrium where both projects have one unit of capital. From Table 3, predatory capital raising with $\pi_H \in R5'$ implies two units for Project 2 and one unit for Project 1 if $\tilde{\pi} = \pi_H$. Thus, the joint expected payoff for HQ and Project 1 if they are integrated equals

$$p(1-p-\Delta p)E\pi - q \quad (4)$$

whereas their joint expected payoff in the benchmark model is

$$p(1-p)E\pi - 1. \quad (5)$$

Subtracting (5) from (4), we get the condition stated in the proposition.

Now assume $E\pi > \frac{1}{\Delta p(1-p)}$ (i.e., $E\pi \in R5$). In this case, the benchmark model has $K_1 = 2$ (if $\tilde{\pi} = \pi_H$) and $K_2 = 1$. Thus, the joint payoff of HQ and Project 1 in the benchmark model is

$$(p + \Delta p)(1-p)E\pi - 2. \quad (6)$$

Subtracting (6) from (4), 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 hold simultaneously. To see this, note that this would require that $2-q > \frac{1}{1-p}$, and this is more likely to hold the lower is q . The lowest possible q under these two conditions and $\pi_H \in R5'$ corresponds to the case $\pi_H = \frac{1}{\Delta p(1-p-\Delta p)}$ 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, predatory capital raising can occur only in three ranges of π_H , and in each range there is a minimum level of

$E\pi$ beyond which predatory capital raising occurs. We prove the result by showing that for a given p and Δp , the area of the (q, π_H) parameter space corresponding to predatory capital raising falls, while the space corresponding to deterrence rises as α rises.

For notational simplicity, 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 $\Psi_4 \equiv p(1 - p) + \alpha p$. Now note that Ψ_i in each case is clearly increasing in α , so that $\frac{1}{\Psi_i}$ is decreasing.

Now consider the shape of the predatory capital raising regions. In particular, consider the predatory capital raising region with $\pi_H \in R5'$. 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 will occur for all q such that $q\pi_H > \max(\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)})$ or, equivalently, all $q > \frac{\max(\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)})}{\pi_H}$, which is decreasing in π_H .

Given this analysis, to prove the result for predatory capital raising in region $R5'$, 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 analysis provides the results for predatory capital raising in regions $R2'$ and $R3'$. The Mathematica code for the full algebraic analysis is available upon request.

Finally, consider the deterrence region. First note that 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 must weakly increase the deterrence area holding $\frac{1}{\Psi_1}$ fixed (since we always have either deterrence or predatory capital raising if $E\pi \in R3$ and $\pi_H \in R5'$ by Lemma 2). Now note that as $\frac{1}{\Psi_1}$ falls, the deterrence area is weakly increased as deterrence (which always occurs for $E\pi \in R3$ and $\pi_H \in R6'$ according to Lemma 2) replaces any predatory capital raising in the $E\pi \in R3$ region between the old and new $\frac{1}{\Psi_1}$ (i.e., the area that used to have $\pi_H \in R5'$ but now has $\pi_H \in R6'$).

Proof of Proposition 2: For the last sentence, note that if integration does not invite predatory capital raising or deter entry, then it does not affect Project 2's capital allocation at all. To see this note that Project 2 has more than one unit of capital in the benchmark model only if $E\pi > \frac{1}{\Delta p(1-p-\Delta p)}$, and it will continue to have two units of capital in such cases following integration (from equations (2) and (3), being a two unit firm is always profitable in this case, and the second unit has a positive incremental NPV). Thus, as in the

proof of Proposition 1, integration has a minimum flexibility benefit of $1 - q$ and no offsetting cost.

For the first part of the result, first consider cases where predatory capital raising drives the integrated firm out of the market, ie $\pi_H \in R2'$ or $R3'$. First, if $\pi_H \in R2'$, from equations (1) and (3) it is clear that Project 2 will 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. Now note that 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 as a one unit firm according to equation (1)). Thus, HQ and Project 1 have a joint payoff of

$$(p + \Delta p)E\pi\alpha \quad (7)$$

if they are integrated. If they are not integrated, their joint benchmark payoff is either

$$pE\pi(1 + \alpha) - 1 \quad (8)$$

if $E\pi \in R2$ or

$$E\pi(p(1 - p) + 2\alpha p) - 1 \quad (9)$$

if $E\pi \in R3$. Subtracting (8) from (7), we have that integration will be chosen despite predatory capital raising whenever $E\pi < \frac{1}{p - \Delta p\alpha}$ if $E\pi \in R2$. Subtracting (9) from (7) yields $1 - E\pi(\alpha p + p(1 - p) - \alpha\Delta p) < 0$, where the inequality follows from the fact that $E\pi > \frac{1}{p(1-p)}$ when $E\pi \in R3$, so predatory capital raising always deters integration in this case.

Now consider cases with $\pi_H \in R5'$. In this case predatory capital raising implies $K_2 = 2$ and $K_1 = 1$ (if $\tilde{\pi} = \pi_H$). Note from Lemma 2 that this requires $E\pi > \frac{1}{p(1-p)}$ given $\Delta p \leq p(1 - p)$. If they are integrated, HQ and Project 1 have a joint payoff of

$$E\pi(2p(p + \Delta p)\alpha + p(1 - p - \Delta p)(1 + \alpha) + (p + \Delta p)(1 - p)\alpha) - q. \quad (10)$$

If they are not integrated and $E\pi \in R5$, according to Lemma 1 they have a joint payoff of

$$E\pi(2p(p + \Delta p)\alpha + (p + \Delta p)(1 - p)(1 + \alpha) + p(1 - p - \Delta p)\alpha) - 2. \quad (11)$$

Subtracting (11) from (10) yields

$$2 - q - \Delta pE\pi < 0. \quad (12)$$

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 (12) yields $\frac{\Delta p-p}{1-p} < 0$, implying that integration is never 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 equal to (9). Subtracting (9) from (10) and rearranging proves the second bullet.

