MARKET STRUCTURE, INTERNAL CAPITAL MARKETS, AND THE BOUNDARIES OF THE FIRM

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Abstract. We study how the optimal organizational design of a firm depends on the features of the product market in which it operates. We focus on internal capital markets, which provide the flexibility to allocate resources efficiently ex post, but do not allow firms to commit to specific capital allocations ex ante. Depending on market size, uncertainty, and the firm's horizontal or vertical relation to the industry in question, these features of an internal capital market can either invite predation or deter entry from potential competitors. We show how these effects translate into ex ante optimal integration decisions. We then illustrate how organizational forms like strategic alliances can dominate either vertical or horizontal integration by offering some of the benefits of integration without imposing strategic costs.

Keywords: Internal Capital Markets, Theory of the Firm, Product Market Competition

1. Introduction

Most theories of the firm hold a firm's economic environment fixed and study the costs and benefits of alternative organizational structures. Our goal in this essay is different. In this paper, we study how the optimal organizational design of a firm depends on the economic environment in which it operates. In our model, the equilibrium configuration of firms in an industry as well as these firms' internal organizational structures are endogenously driven by the market's size and profit uncertainty.

Our analysis is motivated by a number of empirical observations. First, patterns of integration in various markets seem to be related to the nature of firms operating in these markets. For example, consider the biotechnology sector. In this industry, large pharmaceutical firms and small, boutique research organizations coexist. It is common to see both vertical integration (outright acquisitions of R&D shops by pharmaceutical firms), horizontal integration (mergers between pharmaceuticals and between complimentary research organizations), and strategic alliances. This contrasts with

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other industries, equally technological in nature, which see much less heterogeneity in organizational design.

Second, 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."

Wal-Mart's exit of the online DVD rental market provides two insights that are key to our analysis. The first is that integration—whether horizontal or vertical—by its very nature entails operating an internal capital market. The second is that the expected profitability and uncertainty in an industry are important determinants of a firm's optimal strategy.

Note that it was Wal-Mart, with the relatively more diverse internal capital market (and considerably deeper pockets) that chose to exit the industry, not Blockbuster. Wal-Mart could easily outspend Blockbuster 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. As Khanna and Tice (2001) and Guedj and Scharfstein (2004) demonstrate in related empirical work, this implies there is an important link between a firm's internal organizational structure and its behavior in product markets.

At the same time, news coverage of the event suggests that there is a high degree of uncertainty in the overall size and profitability of the online DVD rental market, and that this was an important component in their decision-making. At the time of Wal-Mart's pullout, industry analysts noted that "companies renting DVDs ... may all be running on borrowed time ... " in light of impending technological changes that stand to alter the underlying business model for movie distribution.

To capture these elements, we develop a simple model of integration in an uncertain environment. In our model, a firm has the potential to integrate into an industry where other firms also operate. If the firm chooses to integrate, it operates an internal capital market, re-directing resources towards or away from this industry after it has learned whether the industry is profitable. The configuration of firms in the industry affects overall industry profits, which in turn may cause firms to behave differently in the capital market, where they initially raise funds to invest in the industry.

First we analyze the strategic affects that this integration decision has on the fund-raising actions of the other firms in the industry. Based on these strategic affects, we then consider the optimal organizational design of a firm.

Two features of internal capital markets are important for our analysis. First, we assume that internal capital markets provide an integrated firm with the flexibility to move resources after it has learned about a division's potential profitability. In the language of Stein (1997), this flexibility allows firms to engage in ex-post winner picking. Along the lines of Maksimovic and Phillips (2002), we model the firm's internal capital markets decisions as though they arise from rational, profit-maximizing behavior on the part of headquarters.

If other firms were not present in the industry, the firm would generally always want to integrate into the industry. This is because in our model, flexibility is always valuable ex post. However, in some situations, this flexibility can have important strategic consequences. The financial slack created by the internal capital market may act as an endogenous barrier to entry that prevents the remaining standalone from entering the industry. This is likely to occur when the industry is very risky, and its expected size is moderate.

Second, following Robinson (2002), Scharfstein and Stein (2000), Rajan, Servaes, and Zingales (2000), and many others, we assume that the firm operating the internal capital market cannot commit to capital allocations in advance. This inability to commit can invite predation from the other firms in the industry, effectively limiting the integrated firm's commitment or driving it out of the industry completely. In essence, because a standalone firm in the industry has no financial slack, it can use fund-raising in the capital market to commit to aggressive actions in the product market. Such behavior is likely when the industry is less risky, and its expected size is small or moderate.

Both the scope for entry deterrence and predation and their effect on the firm's integration decision depend on how the potential integrator is related to the industry in question. If the integrator is neither a competitor nor vertically related to the contested market, the scope for predation is maximized while the chance of entry deterrence is minimized. Such an integrator is happy to deter entry, and thus avoids integration only when it invites predation.

On the other hand, a downstream integrator has its own stake in the success of the contested market, which naturally makes it more aggressive. This reduces the scope for predation, and increases the chance of entry deterrence. Furthermore, 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. In the limit, a downstream integrator with a large stake in the contested market will avoid integration only when it deters entry and uncertainty is low enough that the desire to have multiple potential sources of supply overpowers the flexibility value of the internal capital market.

In light of these findings, a natural question that arises is whether some intermediate organizational form can do better than either a standalone or an integrated firm can do. We address this question in a separate section of the paper, where we consider strategic alliances. 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 Hart and Moore (1998) or Grossman and Hart (1986), we assume that certain aspects of the physical synergy can be contracted upon, whereas the noncontractible aspects are captured by the internal capital market.

We model a strategic alliance between two firms as a contract that allows them to enjoy part of the physical synergies of integration without exposing the alliance project to the commitment uncertainty of the internal capital market. We then ask when alliances dominate traditional vertical or horizontal integration. The key result in this section is that vertical integrators may strictly prefer alliances to standard integration, since alliances deter entry less often. This is likely when 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 final step in our analysis is to assemble these pieces and consider multiple types of integration simultaneously. When horizontal and vertical integration are allowed to occur at the same time, 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 would 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. Ultimately our analysis results in a map that relates equilibrium configuration of firms in product markets and their organizational design choices to underlying exogenous technological features of product markets.

