Locating Innovation: The Endogeniety of Technology, Organizational Structure and Financial Contracting

Ronald J. Gilson, Stanford Law School
Abstract

There is much we do not understand about the “location” of innovation; the confluence, for a particular innovation, of the technology associated with the innovation, the innovating firm’s size and organizational structure, and the financial contracting that supports the innovation. This article develops the theme that these three determinants of the location of innovation are simultaneously determined through examination of examples of innovative activity whose location is characterized by tradeoffs between pursuing the activity in an established company or in a smaller, earlier stage company, or some combination of the two. It first considers the dilemma faced by an established company in deciding whether to keep an employee’s innovation or allow the employee to pursue the innovation through a venture capital-backed startup. It next takes up a very different relationship between an established company and an earlier stage company: the development by the smaller company of an innovation that “disrupts” existing industry patterns by devaluing the skills and experience of the industry’s dominant companies. The article then considers an established company’s instrumental use of the startup market to outsources development of a particular innovation to a technology race with the intention of acquiring the winner of the race. Finally, the article addresses a form of innovation located between an established and earlier stage company – the pattern of joint ventures between large pharmaceutical companies and smaller, earlier stage biotechnology companies.

There is much we do not understand about what I will call the “location” of innovation -- the confluence for a specific innovation, of the technology associated with
the innovation; the innovating firm’s size and organizational structure; and the financial contracting that supports the innovation. Why do certain technologies match with certain financial contracts and certain organizational structures? For example, why are innovative drugs increasingly developed through joint ventures between capital-heavy large pharmaceutical companies and the smaller but technologically savvy biotech firms, rather than within the large pharmaceutical? Also, why did so much of Cisco’s 1990s development of networking infrastructure take place through acquiring and then quickly integrating hundreds of startups with relevant pre-market technologies, rather than Cisco simply developing those technologies in-house? The same kind of question arises with respect to the location of any innovation, including those with the highest profile -- venture capital-backed startups, which have given rise to companies such as Intel, Apple and Google.

The gaps in our knowledge are not the result of lack of effort. Few matters of commerce have captured the energy and resources of so many in business, academia, and government. This attention is unsurprising; after all, innovation represents the source of future economic growth and, in a global economy, holds out the prospect of economic success based on something other than wage competition. And, indeed, we have much to show for these efforts. For example, there is now an extensive literature analyzing the financial contracting forms associated with venture capital and the organizational structure both of venture capital funds and the startups in which they invest,¹ as well as

assessments of the conditions necessary to the success of the venture capital market, and the potential role for the government in creating a venture capital market. This literature is characterized by a vibrant interaction between theory and empirical investigation, with the particular advantage that investigators have worked directly with actual transaction documents. Theory is brought to bear on what those individuals and firms engaged in innovative work actually do and how the organizations that pursue innovation are actually structured.

But venture capital, while certainly important in its own right, is just a drop in the innovation bucket. In 2006, the four largest U.S. corporate R&D programs alone invested more than five times what the entire U.S. venture capital industry put into seed, early stage and startup investments. And even large R&D programs don’t capture the full picture of the location of innovation. Indeed, we see research and development carried out in a virtual Cambrian explosion of organizational forms. In addition to venture capital and the research efforts of major companies, innovation is at the core of, among others, angel financed-startups operating earlier in the life cycle than venture capital is available; joint ventures between large companies to combine research efforts

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in a particular field;\textsuperscript{6} joint ventures between large and small companies, especially prevalent in the pharmaceutical industry;\textsuperscript{7} and collaborative innovation between adjacent parties in the vertical supply chain.\textsuperscript{8}

While each of these individual examples has been the object of academic attention, they have by and large been treated separately, as stand-alone silos of innovation rather than as different manifestations of the same coherent whole. The features of each location are mapped, but less attention is paid to why particular types of innovative activity take place in different locations that correspond to different combinations of the technology associated with an innovation, the organizational structure in which the technology is developed, and the means by which it is financed. In this preliminary framing of the problem, I will suggest that technology, organizational structure and financing are determined simultaneously, each dependent on the others. In this sense, in the location of innovation, there is no independent variable.

My approach to this problem is found at the “T” intersection of Ronald Coase; Franco Modigliani and Merton Miller; and Oliver Williamson and the property rights literature initiated by Sanford Grossman, Oliver Hart and John Moore. Coase tells us that frictions determine the organizational location of productive activities: whether a product will be produced entirely within a single company or elements of it acquired by contract across a market, is determined by differentials in transactions costs, including especially

\textsuperscript{6} For example, Pioneer Hi-Bred, a developer of bio-engineered seed stock, and DuPont, a leading producer of plant pesticides, combined large parts of their research efforts in a joint venture focused on developing seeds that were resistant to chemical pesticides. DuPont to Invest $1.7 Billion in Pioneer Hi-Bred, August 8, 1997, available at http://www.nytimes.com/1997/08/08/business/dupont-to-invest-1.7-billion-in-pioneer-hi-bred.html

\textsuperscript{7} See, e.g., David T. Robinson & Toby E. Stuart, Financial Contracting in Biotech Strategic Alliances, 50 J. L. & Econ. 559 (2007).

\textsuperscript{8} See Ronald J. Gilson, Charles Sabel, & Robert Scott, Contracting for Innovation: Vertical Disintegration and Interfirm Collaboration, 109 Col. L. Rev. 431 (2009). Even the litany in the text is limited to commercial locations of innovations; university and government based research projects are not mentioned.
the cost of information, associated with the alternative modes of production. In the absence of frictions, the organizational form in which an innovative activity is carried out is irrelevant to firm value -- all silos are the same.

Modigliani and Miller, reframed in the spirit of Coase, tell us that frictions also determine a firm’s capital structure – how the assets on the left side of the balance sheet are financed by the contributions on the right – and the terms of the financial contract associated with particular capital structure instruments. In the absence of transaction costs, including problems of incomplete contracting resulting from information costs, the particular source of the funds that finance an innovation and the particular financial contract that governs their provision also are irrelevant to firm value.

Williamson steps behind the no-transaction-costs veil and addresses the types of transaction costs that shape organizational structure and financial contracting in the real world where frictions are pervasive and information is costly and unequally distributed among the parties whose inputs are necessary to production. When information differentials are combined with specific investment, the potential for opportunism – “self-...

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11 Coase was explicit that his emphasis was not on the fact that the location of liability was irrelevant in a transaction cost free world; his point was that because the world was so messy, the study of frictions should be at the core of the agenda. The Problem of Social Cost, 3 J.L. & Econ. 1 (1960). Miller reports having the same point in mind. Writing thirty years after the irrelevancy propositions were first published, Franco Modigliani & Merton H. Miller, The Cost of Capital, Corporate Finance, and the Theory of the Firm, 48 Am. Econ. Rev. 261 (1958), Miller stated that “[t]hree decades from now, perhaps we should have put more emphasis on the other, upbeat side of the ‘nothing matters’ coin: showing that what doesn’t matter can also show, by implication, what does.” Merton H. Miller, The Modigliani-Miller Propositions After Thirty Years, 2 J.Econ. Persepc. 99, 100 (1988). Of course, that implication drove a significant research agenda in financial economics over the thirty years following its publication. See, e.g., Holmstrom, Bengt, and Tirole, Jean, "The Theory of the Firm III. Capital Structure," in Richard L. Schmalansee and Robert Willig, eds., Handbook of Industrial Organization I, pp. 79-86.
12 As Miller put it his thirty year later retrospective, capital structure irrelevance was simply “an implication of equilibrium in perfect capital markets.” Miller, supra note 11, at 99.
seeking with guile” as Williamson puts it – arises.\textsuperscript{13} Grossman, Hart and Moore build on the contract theory literature to explain firm boundaries (in their framing, the distribution of asset ownership) as a means to address problems of incomplete contracting motivated by information problems, and hence the financial structure that supports that ownership.\textsuperscript{14}