For the remainder of the result, note that deterrence implies $K_2 = 0$ and $K_1 = 2$ (if $\tilde{\pi} = \pi_H$). Thus, the joint payoff of HQ and Project 1 if they are integrated is

$$(p + \Delta p)E\pi(1 + \alpha) - 2q. \quad (13)$$

The only benchmark equilibrium that is relevant given deterrence has one unit of capital for each firm, so their joint payoff is equal to (9). Subtracting (9) from (13) and rearranging provides the result.

Proof of Proposition 3: The first part of the result relating to entry deterrence follows from the proof of the last part of Proposition 2 above, substituting $\alpha = 1$. The second part follows from the remainder of Proposition 2 with $\alpha = 1$. In particular, note that predatory capital raising is not possible with a single downstream firm if $\pi_H \in R2'$ or $R3'$. To see this, note from Table 2 that the border between $R3'$ and $R4'$ with $\alpha = 1$ is given by $\frac{1}{2p-p(p+\Delta p)} < \frac{1}{p}$, so we must have $\pi_H \leq \frac{1}{p}$. But from equations (1) and (2) we see that Project 2 can never successfully enter if $E\pi < \frac{1}{p}$, so we can never have $\pi_H \in R2'$ or $R3'$ in a region of $E\pi$ where predatory capital raising is possible.

Next consider cases with $\pi_H \in R5'$. From Table 2 we see that 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 denote the horizontal HQ. Furthermore, let P_1 be the equilibrium probability of success for project 1 conditional on $\tilde{\pi} = \pi_H$ if DS does not buy project one, and similarly let P_2 equal the equilibrium probability of success for Project 2 if DS does not buy project 1. Then let P_1^* and P_2^* be the equilibrium probabilities of success conditional on $\tilde{\pi} = \pi_H$ if DS does buy project 1. We begin by showing that if integration by DS will not deter entry, then the total probability of success for Projects 1 and 2 conditional on $\tilde{\pi} = \pi_H$ will always be at least as great under integration by DS as under the alternative equilibrium

(ie, $P_1^* + P_2^* \geq P_1 + P_2$), and then show that this implies the DS firm will always purchase Project 1 if its purchase does not deter entry.

Note that if DS does not purchase Project 1, the equilibrium structure will be as in Proposition 1. Also, anytime H would deter entry with its purchase, DS would as well according to Lemma 2 and Table 2. Thus, there are three possibilities for what could happen if DS does not integrate with Project 1 conditional on DS integration not causing entry deterrence: 1) it could remain as a stand alone; 2) it could be purchased by H with no effect on Project 2; 3) it could be purchased by H despite inviting predatory capital raising by Project 2. Consider possibility 1). In this case, DS' allocation to Project 1 will be at least as great as its allocation in the benchmark model according to the proof of Proposition 2. Furthermore, Project 2 will have the same capital level under DS integration as in the stand-alone game, or it will have more because of predatory capital raising (we have ruled out entry deterrence caused by DS integration, and the only time project 2 has 2 units of capital in the benchmark model is when project 1 will also have 2 units, so it will still prefer 2 units under DS integration). Now consider possibility 2). Similarly here, Project 2 must have the same capital level under DS integration as under H integration, or it will have more because of predatory capital raising. Project 1 will have at least as much capital under DS integration if it does not invite predatory capital raising as under H integration according to Table 2. If DS integration invites predatory capital raising, either H integration will as well, in which case $P_1^* + P_2^* = P_1 + P_2$, or H integration will not. Note from the Proof of Proposition 3 that DS integration can invite predatory capital raising only if $E\pi \in R3$ or $R4$. Thus, if DS integration invites predatory capital raising but H integration does not, capital levels under H integration will be $K_1 = 1$ or 2 and $K_2 = 1$, while under DS integration they will be $K_1 = 1$ and $K_2 = 2$. Thus, we always have $P_1^* + P_2^* \geq P_1 + P_2$ under possibility 2). Finally consider possibility 3). From Proposition 1, we know that if H integrates despite predatory capital raising, it must be that $\pi_H \in R5'$, $E\pi \in R3$ or $R4$, $K_1 = 1$ and $K_2 = 2$. But from Table 2 we see that the $R5'/R6'$ border is given by $\frac{1}{2\Delta p - p\Delta p - \Delta p^2}$ when $\alpha = 1$, while the $R4'/R5'$ border is given by $\frac{1}{\Delta p(1-p)} > \frac{1}{2\Delta p - p\Delta p - \Delta p^2}$ when $\alpha = 0$. Thus, $\pi_H \in R5'$ with $\alpha = 0$ implies that $\pi_H \in R6'$ when $\alpha = 1$, so there can be no predatory capital raising and in the relevant DS equilibrium either entry is deterred (if $E\pi \in R3$), which we have ruled out for now, or $E\pi \in R4$ and $K_1 = 2$ and $K_2 = 1$, so that $P_1^* + P_2^* = P_1 + P_2$.