The papers that are most closely related to our analysis are Matsusaka and Nanda (2002), Cestone and Fumagalli (2005), and Robinson (2002). 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, therefore 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 (2002), where they provide firms with the possibility of contracting around the winner-picking that otherwise occurs in internal capital markets. While Robinson (2002) contrasts alliances with internal capital markets, Robinson (2002) 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. Like Matsusaka and Nanda (2002) and Cestone and Fumagalli (2005), our work builds on the real options literature, notably Dixit and Pindyck (1994). The fact that certain organizational structures invite predation is reminiscent of Bolton and Scharfstein (1990), in which there is a tension between the agency benefits of debt financing and the product market predation that debt invites.

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 the empirical implications of our theory in Section 7. Section 8 concludes. All proofs are collected in the Appendix.

2. The Benchmark Model

The primary unit of analysis in our model is an economic project which operates in a given market. There are two projects, 1 and 2. In the benchmark case, we focus on the two projects operating as standalone firms.

Each project can 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. Each project requires physical capital to initiate and implement research and development. The entire capital to be used must be put in place before any R&D activity can occur.

Denote each project's capital level at the start of the R&D phase as $K_i, i \in \{1, 2\}$. 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 $K_i = 2$. Throughout, we assume $\Delta p \leq p(1 - p)$ and $p < 0.5$.

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 unknown when research is initiated. If a project is successful alone, it is able to generate a net payoff of $\widetilde{\pi}$ by selling its product into the downstream market. If both projects are successful, they both generate a net payoff of zero. This is consistent, for example, with Bertrand price competition with homogeneous products. The random variable $\widetilde{\pi}$ can take on one of two values, $\widetilde{\pi} \in \{0, \pi_H\}$, with $\Pr[\widetilde{\pi} = \pi_H] = q$.[1] The realization of $\widetilde{\pi}$ is unknown until after the capital is fully employed. Capital employed to initiate R&D has no alternative use, and thus is worthless outside of the project.

As standalone firms, the two projects raise funds in a competitive capital market to purchase their physical capital. For simplicity, we assume there are no agency problems, so the projects can fully pledge their (verifiable) output to investors. The timing of the game is as follows. First the two projects simultaneously raise funds, and then they use those funds to buy and employ physical capital without knowing the amount of funds raised by their competitor. Finally, 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. For example, consider Project 1's capital raising choice. Let $E\pi \equiv q\pi_H$, and let Project 1's manager believe that Project 2's capital level is $K_2 = 1$. Then Project 1's manager is willing to raise \$1 and employ

[1] 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.

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 standalone game depend on expected market size in the following manner:*

		Capital Allocation:
Region	*Range of Expected Market Size* ($E\pi = q\pi_H$)	*(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 the two projects in 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 initial allocation of capital but before the final 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 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 standalone firm to use up the capital once they fully commit to the R&D effort. This 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.

It is important at this point to consider why an integrated firm would have a greater ability to reallocate capital at an intermediate stage. One possibility that is perfectly consistent with our model could be the necessity of physical coordination and specialization of resources. In other words, it could be easier for an integrated firm to coordinate types of resources, compatibility between resources, etc. for purely physical reasons. Furthermore, attempts to coordinate capital mobility outside an integrated firm could be subject to a hold-up problem that dilutes the incentive to coordinate. There can also be agency problems, where managers of standalone firms are unwilling to release their capital, whereas headquarters in an integrated firm holds both the property right and ultimate control right over all of the firm's capital. It is not essential to the model's results that the integrated firm has full flexibility and the standalone firm none, only that there is a significant difference and the gap cannot be eliminated *ex post*.

We also assume that one of HQ's divisions operates 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 only one. 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 $\widetilde{\pi}$) of $\alpha\widetilde{\pi}$, where $\alpha \in [0, 1]$. If both projects are successful, we assume that HQ gets a benefit of $2\alpha\widetilde{\pi}$. To operationalize this further, one could assume that if one project is successful, HQ engages in bilateral Nash bargaining with it, thus leading to an even split of $2\alpha\widetilde{\pi}$, the total surplus generated by their bilateral trade. If both are successful, HQ is able to enjoy the entire $2\alpha\widetilde{\pi}$ surplus since the two projects compete for its business. 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 standalone 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 standalones 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 standalone firm upon sole success is still $\widetilde{\pi}$. 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, and an intermediate move in which it can reallocate capital if it is integrated. Thus, HQ first decides whether or not Project 1 should

[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.

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 standalone 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.

After the integration decision is made, funds are raised simultaneously in a competitive capital market, and then capital is purchased and employed in each project to initiate the R&D phase.[3] If HQ and Project 1 are integrated, HQ then observes a private, unverifiable signal revealing the value of $\widetilde{\pi}$ prior to the final implementation of R&D. After observing this signal and Project 2's capital level, it chooses whether to reallocate any capital among its divisions. Finally, any project with capital at this stage finalizes its R&D, success or failure is determined according to the probability structure introduced in Section 2, and payoffs are realized. Figure 2 illustrates this modified timeline.

[Please see Figure 2]

Note that it is not essential that the standalone firm not observe $\widetilde{\pi}$ at the intermediate stage along with HQ. It is only necessary that a standalone firm is unable to raise or sell capital at this stage. The inability to raise capital could arise from an information asymmetry; the signal is private and unverifiable. The inability to sell capital could arise from physical incompatibility and lack of coordination, or an agency problem at the standalone firm. It is also not essential that HQ make an initial capital decision for Project 1; the model would be unchanged if the benefit of integration were that the firm could just wait until the signal of market size to allocate any capital to Project 1 at all.

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

[3]Note that if HQ and Project 1 are integrated, it does not matter if HQ raises funds on the capital market or uses internal funds to purchase the capital.

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, i.e. "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, i.e. "predation."

Whether integration invites predation 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 may be more opportunity for strategic predation by Project 2.