From the perspective of this “null form hypothesis,”\textsuperscript{15} the location of innovation – each combination of technology, financial contracting and organizational form that defines a characteristic pattern of investment in innovation whether in a startup, a multinational corporation, a joint venture, or something else – reflects a particular combination of transaction and information costs. We can explain the variety of innovative activity across organizational structure and financial contracts, then, as the interaction of endogenous variables: technology influences informational asymmetries and transaction costs, which in turn—theory tells us—influence organizational form. A fully formulated account should therefore be able to predict which forms of innovation generally (but not exclusively) will take place, for example, within start-up companies financed by venture capital, which within the research labs of existing large companies, and which by cooperation among separate entities.\textsuperscript{16}

The goal here is to contribute to the effort to understand the distribution of innovative activity across different types of organizations in different industries, and using different financial contracts. My ambition at this initial stage of a very large

\textsuperscript{13} See, e.g. Oliver Williamson, The Economic Institutions of Capitalism (1985).


\textsuperscript{15} Miller, supra note 11.

\textsuperscript{16} Sharon Belenzon, Tomer Berkowitz & Patrick Bolton, Intracompany Governance and Innovation, working paper (May, 2008), make a similar point, stressing ia Coasean perspective in assessing the allocation of research and development between business groups and conglomerates.
undertaking is limited. I will consider a small segment of the three dimensional – technology, organizational and financial contracting -- locational distribution of innovation illustrated in Figure 1.

**Figure 1 Here**

The four examples I take up each represents a different cluster of transaction and information costs. These transaction cost clusters, in turn, are sharply influenced by the technology associated with the innovation, both in substance and in stage of development. Thus, these differences do not form a continuum, since each cluster represents not a linear relationship between two factors, but something three-dimensional. The information and transaction costs associated with organization, finance and technology triangulate to dictate, for example, the need for and the ability to design intense incentives, the capacity of managers and investors to monitor the objects of those incentives with comparable intensity, the level of information costs that influence the parties’ ability to determine the characteristics of their counterparties in financing an investment in innovation, the observability and verifiability of opportunistic behavior, and the array of factors necessary to sustain the operation of a reputation market that both supplements and supports the explicit contracts between providers of capital for innovative activity and those needing it. And these factors, in turn, determine the actual location of particular innovative activity.

The particular segment of the locational space I take up here involves four clusters of innovative activity characterized by tradeoffs between pursuing an innovation in an established company or in a smaller earlier stage company, or some combination of

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the two. Part I considers the dilemma faced by an established company in deciding whether to keep an employee’s innovation or to stand back and allow the employee to pursue the innovation in a venture capital-backed startup company. In light of the advantages held by an established company, why do we ever see startups? Part II then addresses a very different relationship between an established company and an early stage company: the development by the smaller company of an innovation that “disrupts” existing industry patterns by devaluing the skills and experience of the industry’s dominant companies. Here we confront the question of organizational “ambidexterity”: can the same organization and financing arrangements successfully support continued development of the dominant technology at the same time that it supports development of the technology that will supplant the dominant technology and devalue the organization’s expertise associated with it?

Part III takes up an established company’s instrumental use of the startup market, that is, the decision to outsource the development of particular innovations to a technology race between startup/early stage companies, with the intention of acquiring the winner of the race. Finally, Part IV addresses a form of innovation located somewhere between a large and small company: the pattern of joint ventures between large pharmaceutical companies, and small, earlier stage biotechnology firms through which a growing amount of pharmaceutical research takes place. Part V concludes.

Of course, focusing on these four clusters that present different locations of innovation among established and early stage companies ignores other locations that account for a large proportion of total innovation, most importantly, the research labs of established large companies, where research is financed by cash flow and the company’s
credit and organized within an existing corporate structure. For now, however, addressing these four patterns, each of which presents a different allocation of innovative effort between established and earlier stage companies, is sufficient both to illustrate the value of a comparative analysis that helps explain how technology, organizational structure and financial contracting combine to influence the location of innovation.

I also should note that the patterns of interaction between forms of financial contracting, organizational structure and the technology underlying the innovative activity highlighted here is preliminary, with no small risk of apophenia. In this respect, it is something of a five-finger exercise, proposing rough hypotheses for what appear to be patterns in the cluster of attributes associated with location of innovative activity. The taxonomy thus invites both expansion to other regions of the innovation three-dimensional space, and further analytic and empirical testing of the hypothesized relationships, which then may falsify some of the hypotheses and refine others.

Nevertheless, I am far more confident that the premise that gives rise to the effort, as opposed to the initial formulation offered here, is correct: we will not understand where innovation takes place – in which organizations and with what kind of financing – without understanding the endogeneity of the innovative technology, the financial contracting that feeds it, and the industrial organization that supports it.

Two final introductory matters remain to be considered, the first a qualification and the second a further justification of the effort. The qualification concerns the static character of the analysis, in which fixed clusters of characteristics place innovative activity at fixed locations. Of course, innovation and its organizational shelter and financing are dynamic, not static; endogeneity itself implies the prospect of change.
Venture capital, for example, is much different and much more important than it was when American Research and Development, the first venture capital fund, was conceived. The capital market has changed, transaction and information costs have changed, and the technologies that must be financed have changed. Rather than a point in three dimensional space, perhaps the better metaphor is the three wheels on a slot machine, one for technology, one for organizational structure and one for financing, each turning in different directions and at different speeds, that coincide for a time, until the lever is pulled again. Nonetheless, by understanding how the characteristics interact in their present coincidence, we learn something about how future changes will affect the organizational outcome.

The last point concerns the normative, rather than the positive payoff to the analysis. Professionals, often but not limited to lawyers, design organizational form and financial contracts. I have elsewhere referred to such professionals in general, and business lawyers in particular, as transaction cost engineers.18 The original structure of venture capital arrangements in Silicon Valley – the venture capital limited partnership that defined the arrangement between investors and venture capital professionals, the range of agreements between the venture capital fund and the portfolio company, and the fit between the two contractual relationships19 – were the product of lawyers engineering a structure that accommodated their clients’ needs.20 Precisely because of the endogeneity of technology, organizational form and financial contracting, and the

dynamic character of innovation, positive theory helps transaction professionals structure the arrangements through which innovation takes place. Put differently, some combination of other people, other entities and someone else’s money stand between an innovator’s idea and an innovation reaching the market. Engineering that arrangement is not the only thing lawyers do, but it is the most interesting. Understanding the endogeneity of the location of innovation will help lawyers do it better.\textsuperscript{21}

I. Why Start-ups? The Differential Effect of Intense Incentives in Established and Startup Companies

The classic Silicon Valley story involves an engineer leaving an established company with no more than an idea and determination, securing venture capital, and becoming fabulously wealthy either through an IPO or a sale of the company. As Willie Nelson said, in the United