We now show that as long as $P_1^* + P_2^* \geq P_1 + P_2$ and DS integration does not deter entry, DS will always bid weakly more for Project 1. 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,

$$E\pi(P_1 + P_2). \quad (14)$$

If it does acquire Project 1, its total payoff can be written as

$$E\pi(P_1^* + P_2^* + P_1^*(1 - P_2^*)) - q1_{P_1^*=p} - 2q1_{P_1^*=p+\Delta p}. \quad (15)$$

DS' willingness to pay can thus be written as

$$E\pi(P_1^* + P_2^* + P_1^*(1 - P_2^*) - P_1 - P_2) - q1_{P_1^*=p} - 2q1_{P_1^*=p+\Delta p} \quad (16)$$

If Project 1 would be a stand alone without DS integration, its payoff is

$$E\pi(P_1(1 - P_2)) - 1 * 1_{P_1=p} - 2 * 1_{P_1=p+\Delta p}, \quad (17)$$

and if H acquires it their joint payoff is

$$E\pi(P_1(1 - P_2)) - q1_{P_1=p} - 2q1_{P_1=p+\Delta p}. \quad (18)$$

Now we consider each possible outcome described above and show that DS' willingness to pay is always at least as great as the payoff enjoyed by the owner of Project 1 in the alternate equilibrium. Note that (18) is always greater than (17) for a constant P_1 and P_2 .

First consider cases with $P_1^* = P_1$. If $P_2^* = P_2$, then DS' willingness to pay is $E\pi(P_1(1 - P_2)) - q1_{P_1=1} - 2q1_{P_1=2}$, which is clearly weakly greater than both (17) and (18). If $P_2^* > P_2$, this only increases DS' willingness to pay.

Now consider cases with $P_1^* > P_1$. If $P_2^* = P_2$ then (16) minus (18) equals $q(\pi_H((P_1^* - P_1)(2 - P_2)) - 1) > 0$, where the inequality follows from the fact that the second unit is positive NPV for DS iff $\pi_H > \frac{1}{\Delta p(2 - P_2^*)}$ and $P_1^* - P_1 \geq \Delta p$. Next note that $P_2^* < P_2$ can happen along with $P_1^* > P_1$ only in possibility 3) above, so we must have $P_1 = p$, $P_2 = p + \Delta p$, which then implies $P_1^* = p + \Delta p$ and $P_2^* = p$ since we have disallowed entry deterrence. Then (16) minus (18) equals $q(\Delta p\pi_H - 1) > 0$, where the inequality follows from the fact that $\pi_H > \frac{1}{\Delta p(1 - p)}$ in order for H to integrate in the face of predatory capital raising according to Proposition 1.

Finally, consider the case $P_1^* < P_1$ with $P_2^* > P_2$. According to Table 2, the DS firm will always supply at least one unit of capital if it integrates since, from the proof of Proposition 3, predatory capital raising is only possible if $\pi_H \in R5'$. Thus, we have $P_1^* = p$, $P_1 = p + \Delta p$, $P_2^* = p + \Delta p$, and $P_2 = p$ as the only possible case. Then (16) minus (18) equals $q(1 - \Delta p\pi_H) > 0$. To see the inequality, note that $P_1^* < P_1$ implies predatory capital raising, which is

possible for the DS firm only if $\pi_H \in R5'$, which implies $\Delta p \pi_H < \frac{\Delta p}{\Delta p(2-p-\Delta p)} < 1$.

Proof of Proposition 5: For part (a), note that DS is always a weakly better integrator than H conditional on entry deterrence. To see this set $P_1^* = P_1$ and $P_2^* = P_2 = 0$ and subtract (18) from (16), which yields zero. Now set $P_1^* > P_1$, the only other possible case, and subtract to get $q(2\Delta p \pi_H - 1) > 0$, where the inequality follows from the fact that the expression in parentheses equals the NPV of the second unit of capital conditional on $\tilde{\pi} = \pi_H$, so $P_1^* > P_1$ only if this is positive.

For parts (b) and (c), note that DS integration always leads to $K_1 = 2$ since we have assumed entry deterrence, while H integration must have $K_1 = 1$ in the good state since $K_1 = 2$ would deter entry and we have assumed the horizontal firm is willing to integrate, so $K_1 = 0$ is impossible. Thus, if H integration does not affect Project 2, we have $P_1^* = p + \Delta p$, $P_1 = p$, $P_2^* = 0$ and $P_2 = p$. Subtracting (18) from (16) yields the condition in part (b) of the proposition. If H integration invites predatory capital raising, we have the same except that $P_2 = p + \Delta p$, so subtracting (18) from (16) yields the condition in part (c) of the proposition.

Proof of Proposition 6: Follows from the preceding discussion in the text.

Proof of Proposition 7: First consider part (a) of the proposition. For $E\pi$ in this range, Project 2 cannot profitably enter if it expects Project 1 to be specialized to the downstream firm, 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). Since we have assumed that specialization will always be optimal with an alliance or integration, this implies that entry will be deterred in either case. Integration is always superior conditional on deterrence (because of its flexibility value), so in this range HQ will choose either stand alone or full integration. The joint payoff of HQ and Project 1 in the benchmark stand-alone model is $E\pi(3p - p^2) - 1$ (see below for the proof that each project has one unit in the benchmark model over the relevant range), which does not vary with q for a given $E\pi$ (note that we allow π_H to vary with q to keep $E\pi$ constant). Their integrated payoff depends on whether they will take on one or two units if $\tilde{\pi} = \pi_H$. Their expected payoff if it is one unit equals $E\pi(2p(1+\delta_1)) - q$, and if it is two units $E\pi(2(p+\Delta p)(1+\delta_1)) - 2q$. Now note that both of these rise as $(1-q)$ rises, but the latter rises faster. Thus, they will either choose 2 units for all $(1-q)$ or first choose 1 unit when $(1-q)$ is small, then switch to two units as it rises. Either way, their integration payoff rises smoothly as $(1-q)$ rises, which proves the result.