We solve the model via backward induction, starting with HQ's final capital allocation assuming integration. Clearly, if HQ learns that $\widetilde{\pi} = 0$ it redeems any capital previously provided to Project 1 and shuts it down. If it learns that $\widetilde{\pi} = \pi_H$, 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 $p(1-p_2)\pi_H(1+\alpha)+p_2(1-p)\alpha\pi_H+2p_2p\alpha\pi_H$, 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. 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. 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 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 Project 1's final allocation with its own allocation. Also, if Project 2 enters in region $R2'$, it will drive the integrated firm to zero (note that it can never profitably enter in region $R1'$). Whenever these possibilities induce Project 2 to take on a higher capital level under integration than in the benchmark model, we call this "predation." 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 $1^{\pi_H}_{(Ri')}$ 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

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

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

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

The strategic effect of Project 2's capital raising decision is seen in the fact that it faces a zero or one unit firm instead of a one or two unit firm at higher levels of π_H when it increases K_2 from one to two.

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):

(3)

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

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 predation and 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).

Note from Table 2 that by definition π_H must always fall in the same or higher region than $E\pi$. The possibilities for predation and deterrence are as follows.

Lemma 2. *Predation occurs if and only if: (a) $\pi_H \in R2'$ and $E\pi > \frac{1}{p}$; (b) $\pi_H \in R3'$ and $E\pi > max(\frac{1}{\Delta p + p^2}, \frac{2}{p+\Delta p})$; or (c) $\pi_H \in R5'$ and $E\pi > max(\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)})$. Entry deterrence occurs if and only if $E\pi \in R3$ and either $\pi_H \in R6'$ or $\pi_H \in R5'$ and there is no predation according to part (c).*

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 $p = 0.45$ and $\Delta p = 0.17$.

[Please see Figure 3]

In this figure, the curved lines represent iso-expected market size lines: they fix Eπ 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.

Predation, 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, predation 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 $\alpha = 0$. We then proceed to show the effect of increases in α and the extreme case of a single downstream firm in the next section.

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 the following result, which describes whether a horizontal integrator optimally chooses to integrate with Project 1:

Proposition 1. *If integration does not invite predation, integration always occurs. If integration does invite predation, integration never occurs unless the following three conditions hold:*

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

Clearly, the horizontal firm is always happy to integrate and enjoy the benefits of flexibility when the industry can sustain at least one integrated firm, and 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. The only exception occurs when expected market size is small enough relative to the degree of uncertainty that the value of the internal capital market exceeds the strategic cost of facing a more aggressive competitor (note that in the exception 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 the integrated firm 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]

Clearly, the regions with non-integration occur only when integration would invite predation (compare this figure to Figure 3). Notably, the horizontal firm always avoids integration when predation would drive it out of the market completely ($\pi_H \in R2'$ or $R3'$). However, when predation 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 predation region in Figure 3).

5. Vertical Integration

Many innovative markets are characterized by different types of integration in seemingly similar circumstances. For example, in the Pharmaceutical/Biotechnology industry drug innovation may take place in standalone firms with a single project, or in multi-project biotechnology firms, or in vertically integrated pharmaceutical firms. Mergers occur both among biotech firms and between pharmaceutical and biotech firms. What drives one type of integration versus the other? Can the competitive environment make a horizontal internal capital market more profitable than a vertical one?

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 standalone project tends to underinvest relative to the optimum because it receives only part of the surplus. Thus, predation 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 predation and increases the scope for entry deterrence: an increase in α decreases the area of the parameter space in which integration causes predation, 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 predation 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 predation and deterrence, they also change their impact on HQ's integration decision. Predation becomes both less likely and less costly, since HQ gains some surplus even if Project 2 is successful alone. 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 the following result, which characterizes the equilibrium entry decision for the downstream integrator.

Proposition 2. *A vertical integrator always integrates with Project 1 if integration neither invites predation nor deters entry. If integration invites predation, then it never integrates unless one of the two sets of conditions hold:*

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

If integration deters entry, integration never occurs unless π_H is sufficiently large or q is sufficiently small. The condition for integration to occur in the face of entry deterrence is

$$\pi_H > \frac{1 + [1 - \frac{1}{q}]}{\Delta p(1+\alpha) - p(\alpha - p)}.$$

Note that the cutoff above which the firm chooses non-integration in the $E\pi \in R3$ or $R4$, $\pi_H \in R5'$ case is weakly higher than the analogous cutoff for the horizontal firm. This reflects the fact that predation is less costly now that HQ gets a positive payoff when Project 2 is successful alone. 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 predation (the $E\pi \in R2$, $\pi_H \in R3'$

case in the second bullet point). This can occur because the alternative standalone 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).

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, integration occurs for sure when uncertainty is high enough relative to 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 predation 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* $\pi_H > \frac{1+[1-\frac{1}{q}]}{2\Delta p - p(1-p)}$. *If entry deterrence is not anticipated, integration always occurs.*

Here, we see that predation 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 predation 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. 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 predation 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. Note that the horizontal lines demarcating the critical regions for π_H have collapsed downward so far that the predation 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 predation. 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 predation 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 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 $\pi_H > \frac{1}{2\Delta p - p(1-p)}$*; or*

(c) its purchase would invite predation and $\pi_H > \frac{1}{p\Delta p}$*.*

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 (a) 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 it 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 predation (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 predation. 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 intermediate 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, Oxley, and Silverman (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 brings with it the ability to exploit the physical synergy but no internal capital market 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 standalone and integrating firm á la Allen and Phillips (2000) or Mathews (2005); 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 predation 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 standalone equilibrium since it increases Project 1's expected payoff but cannot invite predation. Thus we have the following result.

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

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 standalone 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) 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 $E\pi < [\frac{1}{p(1-p)(1-\delta_2)}, \frac{1}{p(1-p-\Delta p)(1-\delta_2)})$*, there is an alliance if* $\pi_H > \frac{1}{\Delta p(2(1+\delta_1)-p(1-\delta_2))}$ *and* $q\pi_H(2\Delta p(1+\delta_1) - p(1-p)(1-\delta_2)) + 1 - 2q < 0$*, 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 standalone 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 (π_H is low enough) that integration does not deter entry, or uncertainty is high enough that the flexibility benefit outweighs entry deterrence. 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.