\textsuperscript{21} Recently, a number of articles have taken aim at the characterization of a lawyer’s role reflected in the text. See, e.g., George W. Dent, Business Lawyers as Enterprise Architects, 64 Bus. Law 279 (2009); Steven L. Schwarz, Explaining the Value of Transactional Lawyering, 12 Stan. J. Law Bus.& Org. 486 (2007). Mostly I am flattered that people continue to pay attention to a 25 year old article in which the role of the business lawyer as a transaction cost engineer was developed. See Gilson, Value Creation by Business Lawyers, supra note 18. Nonetheless, the thrust of the criticism warrants comment. First, commentators point out that transaction lawyers do many kinds of things, and only one, perhaps small part, of their role is the application of theory, explicit or intuitive, to engineering the organizations and contracts through which innovation takes place and moves to market. In short, as Professor Dent put it, my approach -- what he calls the “received wisdom”, “is too narrow.” Dent, supra at 281. He has in mind “a fuller vision showing that business lawyers perform a greater range of activities using a larger set of skills than in the received model.” Id. Second, they point out, as did I, that other professions can do the very same thing. I agree with both points. Business lawyers do many other things; transaction engineering is merely the most interesting and challenging. However, I take the broader theme of my now slightly dated claim to be largely accepted by the commentators, and I would happily substitute the following for the “received wisdom.” The mark of a professional – how a lawyer creates value – is taking serious theory developed elsewhere in the university and bringing it to bear on practice of law. Much theory has been developed since I wrote in 1984. The notion of teaching law students the tools with which to create value has given rise to successful courses in “Deals” at, among others schools, Columbia, Stanford, and the University of Pennsylvania Law Schools, on some occasions taught jointly in the law school and business school. See Victor Fleischer, Deals: Bringing Corporate Transactions into the Law School, 2002 Col. Bus. Rev. 475, 490–92. Since 1984, developments in the rest of the university have not stopped, and neither has development of the Deals course or the role of the lawyer in creating value by bringing cutting edge theory to bear on practice.
States, “our heroes have always been cowboys.” Start-up entrepreneurs are the cowboys of the high tech world. The puzzle, however, is why we ever observe them.

The story of start-ups illustrates the endogeneity of financing, technology, and organizational structure. There is a logic to why innovative technology conceived of by large-company engineers eventually become the crown jewels of venture capitalists. The technology, the organizational structure of the small firm, and the staged financing offered by venture capitalists are endogenous variables. Each component tells a vital piece of this story.

As a starting point, one might expect that innovation would be located largely within established firms. Such firms have a number of inherent advantages. External financing of high-risk future growth options is extremely expensive; the information asymmetry between capital providers and the company should make internal financing a far cheaper alternative. Moreover, a successful company that knows its customers and its industry should have better information about what industry customers want now, and, perhaps more importantly, will want in the future. As a result, their capital budgeting with respect to supporting innovation should be less error-prone. To the extent research and development will lead to extensions of existing products or markets, innovation by established companies should benefit from economies of scale or scope – for example, shared production, distribution and marketing facilities, as well as the opportunity for shared general overhead expenses – that cannot be duplicated by a startup. Finally, the U.S. tax code subsidizes research and development by existing successful companies by allowing losses that result from failed attempts at innovation to offset income from other

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24 See Part III infra for a circumstance when the established firm will be at a disadvantage.
activities that would otherwise be taxed.\textsuperscript{25} Since startups have no other income against which its losses from a particular project may be set off, the government in effect gives established companies with a stable source of income a tax subsidy for R&D that is not available to a startup entity.

And yet, significant innovation does occur within these seemingly disadvantaged startup or early stage companies. In this part, we take up the puzzle presented by this location of innovation.

A. Why Start-ups?\textsuperscript{26}

To see why any innovation takes place within startups, it is helpful characterize the venture capital process as an auction: the employee innovator offers to sell an ownership interest in the intellectual property represented by the employee’s innovation.\textsuperscript{27} While venture capital firms can participate in the auction, so too can the employer. And on a first cut, the employer should always win – the opportunity should be worth more to the employer, for the following reasons.

The employer’s first advantage is a more favorable tax treatment. As stated above, in the United States an investment made by an established company that has past income and can expect future income is subject to symmetric tax treatment: gains are taxed, and losses offset other income from tax. Since innovation is risky, the ability to reduce taxes by the amount of losses from unsuccessful efforts is significant. In contrast, the startup’s future tax treatment is asymmetric: gains are taxed, however losses provide

\textsuperscript{25} See Gilson & Bankman, supra note 22.
\textsuperscript{26} This section draws on Gilson & Bankman, supra note 22.
\textsuperscript{27} This formulation assumes that the engineer, rather than the employer, has the property rights in the idea, despite the fact that the innovation was typically conceived while the engineer was an employee. For a discussion of the engineer’s property rights, see Ronald J. Gilson, The Legal Infrastructure of High Technology Industrial Districts: Silicon Valley, Route 128, and Covenants Not to Compete, 74 N.Y.U.L. Rev. 575 (1999).
no tax benefit because the failed startup has no past income and will have no future income.28

The employer’s advantage is not limited to a tax subsidy. The employer also has a range of informational advantages. If the innovation has some relation to the employer’s business, a not unreasonable assumption given its development during the employee’s job tenure, the employer should have better information than a venture capital firm about the engineer’s talents, the underlying technology, and the potential market. Writ large, the argument reflects the pecking order theory of capital structure:29 the spread between the costs of internal and external capital will increase as the information asymmetry that exists between the company and providers of outside capital like the venture capitalists increases.

Finally, as previously noted, the employer’s informational advantage shades into scope and scale economies. To the extent that the innovation is complimentary to the employer’s business, the innovation can benefit from shared customers, distribution channels and marketing, and perhaps some elements of manufacturing. Also, to the extent that the employer’s marketing and distribution staffs have excess capacity, there may be additional scale efficiencies through better utilization of the employer’s labor force.

So why do we ever observe startups? Under these circumstances, something about the transaction and informational costs associated with the organizational structure of both the established employer and the venture capital-backed startup must result in efficiency advantages for the startup form that offsets the employers’ tax, informational

28 The tax analysis is set out in more detail in Gilson & Bankman, supra note 22, at 293-95.
29 See Myers, supra note 23.
and scale and scope advantages. The explanation for the presence of startup ventures takes two forms: problems that the employer has in actually taking advantage of the innovation, and advantages of the venture capital-backed startup form. In this case, the technology favors locating the innovation in the employer; however, that advantage is trumped by the transaction and information cost differences between a large established employer and a single project startup.

A. Employer Problems.

The literature identifies a number of problems with employer implementation of the employee’s innovation that would not burden a startup, and so would operate to reduce the employer’s bid in our metaphorical auction relative to that of a venture capitalist. A number of scholars have focused on the risk to the employee posed by the fact that merely by disclosing the innovation, the employee will compromise his intellectual property. The risk that the employer will misappropriate the innovation if it is disclosed in order to give the employer the opportunity to “bid” against the venture capitalist, may cause the employee to favor a startup even if the innovation would be worth more if implemented by the employer. Presumably, the venture capitalist does not present that risk. While misappropriation is certainly a matter of concern, there is reason to be skeptical over the risk of employer misappropriation.

Two elements arguably, though not decisively, reduce the potential that the venture capitalist will misappropriate an innovation disclosed in a submitted business plan as compared to the established employer, neither of which is wholly satisfactory.

30 Most of the literature addresses the misappropriation problem not with respect to the employer company, but on the prospect of corporate venture capital -- for example, the innovating employee taking financing from Microsoft rather than a traditional venture capitalist. See, e.g., James J. Anton & Dennis A. Yao, Start-ups, Spin-offs, and Internal Projects, 11 J. L.Econ. & Org. 362 (1995). In the case of the employee-employer interaction, the feared misappropriation takes place through pre-bid disclosure.
The first, and less significant, is that because the venture capitalist is not an operating company, it has less reason than the employer to misappropriate the innovation. This analysis ignores, however, the fact that the particular startup is not the venture capitalist’s only investment. Even though the venture capitalist cannot itself use the employee’s innovation, it will have ongoing investments in other startups, to which the employee’s innovation might be valuable. The temptation to profit from misappropriated innovation by giving it to another portfolio company provides the venture capitalist a motive for misappropriation especially if the venture capitalist has a specialized portfolio that overlaps with the innovator’s technology.