Now consider part (b). In this range of $E\pi$, Project 2 will always enter against a specialized Project 1 if it expects to face a one unit competitor, but never if it expects to face a two unit competitor. Also, Project 2 will never take on two units unless it can predate against an integrated firm (predatory capital raising against an alliance is impossible since its capital level is fixed ex ante). Now note that our assumption that $p(1 - p - \Delta p)(1 - \delta_2) > \Delta p(1 - p)(1 + \delta_1)$ implies that Project 1 will never take on two units of capital if it is in an alliance. To see this note that it will take on two units if $K_2 = 1$ iff $E\pi > \frac{1}{\Delta p(1-p)(1+\delta_1)}$, which is impossible in the range of $E\pi$ we consider given our assumption. This assumption 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 any different, we would have to have $E\pi > \frac{1}{\Delta p(1-p)}$, which clearly cannot hold if $E\pi > \frac{1}{\Delta p(1-p)(1+\delta_1)}$ is impossible. Altogether, this analysis implies that an alliance always dominates stand alone since capital levels are the same, but the firms get the benefits of specialization, which is always optimal by assumption.

Now it remains to compare an alliance to integration. First we show that integration cannot invite predatory capital raising given our assumptions. From the proof of Proposition 3 we know that predatory capital raising can occur with a single downstream firm only if $\pi_H \in R5'$. An equivalent result will be true with specialization since the incentive to provide capital to Project 1 can only be stronger. The analogous range for π_H with specialization is $[\frac{1}{\Delta p(2(1+\delta_1)-p(1-\delta_2))}, \frac{1}{\Delta p(2(1+\delta_1)-(p+\Delta p)(1-\delta_2))}]$. In this range, if Project 2 does not predate with two units, the integrated firm will allocate two units to Project 1 if $\tilde{\pi} = \pi_H$. Thus, given the statement above that Project 2 will not enter against an integrated firm if it expects to face a $K_2 = 2$ competitor, the predatory capital raising decision is a decision between no entry and entry with two units. Predatory capital raising will therefore occur iff $(p + \Delta p)(1 - p)E\pi(1 - \delta_2) > 2$, or $E\pi > \frac{2}{(p+\Delta p)(1-p)(1-\delta_2)}$. 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 we have ruled out by assumption.

Given that predatory capital raising is impossible, integration either deters entry if $\pi_H > \frac{1}{\Delta p(2(1+\delta_1)-p(1-\delta_2))}$ (the condition for the integrated firm to take on two units of capital), or has both projects with one unit of capital if $\pi_H < \frac{1}{\Delta p(2(1+\delta_1)-p(1-\delta_2))}$. In the latter case integration must be better than an alliance since it has the same capital levels but adds the ability to redeem capital if $\tilde{\pi} = 0$. In the former case, integration yields a joint payoff of

$$E\pi(2(p + \Delta p)(1 + \delta_1)) - 2q, \quad (19)$$

whereas the alliance equilibrium, which has one unit for each project, yields

$$E\pi(2p(1 + \delta_1) + p(1 - p)(1 - \delta_2)) - 1. \quad (20)$$

Subtracting (20) from (19) yields the condition in the proposition.

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Table 1
Payoff Matrix with Potential Integration

<i>Successful?</i>		HQ	Proj 1	Proj 2
<i>Both</i>	stand-alone	$2\alpha\tilde{\pi}$	0	0
	Integrated	$2\alpha\tilde{\pi}$	-	0
<i>1 alone</i>	stand-alone	$\alpha\tilde{\pi}$	$\tilde{\pi}$	0
	Integrated	$\alpha\tilde{\pi} + \tilde{\pi}$	-	0
<i>2 alone</i>	stand-alone	$\alpha\tilde{\pi}$	0	$\tilde{\pi}$
	Integrated	$\alpha\tilde{\pi}$	-	$\tilde{\pi}$
<i>Neither</i>		0	0	0

Table 2
Critical Market Size Ranges under Integration

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 3
 HQ and Project 2 Capital Allocations

<u>Profit Region</u>	<u>Project 2</u>	
π_H in	HQ Allocation	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