Also note that in the lower $E\pi$ range (part (a)), specialization tilts the decision in favor of integration relative to a case with no specialization (the inequality given in the proposition is less likely to hold the higher is δ_1). Furthermore, in the higher range of $E\pi$ (part(b))the conditions for an alliance are less strict than they would be for complete non integration.

To see this more clearly, 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 5]

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

Our model is narrowly framed in terms of a single potential integration opportunity operating alongside another stand-alone firm. As such, it provides specific predictions about the optimality of horizontal and vertical integration based on the uncertainty and profitability of the market. However, the basic intuition arising from the interaction of entry deterrence, predation, and internal capital markets can be also 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 predation 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 lots 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 predation; 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 predation 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 predation from other firms. This underscores an important distinction between horizontal and vertical alliances. The former are motivated solely by the desire to thwart predation. 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.

More generally, our model develops a role for strategic alliances that does not rely on real options based arguments for their formation. Many authors have argued that alliances are like organizational real options, optimally used as a way of testing the waters in an uncertain environment without committing irreversible organizational resources. Our theory of alliances does not view intermediate organizational forms as options on later stage integration.

8. Conclusion

Innovative markets are often contested and initially inhabited by an odd mix of firms. Some are incumbents in related markets, others are completely new startups formed specifically to address the opportunities present in the new market. These firms employ an array of organizational choices as they jockey for position in an uncertain world.

Internal capital markets play an important role in determining how these 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, firms must balance the benefits of an internal capital market against the potential strategic costs that a firm faces vis-a-vis other firms operating in the same industry.

In our analysis, we study the balance between these considerations with a simple model of a potential integrator operating an internal capital market. To keep the analysis as simple as possible, our basic model has no costs to integration in the absence of product market interactions. From this basis, we can study how product market interactions with other potential competitors reinforce or work against a firm's desire to integrate.

In the presence of product market interactions, operating an internal capital market brings costs, as well as benefits. The main direct benefit of an internal capital market is the flexibility to allocate capital towards its most efficient use ex post. But this flexibility comes at a cost: firms cannot commit to capital allocations in advance.

Two strategic effects arise from the inability to commit capital in advance. 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 is likely to be the case when the ex ante expected market size is relatively modest, but the ex post size of the market can be quite large if things turn out well (uncertainty is high).

Flexibility may also invite predation, 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 the ex ante expected market size is small to moderate, but the market is subject to less uncertainty.

How firms optimally balance the costs and benefits of integration depends on how they are positioned with respect to an industry in question. A horizontal integrator is always happy to deter entry but may wish to avoid predation. A vertical integrator may also wish to avoid entry deterrence if they are heavily dependent on the upstream product's success.

The model 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 the organizational distinction between the two firms prevents any internal capital market reallocations from occurring. Alliances generally dominate traditional collaboration, except when the potential threat of ex post capital reallocation through the internal capital market creates valuable entry deterrence.

These findings illustrate the rich scope for interaction between organizational design decisions and product market characteristics. Ultimately, they lead us closer to an understanding of why some industry configurations seem to go hand in hand with certain organizational design choices.

Appendix

Proof of Lemma 1: The discussion in the preceding 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 predation 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 predation 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 predation 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 predation. The result follows.

Proof of Proposition 1: First note that if integration does not invite predation, 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 predation, and always a gain in expectation.

Now assume that integration invites predation. First note from Lemma 2 and Table 3 that if $\pi_H \in R2^{'}$ or $R3^{'}$, predation 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 predation is possible. From the proof of Lemma 2, we know that predation in this case requires $E\pi \in [\frac{1}{p(1-p)}, \frac{1}{\Delta p(1-p-\Delta p)}]$. From Lemma 1, if $E\pi < \frac{1}{\Delta p(1-p)}$, HQ will compare the integration payoff with a benchmark equilibrium where both projects have one unit of capital. From Table 3, predation with $\pi_H \in R5^{'}$ implies two units for Project 2 and one unit for Project 1 if it is successful. Thus, the joint payoff for HQ and Project 1 if they are integrated equals

$$p(1-p-\Delta p)E\pi - q \tag{4}$$

whereas their joint payoff in the benchmark model is

$$p(1-p)E\pi - 1. \tag{5}$$

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

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

$$(p+\Delta p)(1-p)E\pi - 2. \tag{6}$$

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, predation can occur only in three ranges of π_H, and in each range there is a minimum level of $E\pi$ beyond which predation 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 predation 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 predation regions. In particular, consider the predation region with $\pi_H \in R5'$. In (q, π_H) space, for any given $\pi_H \in R5'$, predation 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 predation in region $R5'$, it suffices to show that the predation region shrinks along both the π_H dimension and the q dimension as α or a_B 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 predation, $\frac{max(\frac{1}{\Delta p}, \frac{2}{(p+\Delta p)(1-p)})}{\pi_H}$, rises as π_H falls. An analogous analysis provides the results for predation in regions $R2'$ and $R3'$. The Mathematica code for the full algebraic analysis is available upon request.

Finally, consider the deterrence region. Here, deterrence occurs for all $E\pi \in R3$ such that $\pi_H \in R5'$ or $R6'$. 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 predation 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 predation 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 first sentence, note that if integration does not invite predation 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 second sentence, first consider cases where predation 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 $\pi_H \in R3'$, predation 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 $E\pi < \frac{1}{p(1-p)}$ Project 2 cannot be profitable as a one unit firm according to equation (1)). Thus, HQ and Project

1 have a joint payoff of

$$(p + \Delta p)E\pi\alpha \tag{7}$$

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

$$pE\pi(1 + \alpha) - 1 \tag{8}$$

if $E\pi \in R2$ or

$$E\pi(2p^2\alpha + p(1 - p)(1 + 2\alpha)) - 1 \tag{9}$$

if $E\pi \in R3$. Subtracting (8) from (7), we have that integration will be chosen despite predation whenever $E\pi < \frac{1}{p-\Delta p\alpha}$ if $E\pi \in R2$. Subtracting (9) from (7) yields $1 - E\pi(p^2\alpha + p(1 - p)(1 + \alpha) - \alpha\Delta p) < 0$, where the inequality follows from the fact that $E\pi > \frac{1}{p(1-p)}$ when $E\pi \in R3$, so predation always deters integration in this case.