The second and more persuasive protection against venture capitalists misappropriating an employee’s innovation is the fact that venture capitalists operate in a reputation market. Venture capital markets are local, and rich information about venture capitalists’ conduct spreads very quickly.\(^\text{31}\) As a result, misappropriating an innovation in the course of its evaluation would be punished in the market for venture capital.\(^\text{32}\) But while more plausible, it also exaggerates the difference in position between the employer and the venture capitalist. Employers also are constrained by a reputation market, albeit an internal one.

Although it is not misleading to frame the employee’s decision to pursue his innovation through a startup as an auction, it also is important to realize the limits of the metaphor. The employer actually bids for a portion of the employee’s innovation not ex post through a venture capital-like bid when the innovating employee has decided to leave, but ex ante through the incentive compensation structure of the company. For

\(^{31}\) Gilson, Engineering a Venture Capital Market, supra note 19, at 1092
\(^{32}\) Id. at 1092 discusses the operation of a reputation market in connection with venture capital.
example, the employer’s compensation structure may contemplate that an innovative employee might receive an equity participation in an employer subsidiary – intrapreneurship – if she has a great idea, or may receive a large bonus. The employer’s misappropriates the innovation by not making the anticipated payoff. The point is that the employer, just like the venture capitalist, is a repeat player in an information rich context, and the conditions necessary for an internal reputation market concerning the treatment of employee innovations, will also operate to constrain misappropriation.  

Thus, the argued difference between an employer company’s incentives to misappropriate versus those of a venture capitalist is overstated.

The more persuasive barriers to the employer’s bidding to retain an employee’s innovation grow out of internal conflicts whose costs may outweigh the benefits of the innovation’s retention. Thomas Hellman has argued that employees within the company whose positions would be threatened by the innovation may act to undermine its further development. In a related vein, Paul Milgrom and John Roberts’ focus on the company’s opportunity cost when employees divert their efforts from productive activities to efforts to protect their positions against the effects of the innovation by influencing company decision makers. If these opportunity costs are sufficiently high, 

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33 In the context of the labor market, the role of a reputation market is framed in terms of “implicit contracts.” For a model in which employer misappropriation is central to the process, see Mariagiovanna Baccara & Ronny Razin, Curb Your Innovation: On the Relationship Between Innovation and Governance Structure, working paper (March 2006).


35 Paul Milgrom & John Roberts, An Economic Approach to Influence Activities in Organizations, 94 Am. J. Soc. S154 (1988). Bengt Holstrom stresses differential measurement and monitoring costs between innovation and other employee activities. If measuring the employee’s effort at innovation is more difficult than measuring her effort in more routine activities, it may be desirable to restrict the employee’s activities. See Bengt Holstrom, Agency Costs and Innovation, 12 J.Econ. Behav.205, 312 (1989); Bengt Holstrom & Paul Milgrom, Multitask Principal-Agent Analyses: Incentive Contracts, Asset ownership, and Job Design, 7 J.L.Econ. & Org., Special Issue, 1991, at 24.
the employer will prefer to push the “threatening” innovation out the door and into the hands of waiting venture capitalists.

Finally, Bankman and Gilson highlight the effect of the measurement problems that flow from giving employees a powerful incentive for innovation. In order for an internal incentive to reward innovative employees, the employer must identify, ex post, the employees to whom an innovation belongs. The necessity for this identification process may have significant costs. To see the problem, assume that research and development is most efficiently carried out in teams. Further assume that the research process has economies of scope – there is a benefit from the ongoing sharing of research among teams – and that the more widely distributed the results of ongoing research, the more difficult it is for any single individual or team to establish property rights in a single invention. Under these circumstances, employees have a powerful incentive to perfect their property rights by hoarding their results, a strategy that will be costly for at least two reasons. First, any time spent on concealment reduces the time the employee spends on productive activities. Second, and more important, this concealment restricts economies of scope by reducing other employees’ productivity whose performance would have been better had information been shared rather than hoarded.

So what is an employer to do? Both the benefits and costs of the employers’ bid – its internal incentive system that rewards innovative employees – increase in the intensity of the incentive. The higher the incentive, the larger the number of employees who will turn the innovation over to the employer rather than founding a startup. But the higher the incentive, the more employees are encouraged to hoard their research to protect their property rights, and the larger the cost the employer’s bidding imposes on its overall

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36 Bankman & Gilson, supra note 19.
R&D effort. In equilibrium, the employer will set the intensity of the incentive at the point where the costs associated with the increase in incentives necessary to keep one additional employee are higher than the expected value of the innovation that would be kept. At the margin, some innovative employees leave for start-ups, while others remain in-house. This outcome is consistent with observed experience: established technology companies both do substantial amounts of research and lose employees to startups.37

The outcome also is consistent with another observation concerning the distribution of innovation between established companies and startups. One would expect that established companies do best at incremental innovation, and startups do better at discontinuous innovation. This is due in part to the lower payoffs to and, consequently, a more limited external financial market for incremental innovation. Thus, established companies need to offer less intense internal incentives to retain incrementally innovative employees. But it is also due to the reduction in influence costs, and a reduction in the hoarding of innovation resulting from the need to perfect property rights in the innovation.

Masahiko Aoki makes this point in an interesting way.38 Aoki stresses that the genius of Japanese manufacturing is the enormous emphasis on team work and information sharing both horizontally and vertically, the opposite of the Milgrom and Roberts-style influence activities and property rights perfection associated with the intense incentives necessary to retain the discontinuous innovations associated with

37 The time it takes to go from being an early stage company to an established employer concerned about losing employees seems to be shrinking. See Jessica E. Vascellaro, Google Searches for Ways to Keep Big Ideas at Home., Wall ST.J., June 18, 2009, p. B1 (“Google Inc. is revamping how it develops and prioritizes new products, giving employees a pipeline to the company’s top brass amid worries about losing its best people and promising ideas to start-ups.”)

venture-backed startups. The Japanese result—counter-intuitive by American standards—is supported by low intensity incentives: a commitment to lifetime employment and lockstep compensation. Aoki argues that these low-intensity incentives encourage employees to invest in firm specific human capital and not to hoard information at the expense of other teams and the firm’s capacity to receive and use new information. Aoki also notes, however, that this cluster of attributes makes the Japanese system very effective when innovation is incremental, as in process innovation, and not very effective when innovation is discontinuous and powerful incentives matter very much more.  

Thus, the balance is sensitive not only to organizational structure and incentives, but also to the character of the technology and the related innovation. As argued above, organizational structure and technology are simultaneously determined. In Japan, the organizational structure of flat hierarchies and the “technology” of process innovation illustrate the endogeneity hypothesis described above. The nature of structural incentives in established companies and venture-backed startups do the same.

B. Advantages of Startups

To this point, we have focused on the factors that influence the size of the employer’s bid to retain an employee with an innovative technology. We turn now to the determinants of the venture capitalist’s bid. What are the value consequences of developing the innovation within a venture capital backed startup?

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39 Id. at 9. Peter A. Hall & David Soskice, Varieties of Capitalism: The Institutional Foundations of Comparative advantage 1-21 (2001), make a similar point but expanding the analysis to include political institutions as well as the organizational structure of the corporation.

40 While the text does not refer to the role of financial contracting within the Japanese firm, both Aoki, supra note 38 and Hall & Soskice, supra note 39, stress the role of the Japanese banks as the primary source of industrial capital during the period where Aoki’s description was most accurate. Put briefly, the banks provided a buffer from market forces that would have destabilized the incentive structure at the heart of the structure of the Japanese firm. See Masahiko Aoki & Hugh Patrick, The Japanese Main Bank 388-408, 57-586 (1994).