Fig. 1. Benchmark time line

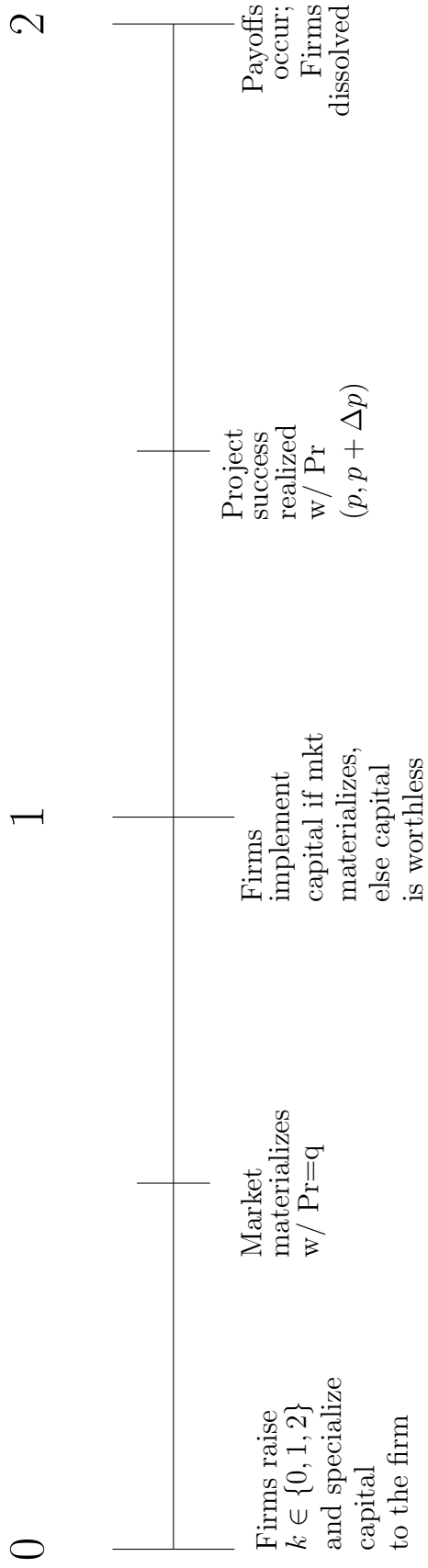


Fig. 2. Time line with Integration

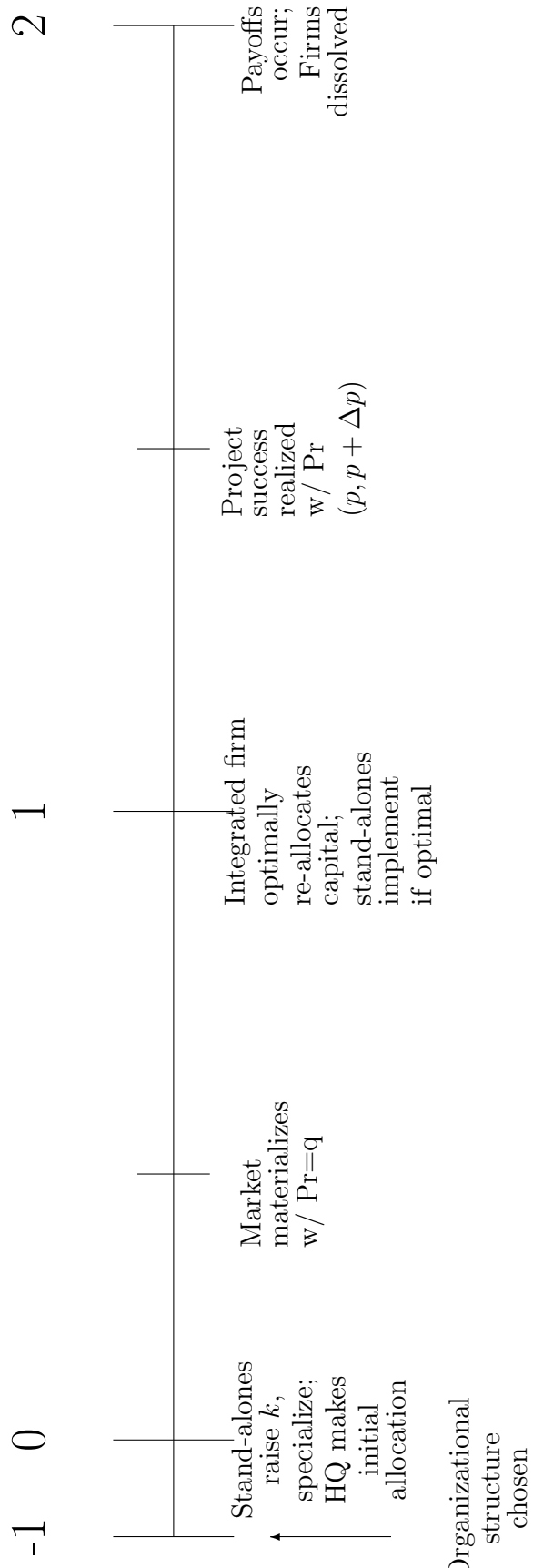


Fig. 3. Plots regions where horizontal integration causes entry deterrence (the black region) or predatory capital-raising (the shaded regions). The figure shows that entry deterrence tends to occur when uncertainty is relatively high and market size is moderate. Predatory capital-raising tends to occur 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 $E\pi$, i.e., R1, R2, R3, etc. The horizontal lines represent the border between different critical regions for π_H , i.e., R1', R2', R3', etc. The graph is drawn assuming the following model parameters: $p = 0.45$, $\Delta p = 0.17$, and $\alpha = 0$.