Now consider cases with $\pi_H \in R5'$. In this case predation implies $K_2 = 2$ and $K_1 = 1$ (if $\widetilde{\pi} = \pi_H$). 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

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

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

$$E\pi(2p(p + \Delta p)\alpha + (p + \Delta p)(1 - p)(1 + \alpha) + p(1 - p - \Delta p)\alpha) - 2. \tag{11}$$

Subtracting (11) from (10) yields

$$2 - q - \Delta pE\pi < 0. \tag{12}$$

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 $\frac{\Delta p-p}{1-p} < 0$. 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 provides the result.

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

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

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 predation 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 predation 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 predation 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 2 conditional on $\widetilde{\pi} = \pi_H$ 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 it. Then let P_1^* and P_2^* be the equilibrium probabilities of success conditional on $\widetilde{\pi} = \pi_H$ if DS does buy project one. 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 $\widetilde{\pi} = \pi_H$ 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. There are four 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 standalone; 2) it could be purchased by H with no effect on Project 2; 3) it could be purchased by H despite inviting predation by Project 2. Note that anytime H would deter entry with its purchase, DS would as well according to Lemma 2 and Table 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 standalone game, or it will have more because of predation. 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 predation. Project 1 will have at least as much capital under DS integration if it does not invite predation as under H integration according to Table 2. If DS integration invites predation, 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 predation only if $E\pi \in R3$ or $R4$. Thus, if DS integration invites predation 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 predation, 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 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 $K_2 = 2$, 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 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,

$$E\pi(P_1 + P_2). \tag{14}$$

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

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

DS' willingness to pay can thus be written as

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

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

$$E\pi(P_1(1 - P_2)) - 1 * 1_{P_1=1} - 2 * 1_{P_1=2}, \tag{17}$$

and if H acquires it their joint payoff is

$$E\pi(P_1(1 - P_2)) - q1_{P_1=1} - 2q1_{P_1=2}. \tag{18}$$

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 predation 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, predation is only possible if $\pi_H \in R5'$. Thus, we have $P_1^* = p$, $P_1 = p + \Delta p$, and $P_2^* = p + \Delta p$, 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 predation, 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: Consider cases where DS integration will deter entry. For parts (b) and (c), note that either H integration will not affect Project 2 or it will invite integration, while DS integration always leads to $K_1 = 2$. If H integration does not affect Project 2, we have $P_1^* = p + \Delta p$, $P_1 = p$, and $P_2^* = 0$ and $P_2 = p$, so subtracting (18) from (16) yields the condition in part (b) of the proposition. If H integration invites predation, 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.

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 $\widetilde{\pi} = \pi_H$, so $P_1^* > P_1$ only if this is positive.

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

Proof of Proposition 7: First consider part (a) of the proposition. Note that 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 $p(1-p)E\pi(1-\delta_2)$ and predation cannot keep Project 1's capital level to zero (see the proof of Proposition 3). Thus, the joint payoff of HQ and Project 1 in the benchmark model is $E\pi(3p-p^2)-1$, 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 $\widetilde{\pi}=\pi_H$. 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 then two units. Either way, their integration payoff rises smoothly as $(1-q)$ rises, which proves the result.

Now consider part (b). Note that 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 (predation 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. Finally note that this assumption 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 standalone 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 predation given our assumptions. From Proposition 3 we know that predation can only occur with a single downstream firm 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 with predation. The equivalent 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 $\widetilde{\pi}=\pi_H$. Thus, the predation decision is a decision between no entry and entry with two units. Predation 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 predation 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 $\widetilde{\pi} = 0$. In the former case, integration yields a joint payoff of

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

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

$$E\pi(2p(1 + \delta_1) + p(1 - p)(1 - \delta_2)) - 1. \tag{20}$$

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

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Table 1. Payoff Matrix with Potential Integration