41 This section draws on Gilson, Engineering a Venture Capital Market, supra note 19.
Here we have the benefit of a large literature that addresses the financial contract between a venture capital firm and a portfolio company, and the fit between that contract and the financial contract between the venture capital fund and its investors. All financial contracts respond to three central problems: uncertainty, information asymmetry and agency costs. In early stage technology financing, these three problems are presented in extreme form. The early stage of the venture magnifies uncertainty; almost all-important decisions concerning the company remain to be made and all of its value depends on uncertain future growth. The same factors expand the information asymmetries between the investor and the entrepreneur, as the entrepreneur’s intentions and abilities are less observable than actions already taken and the actual operation of a business, neither of which is available for many entrepreneurs seeking venture financing. And because the entrepreneur’s interest in a startup funded by venture capital is fairly characterized as an option, in some circumstances there will be significant agency costs: the entrepreneur’s interests and those of the capital provider will sharply diverge, especially concerning the duration and riskiness of the venture.

The organizational and contractual structure of the U.S. venture capital market responds directly to this trio of problems. That response also influences the differential in an innovation’s value if developed within a VC backed startup or developed within an established company. For our purposes, one characteristic of this response is critical: very high-power incentives for all participants – investors in venture capital funds, general partners of the funds, and entrepreneurs – are coupled with very intense
monitoring of entrepreneurs by venture capitalists, and monitoring of venture capitalists by the capital market.  

Consider first the incentives for the entrepreneur – our engineer leaving her employer with an innovation in mind. The first element of the entrepreneur’s incentive structure comes from the fact that the initial venture capital investment typically will be insufficient to fund the startup company’s entire business plan. The investment will instead be “staged.” A particular investment round will provide only the capital the business plan projects as necessary to achieve specified milestones set out in the business plan.  

While first round investors expect to participate in subsequent investment rounds, typically they are not contractually obligated to do so even if the business plan’s milestones are met; the terms of later rounds of investment are negotiated at the time the milestones are met and the prior investment exhausted. The result is to give the venture capitalist the power to decide whether the project (and the startup company) goes forward. This structure both gives the entrepreneur a powerful incentive to perform and gives the venture capitalist the means to monitor that performance. 

Additionally, the powerful incentive provided by staged financing also acts to reduce the information asymmetry between the venture capitalist and the entrepreneur concerning the entrepreneur’s talents. Every incentive has an information related flipside that responds to adverse selection problems. In deciding which startups to finance, the venture capital fund has to distinguish between good and bad entrepreneurs under

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42 This is consistent with Milgrom & Roberts “monitoring intensity principle,” which predicts that because intense incentives give rise not only to incentives to perform but also to incentives to cheat, intense incentives require a significant investment in monitoring Milgrom & Roberts, supra note 17, Ch. 7 (1992).


44 William A. Sahlman, The Structure and Governance of Venture Capital Organizations, 27 J.Fin Econ. 473, t475 (1990), reports that venture capital funds invest one-third of their capital in new investments and two-thirds in later round financing of companies already in their portfolios.
circumstances in which an entrepreneur has better information about her own skills than does the investor. Because the incentive created by staged financing is more valuable to a good entrepreneur than a bad one, an entrepreneur’s willingness to accept an intense incentive is a signal of the entrepreneur’s difficult-to-observe skills. The signal is particularly important for early stage and high technology portfolio companies because the absence of a performance history and the technical nature of the projects make the entrepreneur’s skills particularly difficult to observe. In comparison, the entrepreneur’s employer will have had substantial opportunity to observe her performance. To some extent, the screening function of the venture capital incentive structure overcomes some of the employer’s informational advantage.

The next element of the incentive structure the entrepreneur faces is the portfolio company’s compensation system. Perhaps more starkly than with any other organizational or contractual technique, the portfolio company’s compensation structure creates extremely high powered performance incentives that serve to align the incentives of the portfolio company management and the venture capital fund. In essence, the overwhelming percentage of management’s compensation is dependent on the portfolio company’s success. Low salaries are offset by the potential for a large increase in value of the entrepreneur’s stock ownership, and by the award of stock options to other management members. The performance incentive is further heightened by the practice of requiring the entrepreneur and other members of management to accept the imposition

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45 Conceptually, the signal will result in a separating equilibrium, in which only high quality entrepreneurs will accept the incentive, and low quality entrepreneurs, whose alternatives are more valuable to them than the incentive contract that requires more talent than they have for it to pay off, will not. See Gompers, Ownership and Control, supra note 43, Edward Lazear, Salaries and Piece Rates, 59 J. Bus. 405 (1986).
of a staged vesting requirement on some or all of their stock or stock options. The vesting requirement gives the portfolio company the right to purchase a portion of the entrepreneur’s or other management’s stock, at a favorable price, if employment terminates prior to a series of specified dates. It also restricts exercise of options until after the manager has completed a series of employment anniversaries, following which an additional number of options become both exercisable and no longer subject to forfeiture if employment terminates.

While aligning the interests of the venture capital fund and entrepreneur in some circumstances, the intensity of these incentives can also lead to agency costs in others. In particular, the option-like characteristics of the portfolio company’s compensation structure can lead the entrepreneur to increase the risk associated with the portfolio company’s future returns, because the venture capital fund will bear a disproportionate share of the increased downside but share only proportionately in the upside. Thus, the intensity of the performance incentives created by the compensation structure gives rise to the need for the venture capital fund to monitor the portfolio company’s performance.

The high-powered incentives to perform faced by the entrepreneur are matched by the incentives to monitor faced by the general partner of the venture capital fund. The bulk of the GP’s compensation comes in the form of a carried interest—20 percent of the venture capital fund’s ultimate profits is a common figure—distributed to the general partner when realized profits are distributed to the investor limited partners. In effect, the


GP receives an option on 20 percent of the gain in the portfolio company’s value, which, given the high variance, will be very valuable. Most important, by its actions in monitoring the entrepreneur, the GP has the ability to influence the outcome of the events on which he has an option. Thus, the structure of the general partner’s incentives provides an intense incentive to monitor, which balances the entrepreneur’s intense incentive to perform.

The term structure of the venture capital limited partnership also gives general partners an incentive to monitor the entrepreneur’s performance. The partnership typically has a fixed term, usually ten years, after which the fund’s assets are distributed to the investors. The result is that at predictable intervals, the investor will have the opportunity to assess the general partner’s performance in the context of deciding whether to reinvest the funds distributed with the general partner.

C. Assessment

The employer of an innovative employee on the one hand, and a venture capital fund on the other, have different capabilities and therefore different assessments of the value of the innovation that the employee has offered at auction. We have seen that the employer bids by means of its internal incentive structure. But this structure is not monotonic; at some point increasing the internal incentives another notch in order to retain an additional engineer and innovation results in costs across the rest of the employer’s R&D effort that are greater than the innovation’s value. At that point, overall firm performance decreases as the intensity of incentives increases. And there is reason to speculate that in many companies, the inflection point may come at very low levels of incentive intensity because the cost of too high incentives will be spread over the
company’s entire R&D effort, while the benefit will be limited to retaining discrete innovations. This likely explains the infrequent use of “intrapreneurship” strategies, an arrangement by which an employer locates an employee’s innovation in a newly created subsidiary and, by giving the employee an ownership interest in the subsidiary, effectively matches the intensity of the incentive that the employee would confront through the venture-capital financial contract.