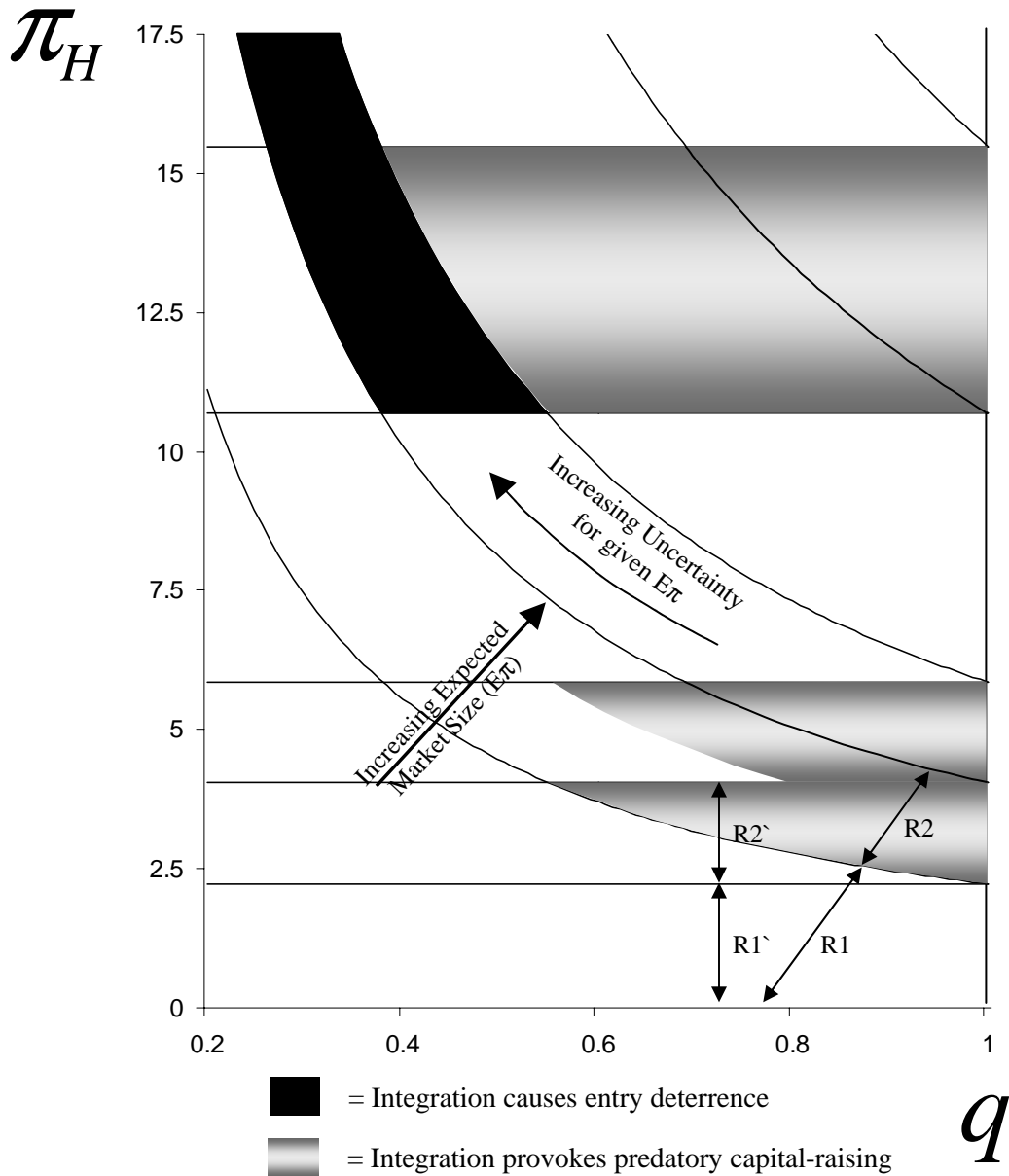


Fig. 4. Plots a horizontal integrator's integration decision using the same model parameters and setup as Fig. 3. The shaded regions represent areas where integration is avoided due to the threat of predatory capital raising. The figure shows that a horizontal integrator avoids integration whenever predatory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