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

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

FIGURE 1. Benchmark time line

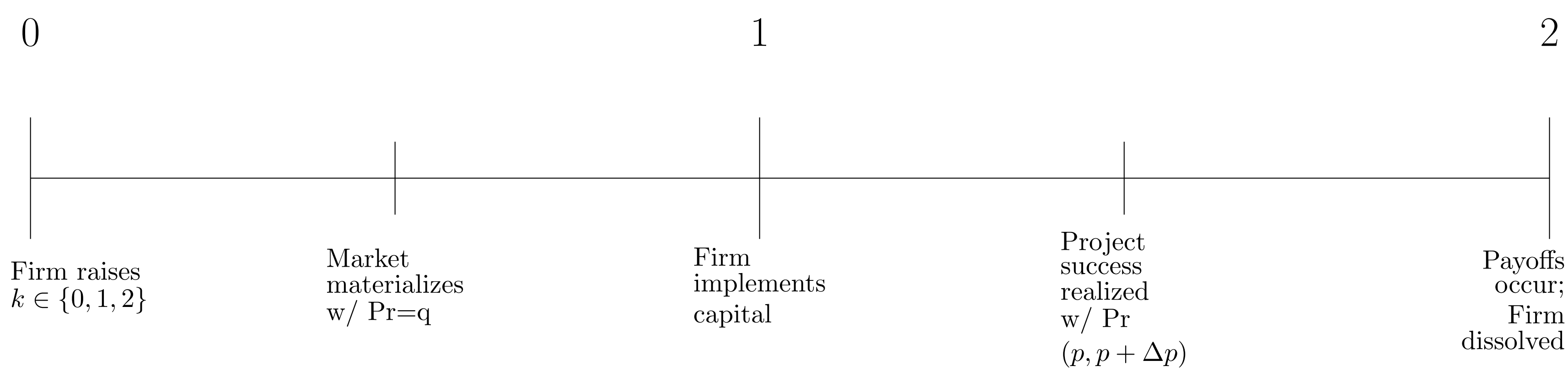

Figure 2. Time line with Integration

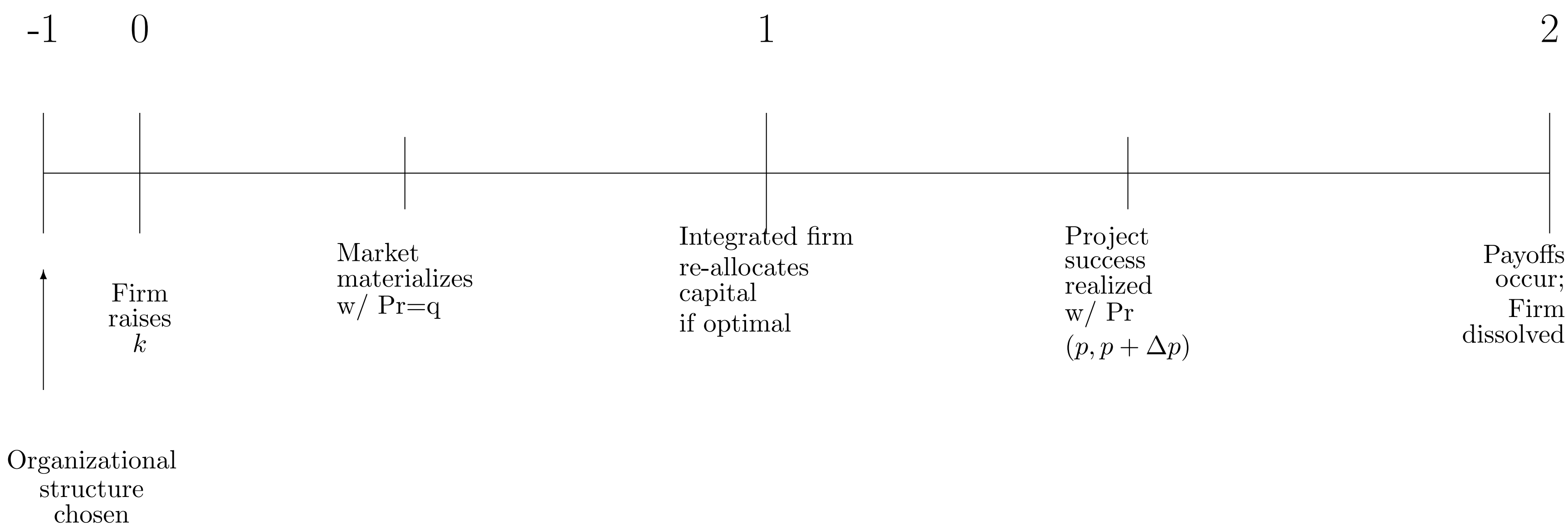

Figure 3

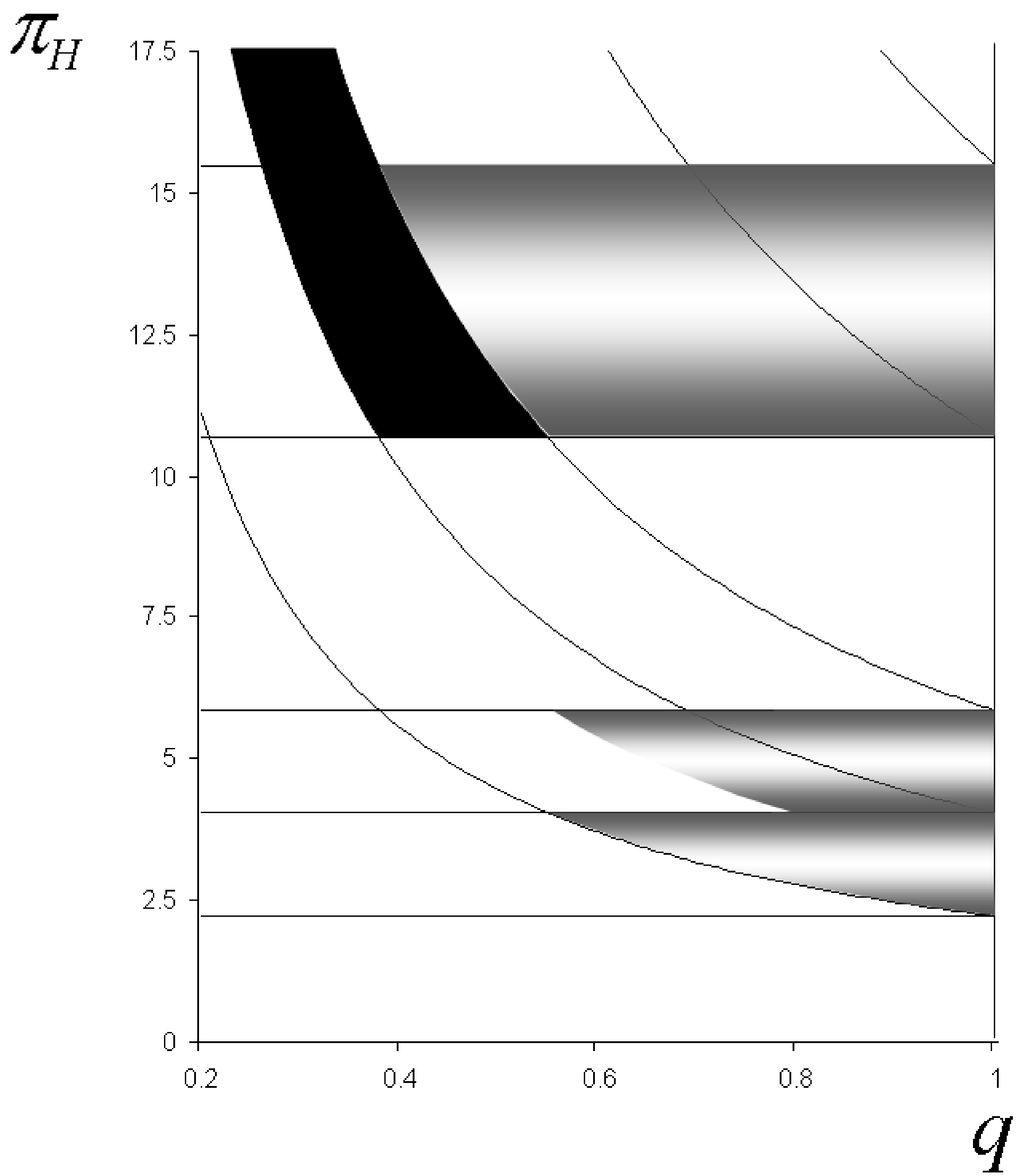