In contrast, in VC-backed startups, where the general partner’s intense incentives to monitor matches the entrepreneur’s intense incentives to perform, and where the company typically has a single project on whose success the incentives are based, there is no need for property right perfection; as a result, the barriers to spillovers to other projects that plague the use of intense incentives in established companies are not present. For the startup, overall performance is increasing in the intensity of incentives.

In the end, this analysis leads one to expect specialization in the location of research efforts of the sort we observe anecdotally. As Aoki concluded with respect to Japanese manufacturing, incremental innovation, like process improvements in manufacturing that depend on team work and information sharing, responds to more gentle incentives, like stable employment and predictable compensation.48 In contrast, intense incentives matched by intense monitoring fit better with single project efforts, especially in fast-moving technology markets where first mover advantage may mean that the race for the next generation of technology has only one winner. While more detailed study is warranted, this allocation of innovative activity illustrates the need to understand the intersection of the financing, organizational structure and technology of an innovative project to understand the project’s location.

48 See text at notes 38-40, supra
II. Disruptive Innovation

We now turn to a widely discussed phenomenon that presents a case of the question whether an innovation is located in an established company or in an earlier stage company. In an influential book, Clayton Christensen describes a quite different interaction between established companies and early stage companies with respect to the location of innovation. Christensen’s focus is on why established industry leaders fail to anticipate an innovation that devalues their skills and products, diluting their dominant position. In Christensen’s term, such an innovation is a “disruptive” technology. The problem is not that the industry leaders are bad managers. Indeed, these companies are extremely well managed, in that they are attentive to their customers’ needs, continuously improve the quality and reduce the prices of their products, and usually anticipate what their customers will want before the customers know it themselves.

Instead, the problem arises precisely because the industry leaders are so good at what they do. Rather than simply being an extension of the existing method of production, a disruptive technology reflects so sharp a break with existing products that neither a leading producer nor its sophisticated customers initially see the technology’s potential. And because the market for the disruptive technology is initially so small, a rational manufacturer would ignore the innovation, sensibly concluding that the returns on an investment would not be worth the effort. As a result, a disruptive technology takes root in secondary markets of no interest to the industry leaders. Later, developments in the disruptive technology allow it to be generalized to the industry core; dominant firms are then displaced because they cannot respond quickly enough to the change in the architecture of production. Christensen examines examples of the

phenomenon in connection with disk drives, electric arc or mini-mill steel producers, and hydraulically activated earth-moving equipment.\textsuperscript{50}

In Part I we considered one circumstance in which established firms chose to allow an innovation to go to a start up – the employer setting its internal incentives at a level such that some number of employees pursue their innovations through a startup. There, however, the problem was not that the employer did not appreciate the value of the innovation. Rather, the employer recognized that the incentive intensity necessary to assure that all employee-inspired innovations remained with the company would reduce the overall efficiency of its existing R&D capacity by more than the value of the marginal innovation. Such firms made a clear-eyed calculation that allowed some of their employees to seek financing through a venture capital firm. In the case of a disruptive technology, an established firm’s decision not to pursue the disruptive technology is also rational, but only because the innovation’s value is not visible when the decision is made. Put differently, a dominant company passes on many innovations because it concludes, based on its experience, that they are not valuable. Sometimes the dominant company turns out to be very wrong. A related phenomenon involves companies that recognize that a competing technology has potential, and some even try to straddle the two technologies, but fail at the task of simultaneously pursuing the existing technology while embracing the new.\textsuperscript{51}

\textsuperscript{50} Microsoft’s reaction to search based advertising appears to have tracked Christensen’s pattern. In 2000, before Google had perfected the technique, Microsoft had an early version of the same technology called Keywords. Microsoft shut the product down after two months out of fear of cannibalizing existing revenue streams. See Robert A. Guth, Microsoft Bid to Beat Google Builds on History of Misses, Wall St. J., Jan. 16, 2009, p.1.

\textsuperscript{51} Michael L. Tushman and Charles A. O’Reilly III, Ambidextrous Organizations: Managing Evolutionary and Revolutionary Change, 38 Cal. Mgmt Rev. 8, 9-10 (1996), offer the example of the transition between vacuum tubes and transistors. The leading vacuum tube manufacturers either never entered the transistor market or did enter and failed. The ultimate winners in the transistor market were, as Christensen would predict, the new companies that worked only with the new technology.
Christensen’s solution for an established company is interesting in that it reflects the realization that for some types of innovation, organizational form is critical. In effect, Christensen recommends that the established company hedge the potential that a technology is disruptive by creating a separate unit that is matched to the smaller market available to the technology at that time, at a sufficient distance that the incentive problems discussed in Part I are minimized. If the technology ultimately proves disruptive, the established company has the resources to grow the small separate unit quickly.

Other management scholars are more optimistic. Although recognizing the problem Christensen poses, they envision an “ambidextrous” firm that “can compete simultaneously in both mature and emerging markets” without the resigned separation Christensen recommends. But regardless of whether firms can be taught to be switch hitters, at this point we are back to the problem confronted in Part I: how does an established company manage the process of keeping innovations without destabilizing the internal incentives for the rest of its business?

Christensen does not address this issue, but the fact that his recommendation highlights it provides support for the effort undertaken here. The location of innovation within an alternative firm or within an ambidextrous firm whose internal organization is

52 Christensen describes the strategy as “a policy of implanting projects to commercialize disruptive innovations in small organizations that will view the projects as being on their critical path to growth and success, rather than as being distractions from the main business of the corporation.” Id. at 158.
54 Comments by Charles Sabel and Bengt Holstrom at the conference at which the paper that gave rise to this article was first presented succinctly presented the pessimistic side. Taking their views together, they argued that firms are good at pursuing known tasks through hierarchical organizations, but that a hierarchy is not good at reprogramming itself. Put differently, the dilemma is that either there is no way to systematize non-incremental innovation – that is, non-incremental innovation is a non-organizational task – or the firm must figure out a way that the innovation is not disruptive.
radically refigured is endogenous, reflecting the particular confluence of transaction
costs, financial contracting techniques and the substance of the technology. The specifics
of which financial and organizational structures most successfully fit a disruptive
technology remains to be seen. For present purposes, however, the point is only that
Christensen identifies another instance where the location of the technology and the
corresponding financing of its development is outside the universe of established firms.
Again, we see the centrality of the tradeoff between established firms and early stage
startup firms.

III. An Established Company Using a Technology Race among Startups: The Cisco
Systems Strategy in the 1990s

We now consider a third intersection between an established company and a
startup firm, which may provide an established company a different way to avoid
Christensen’s innovator’s dilemma. During the 1990s, Cisco Systems confronted a
difficult problem. Cisco specialized in the hardware and software that supported local and
wide area networks.\textsuperscript{55} The company was extremely successful, having grown in 14 years
from a startup to a point where 65 percent of LAN networks used Cisco routers.
However, network technology was growing in power very quickly and was changing just
as quickly – a product lifecycle was estimated to be 18 months and it was expected that
new solutions would double performance at the same price. At any given point, it was
hard to predict the path the technology would take; while the problems that would need to
be solved were visible, a variety of technological solutions might be possible. And
because markets for network hardware often rewarded the winner of the technology race
with significant first mover advantages, being quick was the best way to avoid being

\textsuperscript{55} For general background, see Stanford Graduate School of Business, The Acquisition of Technology is
the Acquisition of People, Case Number HK-10 (1998)
dead. But any single company has limited internal R&D capacity; it can do some things well and not others, and it can only do so much.\textsuperscript{56} The limited visibility of the direction of the market and the short product cycle – said to be six months from when the company knew it needed a product to market – meant that Cisco did not have the time needed to develop the innovation internally. And the further away an innovation was from Cisco’s core technology, the greater the risk that the company would lack the organizational capacity to exploit it. Making the wrong bet on the solution in the face of significant first mover advantages could be far more costly than the company was willing to bear.