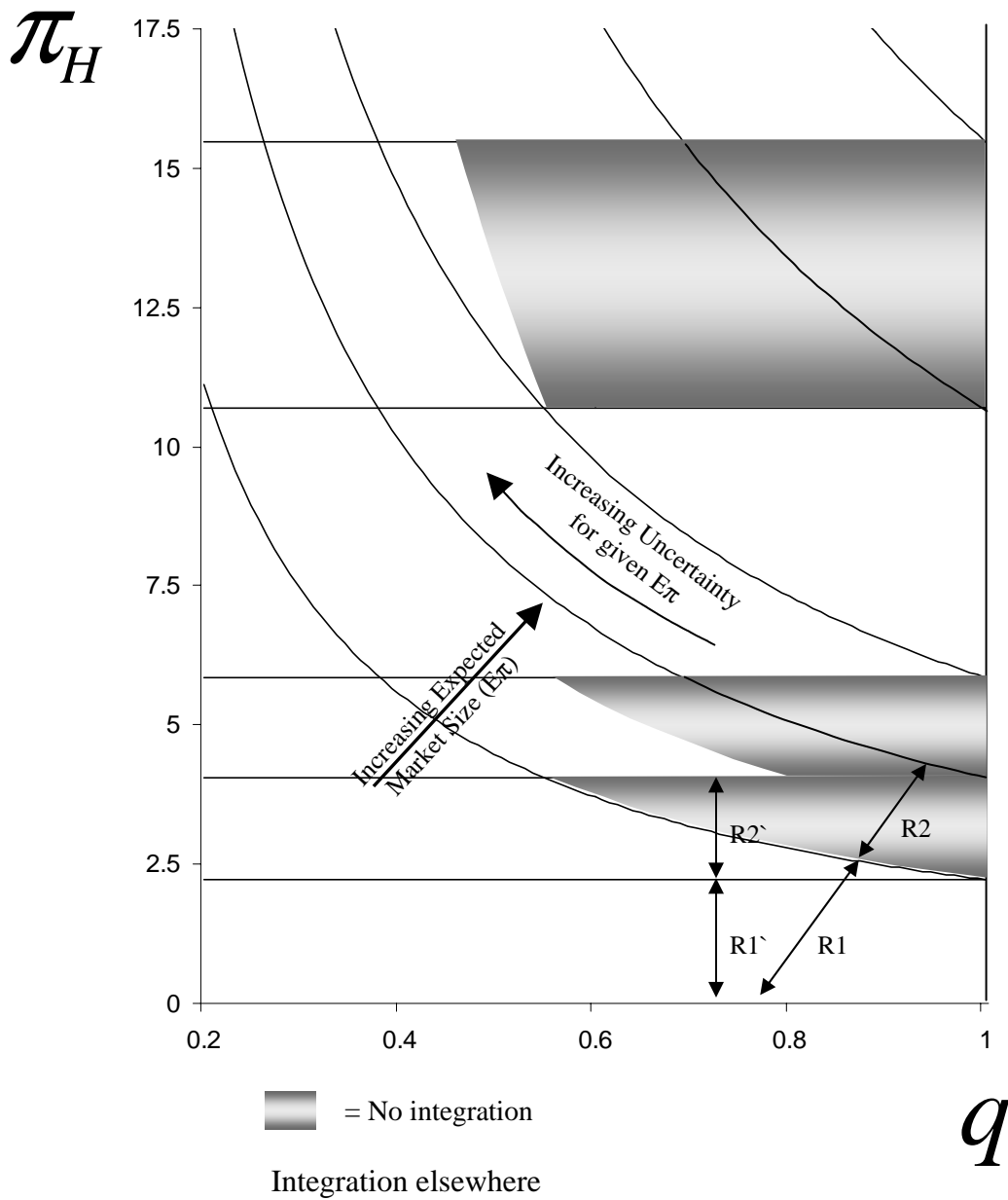


Fig. 5. Plots a single downstream integrator's integration decision using the same model parameters and setup as the preceding figures, except that $\alpha = 1$. The shaded region represents cases where integration is avoided so as to preserve Project 2's participation (i.e., avoid entry deterrence). 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.