Figure 4

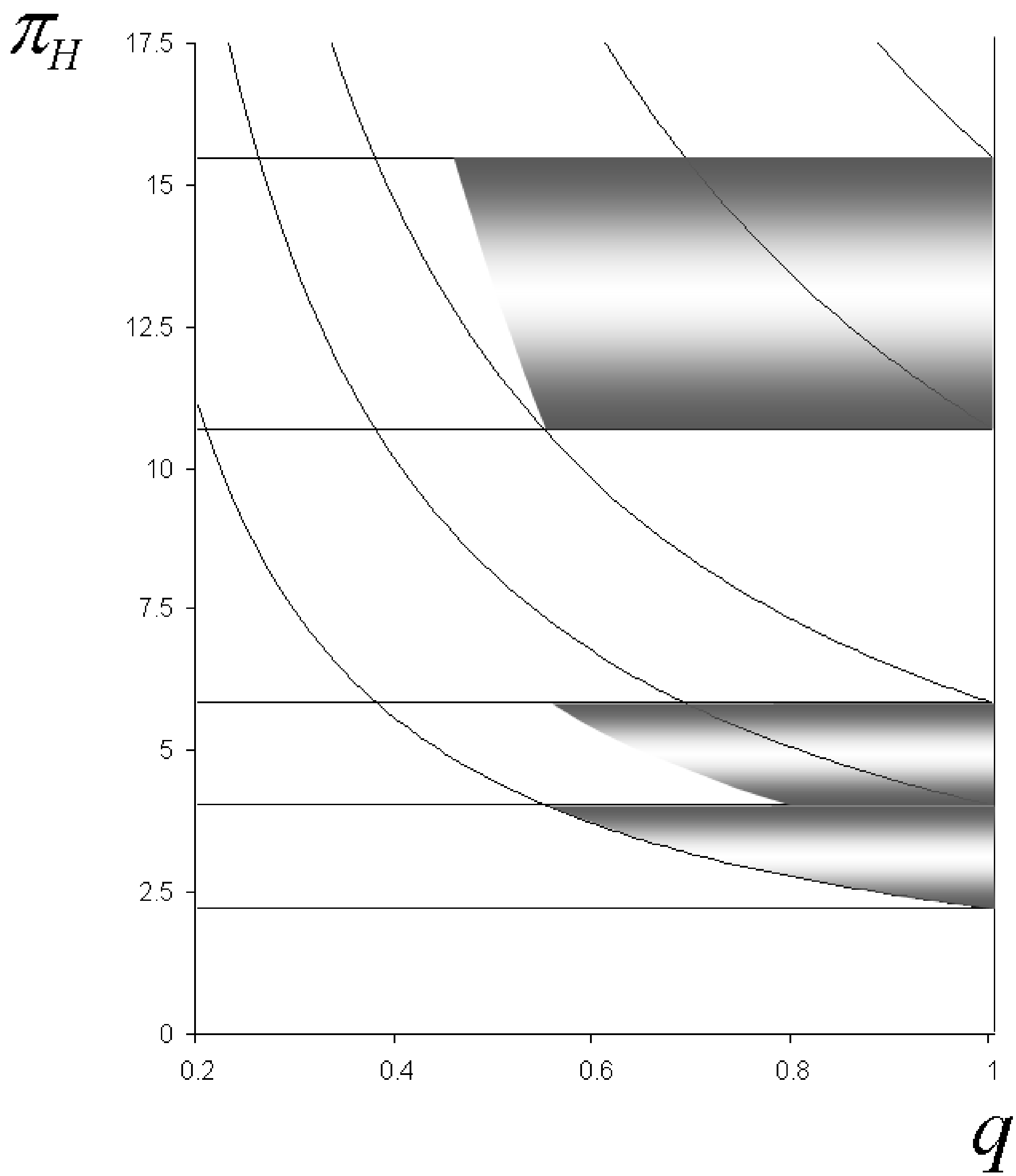

FIGURE 5

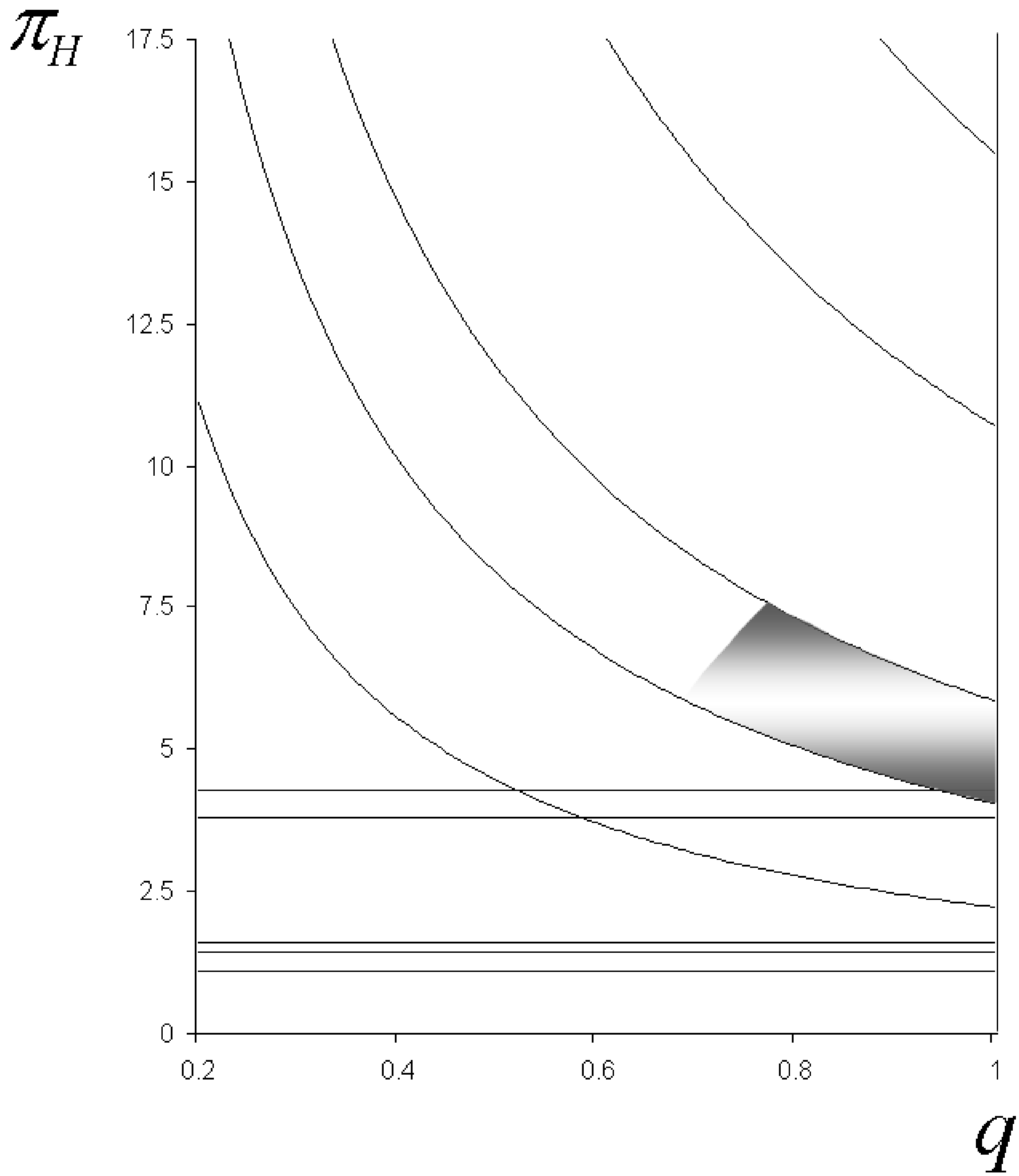

Figure 6

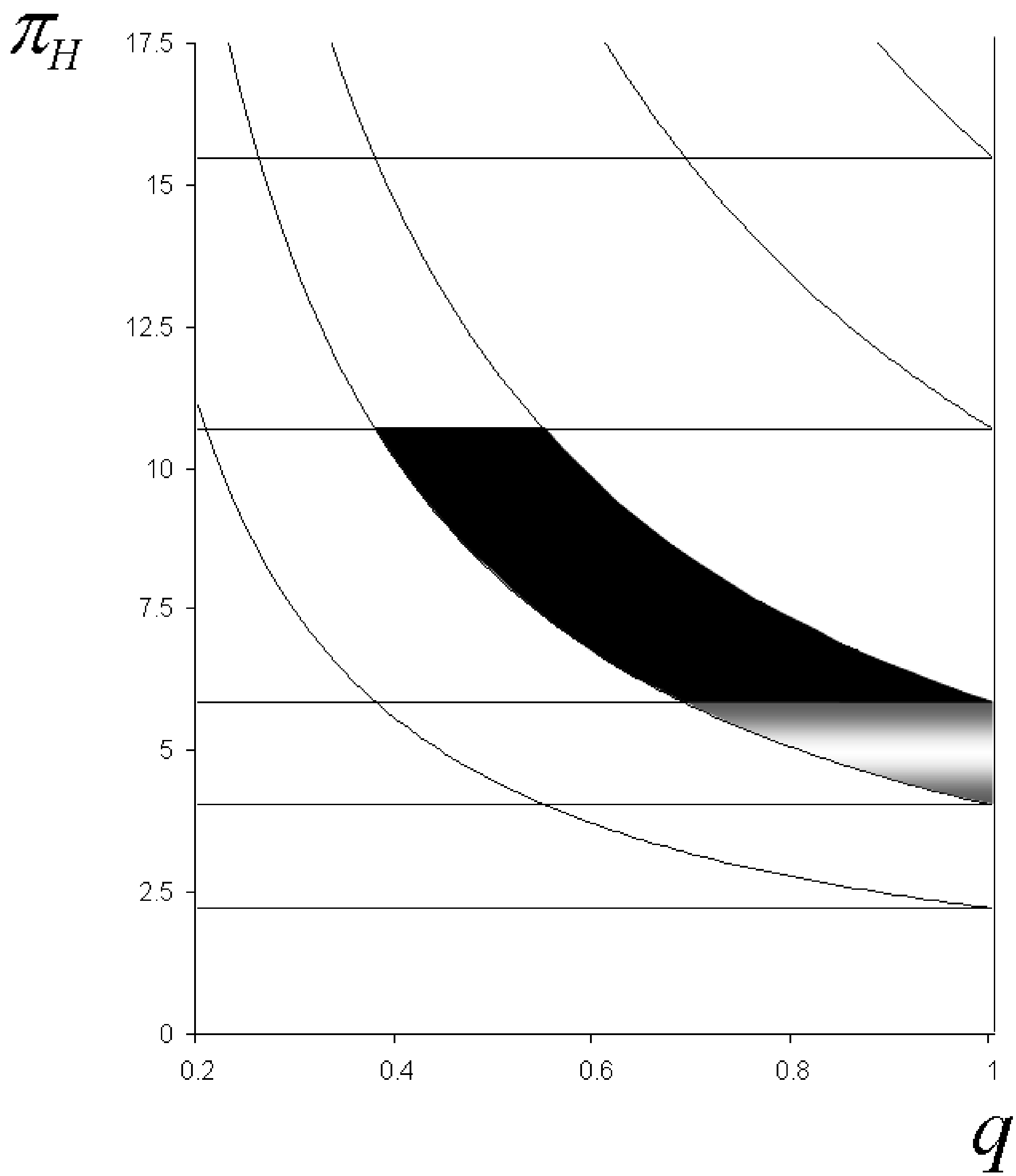

Figure 7