Startup and growing early stage companies provided a way for Cisco to deal with the need for expertise that it might not already have in-house. The lack of visibility of the direction of technology reflected the fact that different solutions were possible to most problems. This is where early stage and startup companies provided an opportunity. If venture capitalists funded startups that pursued alternative solutions to the technology problem, then Cisco could acquire the company that won the technology race in time to have a product to market by the time it was needed.\textsuperscript{57} To be sure, the price for the winner would be high – competitors might bid, and an initial public offering could provide the winner’s venture capitalists an alternative liquidity event. Cisco’s large market share and its extensive marketing and distribution system, however, gave it advantages that the focused winner of the technology race could not match on a stand-

\textsuperscript{56} Cisco is said to have done 70 to 80 percent of its product development through internal R&D, although the engineers who had developed many of these products joined Cisco as a result of an acquisition. Id. at 5.

\textsuperscript{57} John Chambers, Cisco’s CEO, described the process in this fashion: “Our ideal acquisition is a small startup that has a great technology product on the drawing board that is going to come out 6 to 12 months from now. When we do that, we are buying the engineers and the next-generation product. Then we blow the product through our distribution channels and leverage our manufacturing and financial strengths.” Henry Goldblatt, Cisco’s Secrets, Fortune, (Nov. 8, 1999). See Stanford Graduate School of Business, Cisco Systems, Inc.: Acquisition Integration for Manufacturing 5, Case OIT-26 (2/3/04) (“Cisco viewed acquisitions as a means to ensure that it was offering the ‘best of the breed’ product technology.”)
alone basis.\textsuperscript{58} For the same reasons, Cisco could be expected to pay more to exercise the real option that its strategy entailed: to wait and see which technology was best and then acquire it.

For present purposes, the interesting point of the Cisco example is that it frames a different question concerning the efficient location of innovation as between a startup and an established company. In Part I, innovation was allocated between an established company and a startup based on the differential operation of intense incentives in the two environments. Here innovation is allocated based on technological imperative – the ability of the venture capital market to finance a range of alternative solutions to a technology problem and make use of the incentive intensity of a startup structure, neither of which Cisco could match internally. Consistent with this confluence of technology, organizational structure and financial contracting, Cisco developed the ability to quickly and effectively integrate new acquisitions.\textsuperscript{59} In effect, Cisco outsourced R&D to market-based technology races between startups to achieve the basic innovation, but took on the task itself of commercializing the innovation.

\textbf{IV. Joint Ventures between Large Pharmaceutical Companies and Biotechnology Companies}

In this Part we consider the pattern of joint ventures between small biotech companies and large pharmaceutical companies to develop new drugs.\textsuperscript{60} As in the Cisco

\textsuperscript{58}John Chambers described Cisco’s first acquisition in 1993 of Crescendo as follows: “We took Crescendo’s networking product, and within 18 months we had a $500 million run rate. No small company can go from $10 million to $500 million in 18 months. They just can’t scale. But we could scale because of our distribution, financial, and manufacturing strengths.” University of Virginia Darden School of Business, Cisco: Early if not Elegant (A) 8, UVA-BP-0446, available at: http://ssrn.com/abstract=907950.

\textsuperscript{59}This strategy put enormous pressure on Cisco to quickly integrate the companies it acquired into the Cisco structure, including especially the Cisco incentive system. See Stanford School of Business, Acquisition of Technology, supra note9; Stanford Graduate School of Business, Acquisition Integration for Manufacturing, supra note 55; University of Virginia, Cisco, supra note 55.

\textsuperscript{60}See note 7 supra.
case, this final example allocates innovation to a small company and commercialization to an established company. It differs in that the Cisco strategy contemplated sequential cooperation, the acquisition occurring only after the technology is developed, with the incentive structure driving that development supplied by the early stage company and the market. The large pharma-biotech joint ventures, however, contemplate a cooperative arrangement from the beginning, with the result that an organizational structure must be developed to govern that cooperation.

Two important background facts put the large pharma-small biotech joint ventures in context. These concern the costs and risks associated with developing a new drug; and the very large change in technology that gave rise to the new generation of biotech firms.

Consider first the costs and risks associated with new drug development. The initial screening of potential drug candidates and work that precedes the commencement of clinical trials takes some three to six years. During that period, the number of compounds examined runs from 5,000–10,000, which ultimately yield a small number that warrant scientific and animal testing. An application for an Investigational New Drug is then filed with the FDA. If approved, clinical testing on humans can begin, which takes another six to seven years. That period is broken down into three test phases, the first involving fewer than 100 persons, the second between 100 and 500, and the third between 1,000 and 5,000. If the drug passes these tests, the sponsoring company files a New Drug Application (NDA). FDA review of the NDA can take another six months to two years. If the FDA approves, the drug can be brought to market. Out of 5,000 to 10,000 compounds that are initially screened, it is estimated that only 250 begin

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61 This account of the approval process draws on Gilson, Sabel & Scott, supra note 8, at468, and Patricia Danzon, Sean Nicholson & Nuno Sousa Pereira, Productivity in Pharmaceutical-biotechnology R&D: The Role of Experience and Alliances, 24 J. Health Econ. 317, 318 (2005).
preclinical testing, and only about twenty percent of drugs that begin human testing are ultimately approved by the FDA. After receiving this approval, the drug’s commercial success can finally be determined.

The expense of the process is consistent with its length. The average cost of drug development, from initial research and development through FDA approval, but excluding commercialization costs, were estimated in 2003 at $802 million, using even earlier data. Taking into account the time value of money, the scientific risk associated with securing approval, and the commercial risk that even approved drugs will have sufficient sales to provide a return on investment, new drug development presents a daunting challenge.

The second background fact that puts large pharma-small biotech firm alliances in context is the dramatic change in the underlying science that gave rise to them. By the early 1980s, it became apparent that advances in biotechnology required large pharmaceutical companies to develop skills quite different than the chemistry-based science that had previously driven pharmaceutical research. Those skills were found in

64. Id.
small, early stage firms, typically formed by university-affiliated scientists.\textsuperscript{66} Forming 
alliances with these smaller, research oriented companies provided quicker access to this 
knowledge than the pharmas developing the capabilities in-house\textsuperscript{67} and, in turn, took 
advantage of the pharmas’ experience and capabilities at conducting human testing and 
running the FDA licensing gauntlet.\textsuperscript{68}

The large pharma-small biotechnology joint ventures nicely illustrate how the 
intersection of technology, organizational structure and financial contracting dictate the 
location of innovation. As we have already seen, the development of new drugs based on 
biotechnology required a combination of skills that could not be found in either 
traditional pharmaceutical companies or in the early state biotechnology firms. While the 
new biotechnology was potentially “disruptive” in the Christensen sense,\textsuperscript{69} it lacked the 
characteristic that drives Christensen’s account of the displacement of industry leaders by 
the unexpected success of what initially appeared as peripheral technologies. The 
potential of biotechnology, highlighted by the award of Nobel prizes, was plainly evident, 
so that the large pharmaceutical companies did not ignore this avenue of research. 
Rather, the question was how to secure it.