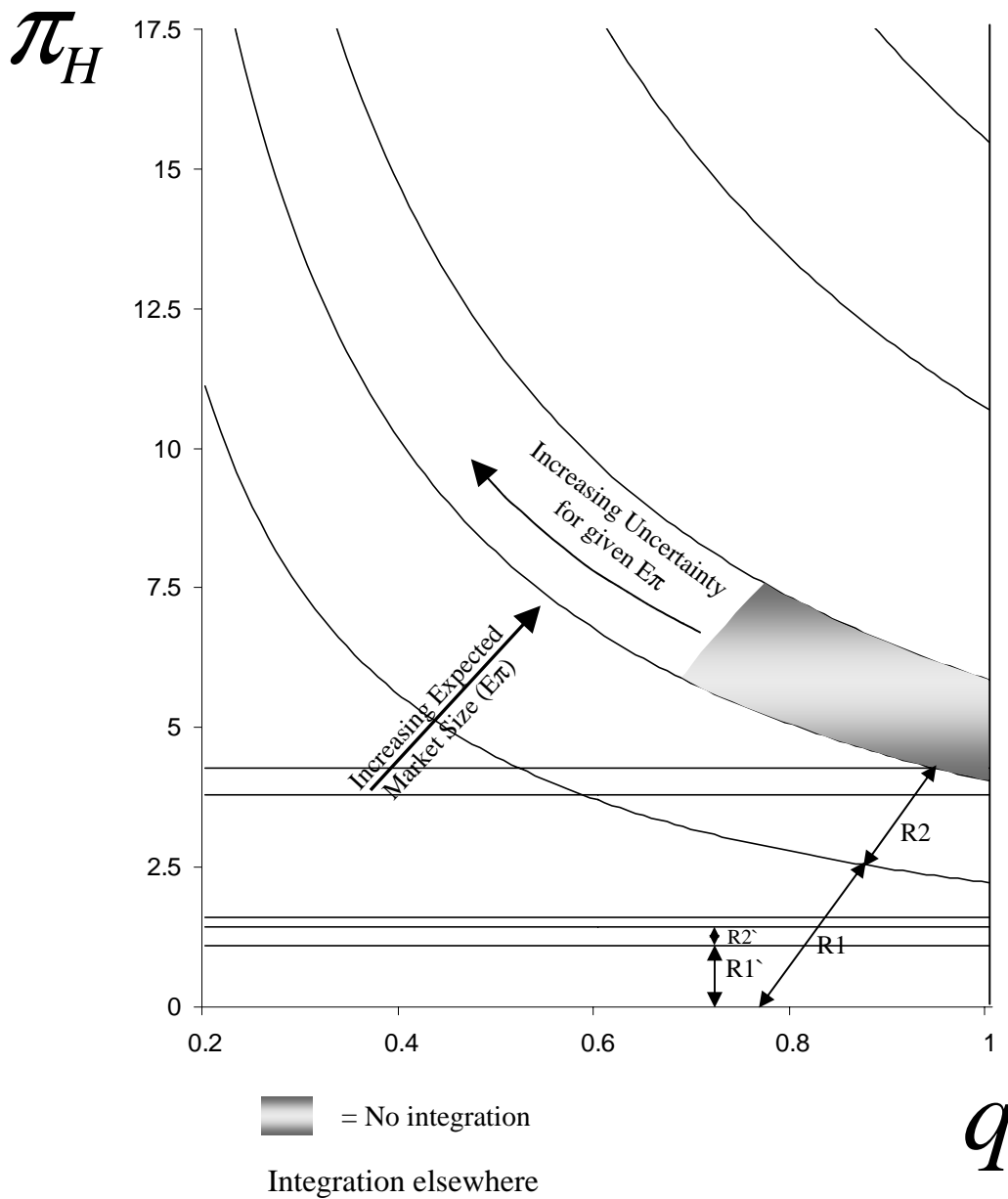


Fig. 6. Plots the outcome of competition between a single downstream integrator and a horizontal integrator for control of Project 1 using the same model parameters and setup as the preceding figures. There is horizontal integration in the black region, no integration in the shaded region, and vertical integration elsewhere. The figure shows that vertical integration is superior unless it will deter entry while horizontal integration will not. Integration is avoided altogether only when vertical integration will deter entry while horizontal integration will invite predatory capital-raising.

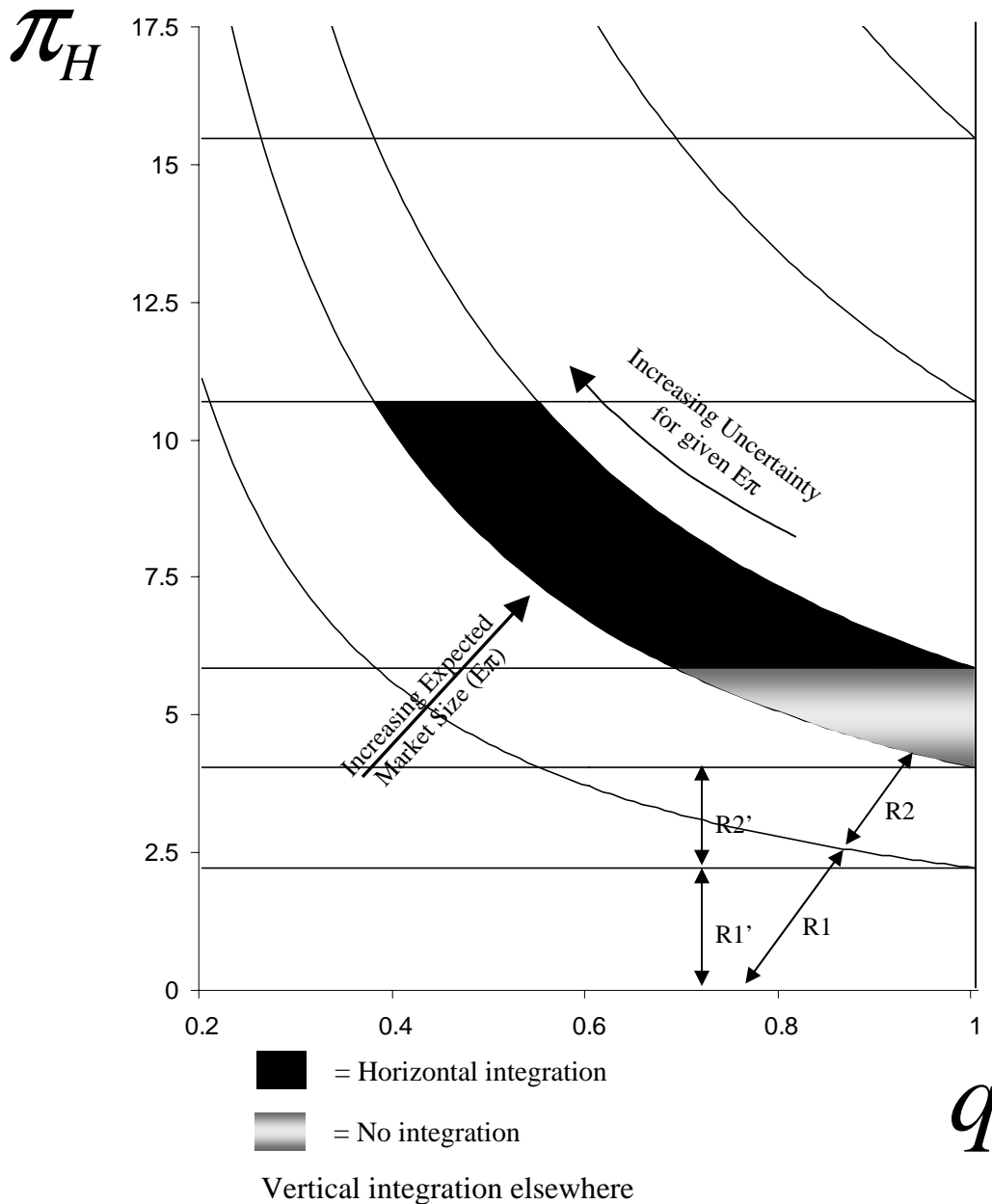


Fig. 7. Plots the alliance versus integration decision for a vertical integrator using the same model parameters (with $\alpha = 1$) and general setup as the preceding figures, adding $\delta_1 = 0.05$, and $\delta_2 = 0.1$. An alliance is chosen in the black region, no alliance and no integration in the shaded region, and integration elsewhere. The figure shows that no alliance and no integration is chosen when both would deter entry and the value of flexibility is not too high. An alliance is chosen when it will not deter entry but full integration will, and the value of flexibility is not too high. The curved lines in this case demarcate the $E\pi$ regions for parts (a) and (b) of Proposition 10.