Here the Christensen analysis is relevant. At least at the outset, the 
pharmaceutical companies did not believe they could be ambidextrous. The 
characteristics of biotechnology research more closely resembled university-based 
research than then how research was organized within the large pharmaceutical firms.\textsuperscript{70}

\textsuperscript{66} See Powell, supra note665 at 199-201
\textsuperscript{67} See, e.g., Powell, supra note 65, at 203.
\textsuperscript{68} See, e.g., Nicholson et. al., supra note 65 at 1434 (large pharmaceutical capabilities with FDA process as 
a cause of alliances).
\textsuperscript{69} See note 49 supra.
\textsuperscript{70} See Powell, supra note 65, at 199-200.
Whether the two research styles, including scientists who both moved between universities and industry and often straddled the two, could be housed in the same organization was thought problematic. In this respect, the analysis tracks our earlier analysis of the different incentive structures of established and startup companies.\(^71\)

Consistent with this assessment, when the Swiss pharmaceutical company Roche acquired 56 percent of Genentech, it both committed not to buy the rest of the company without a majority vote of the minority shareholders, and left Genentech’s headquarters and operations in the San Francisco Bay Area rather than integrating the biotechnology company with its other operations. When Roche bid to acquire the remainder of the shares in 2008, concerns about the impact of the acquisition on Genentech “culture” were widespread, and Roche again committed to leave Genentech in San Francisco, rather than integrating.\(^72\)

The same kinds of concerns also may have counseled against a Cisco-like strategy. Recall that Cisco’s strategy was to rely on the market to motivate a technology race, but once having bought the winner, to quickly and fully integrate the acquired company, including replacing the acquired company’s incentive system with that of Cisco.\(^73\) In the case of biotechnology, especially in the early years, the culture gap, including differences in the incentive structure of biotechnology and large pharmaceutical companies, was too large for the Cisco acquisition and integrate strategy.

If the technology differences between the biotechnology and large pharmaceutical companies made acquisitions generally unattractive, then the combination of the capabilities of the two types of companies would have to be done outside either of the

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\(^{71}\) See TAN_41-47, supra.


\(^{73}\) See TAN 59, supra.
existing entities. This means that the organization of the joint venture would be contractual. And here the problem of crafting the contract was daunting. As Gilson, Sabel and Scott put it: “The inability of the parties to specify ex ante the nature of the product to be produced or its performance characteristics means that the terms of production will be determined by the very governance process the contract creates.”  

The result is a structure that contemplates collaboration through a structure of a joint committee that shapes the research agenda and resolves disputes, but without the specification of provisions that are legally enforceable in terms of the parties’ actual conduct.

That pattern shifts once a compound is indentified and uncertainty is reduced. Instead of contractual provisions that are directed at process rather than outcome, we then observe explicit allocation of property rights in the compound through a set of nested options: the pharma has the option to go forward with clinical testing at its expense and the biotech firm receives a royalty right if the tests are successful that is specified in detail, with the biotechnology company regaining the technology if the pharma does not go forward. Thus, we observe a braiding of implicit contracts supported by an explicit governance arrangement that allow the parties to learn about each other’s capabilities and capacity for cooperation and then carry out the research design that is developed through that cooperation, and explicit contracts that allocate property rights through options on the technology once a compound is identified. In turn, the same provisions facilitate both parties developing reputations for performance in these relationships that facilitate

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74 Gilson, Sabel & Scott, supra note 8 at 467. The authors discuss in detail a particular large pharma-small biotechnology company joint venture.
75 See id. .
their entering into similar arrangements with other companies.\textsuperscript{76}

Finally, the financial contracting arrangements observed in pharma-small biotechnology company joint ventures reflect the simultaneous determination of organizational structure and financial contracting in light of the technology involved. Lerner and Merges suggest that during the 1990s, more funding was provided to biotechnology companies through joint ventures and strategic alliances than from venture capital, initial public offerings or secondary offerings of stock.\textsuperscript{77} This allocation is hardly surprising. Equity financing through venture capital provides a sensible form of financial contracting during periods when compounds are being identified and uncertainty makes it difficult to base payment to the biotech company entirely on performance, and when the biotech company needs assurance that the large pharma company will have the proper incentives when they decide whether to incur the large costs associated with pursuing FDA approval. In turn, the FDA approval process, including especially human testing, involves a level of costs and takes a length of time that are inconsistent with the venture capital funding structure. Recall that the investment required for a single compound to get through the process was on average $800 million based on pre-2003 data, an amount too large for venture capital funds to provide, and that the process takes some 12 years, too long to be feasible for a venture capital fund whose term is typically limited to 10 years.\textsuperscript{78} Thus, we observe a combination of venture capital and joint venture financing.

\textsuperscript{76} David T. Robinson & Toby E. Stuart, Network Effects in the Governance of Strategic Alliances, 23 J. Law, Econ. & Org. 242 (2006), discuss how reputation, measured by centrality within a network of companies, affect the contractual arrangements between joint venture partners.

\textsuperscript{77} Josh Lerner & Robert Merges, The Control of Strategic Alliances: An Empirical Analysis of Biotechnology Collaborations, 46 J. Instit. Econ. 125 (1998). The authors also report that joint venture/alliance funding in 1995 exceeded the sum of the next three largest sources of funds for biotechnology companies.

\textsuperscript{78} See Gilson, Engineering a Venture Capital Market, supra note 19.
that reflects the nature of the technology being financed and the organizational structure through which the product is carried out.

V. Conclusion

The effort here has been to describe the combination of forces – technology, organizational structure and financial contracting – that refracted through the prism of transaction and information costs combine to influence the allocation of innovation either to an established company to be financed by retained earnings or the company’s credit, or to an early stage company, with financing provided through venture capital, or to a joint venture of early stage and established companies. The goal is to develop a better understanding of how innovative activities are distributed across the economy. We considered four patterns where developing an innovation is at the interface of established and startup or early stage companies: when an established company employee with an innovation will pursue the innovation through a startup; when an established company may face the threat of a disruptive technology pursued by a smaller company, when an established company outsources particular R&D projects to a technology race among venture capital funded early stage companies; and when an innovation is located between an early stage biotechnology company and a large pharma through a joint venture or strategic alliance. In the past, scholarship has largely focused on the arrangements associated with a particular location of innovation. Here the focus has been on the determinants of the allocation of innovation across locations, with the hope that positive understanding of that allocation leads to normative implications for those charged with engineering the transactions giving rise to innovation.
In concluding, it is important to note three limits to the effort. First, the range of innovation patterns discussed is quite limited. I believe that the same framework – the endogeneity of technology, organizational structure and financial contracting on the allocation of innovation – will have broader application than the interface between early stage companies and established companies considered here. Nonetheless, that inquiry, as well as more detailed examination of the locations of innovation we did consider, remain to be undertaken.

Second, at any given point in the locational space, there will be overlap. No response to a particular cluster of attributes is exclusive; depending on the particular characteristics of an individual company and the nature of the particular technology, a range of organizational techniques may work. For example, some companies will successfully manage intense incentives without negative spillovers to its existing R&D efforts even though the central tendency will push in the direction of letting some innovations go.79 Thus, the goal is to understand the forces that underpin the observed central tendency, which then can be employed to understand the variance in practice.

Finally, the analysis has been largely static, even though the market for innovation is, tautologically, dynamic. For example, the vertical disintegration of the supply chain,80 by allowing a startup to outsource capital intensive functions like manufacturing and assembly to contract manufacturers and chip fabricators, dramatically reduces the amount of capital that must be raised, and thereby provides another source of financing for innovation. Similarly, the evolution of biotechnology may come to broaden the range of

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79 Bengt Holstrom & John Roberts, The Boundaries of the Firm Revisited, 12 J.Econ. Perspec. 73 (1998), make this point in a more general fashion. From their perspective, the boundary of the firm is dictated by a mix of problems and responses, which will differ depending on particularized circumstances.

80 See Gilson, Sabel & Scott, supra note 8.
organizational structures in which it can be effectively carried out, a conjecture the accuracy of which the Roche acquisition of Genentech and other acquisitions of biotechnology companies by large pharmas will test.
Figure 1: The Innovative Plain